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USERS'S MANUAL FOR ILSS (REVISED ILSLOC): SIMULATION FOR DEROGA--ETC(U)

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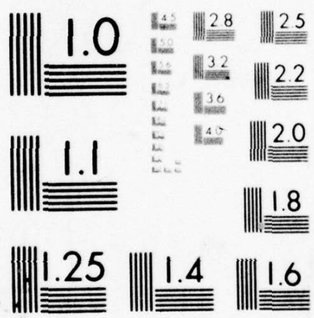

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REPORT NO. FAA-RD-76-217

USERS' MANUAL FOR ILSS (REVISED ILSLOC): SIMULATION FOR DEROGATION EFFECTS ON THE INSTRUMENT LANDING SYSTEM

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DECEMBER 1976

FINAL REPORT

Prepared for

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION
Systems Research and Development Service
Washington DC 20591

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Technical Report Documentation Page

1. Report No. FAA-RD-76-217	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle USERS' MANUAL FOR ILSS (REVISED ILSLOC): SIMULATION FOR DEROGATION EFFECTS ON THE INSTRUMENT LANDING SYSTEM.		5. Report Date Dec[redacted] [redacted]76
		6. Performing Organization Code
7. Author(s) Chin, L. Jordan, D. Kahn, S. Morin, D. Newsom, M. Scotto		8. Performing Organization Report No. DOT-TSC-FAA-76-7
9. Performing Organization Name and Address U.S. Department of Transportation Transportation Systems Center Kendall Square Cambridge MA 02142		10. Work Unit No. (TRAIS) FA607/R7143
		11. Contract or Grant No.
12. Sponsoring Agency Name and Address U.S. Department of Transportation Federal Aviation Administration Systems Research and Development Service Washington DC 20591		13. Type of Report and Period Covered Final Rep[redacted] Aug[redacted] [redacted]73-Mar[redacted] [redacted]76
		14. Sponsoring Agency Code ARD-741

15. Supplementary Notes

16. Abstract

This manual presents the complete ILSS (revised ILSLOC) computer program package. In addition to including a thorough description of the program itself and a listing with comments, the manual contains a brief description of the ILS system and antenna patterns. To illustrate the program, a test case has been created and the figures of the case are incorporated in the report. Program DYNM and program ILSPLT are included as appendixes. The ILSPLT, complete with sample graphs, is a plotting routine for ILSLOC.

For a technical mathematical analysis of the system, see report FAA-RD-72-137 (AD754517), "Instrument Landing System Scattering."

This report revises in part an earlier report FAA-RD-73-76, "Users' Manual for ILSLOC: Simulation for Derogation Effects on the Localizer Portion of the Instrument Landing System." The revisions include the treatment of triangular scatterers and glide slope antenna systems.

17. Key Words	18. Distribution Statement
ILS Derogation CDI Localizer	DOCUMENT IS AVAILABLE TO THE U.S. PUBLIC THROUGH THE NATIONAL TECHNICAL INFORMATION SERVICE, SPRINGFIELD, VIRGINIA 22161

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	122	

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PREFACE

As part of the ILS Performance Prediction program, a first phase ILS Localizer performance prediction computer program package has been prepared. This package consists of the computer program and the present document which describes the capabilities and limitations of the computer model as well as the step by step running of the computer program.

The computer program is intended primarily as an aid in predicting the performance of different ILS antenna candidates for a proposed runway instrumentation or for the upgrading of an already instrumented runway in a known airport environment. It is also intended to provide a relatively inexpensive means by which the effect of proposed changes to an airport environment (addition of terminal buildings, hangars, etc.) on ILS performance may be predicted. Another computer program has been devised to treat the effects of terrain on glide slope performance.*

This document was prepared for the Transportation System Center (TSC) by D. Newsom who was assigned as a full-time programmer to the ILS Performance Prediction program. A. Watson and M. Scotto helped in the writing and editing. The report itself and the attached computer program are based on the theories and analyses which were developed by the TSC group (G. Chin, L. Jordan, D. Kahn, and S. Morin). The ILS program was sponsored by H. Butts of the Systems Research and Development Service of the Federal Aviation Administration.

The present report revises in part an earlier report, FAA-RD-73-76. The revisions include the treatment of triangular scatters and glide slope antenna systems. The revised ILSLOC program has been renamed ILSS-FOR (Instrument Landing System Scattering-Fortran). The use of the term ILSLOC in the body of this report refers to the generalized program, ILSS.

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*S. Morin et al, ILS Glide Slope Performance Prediction, Version A. Report No. FAA-RD-74-157 A. U.S. Department of Transportation, Transportation Systems Center, Cambridge MA 02142, September 1974.

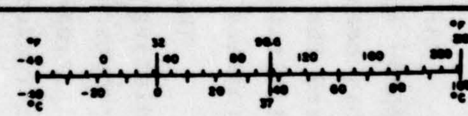
METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



CONTENTS

ILLUSTRATIONS

1. DEFINITION OF INSTRUMENT LANDING SYSTEM

The ILSLOC program has been written to simulate certain airport conditions which affect the localizer portion of the Instrument Landing System. The ILS is used to provide signals for the safe navigation of landing aircraft during periods of low cloud cover and other conditions of restricted visual range. Separate systems are used to communicate vertical and horizontal information; the horizontal system is called the "localizer."

This system operates by the transmission of an RF carrier, amplitude modulated by two audio frequencies, beamed to approaching airborne receivers. In an instrumented aircraft, the localizer receiver serves to demodulate the RF signal, amplify and isolate the corresponding audio signals and derive a signal to drive the ILS horizontal display in the cockpit. The pilot, by reading the display, can determine if he is on course, to the left of the runway, or the right of the runway. These signals must be strong enough to cover a radius of twenty-five miles around the antenna.

The directional information is determined by the relative strengths of the transmitted sideband signals. The audio frequency modulations, which are fixed at 90 Hz and 150 Hz, are radiated in different angular patterns with respect to the runway centerline extended. The "course" is defined as the locus of points where the amplitudes of the two modulations are equal. The display of a difference of the amplitudes (90 Hz and 150 Hz) of the sidebands is referred to as the Course Deviation Indication. Thus, the CDI is the pilot's indication as to what his bearing is relative to the center line of the runway. The CDI is measured in microamps. The actual course generated by any particular ILS installation will deviate from the ideal due to the interference of spurious reflections from buildings present in the range of the transmitting antenna. The deviation, caused by these buildings, or scatterers of the CDI from what the receiver should read ideally at that point in space (e.g., on the center of the runway and CDI reading other than 0) is the derogation effect.

The Localizer system transmits an asymmetrical pattern by beaming a "carrier plus sideband" pattern and a "sideband only" pattern, the composite of which gives the desired effect. If a specific localizer system uses two antenna arrays, four sets of signals will be transmitted; if the system uses a single antenna array, two sets will be transmitted.

2. ANTENNA PATTERNS

The proper angular variation of the transmitted 90 Hz and the 150 Hz modulation is achieved by the radiation of two independent sideband patterns by the transmitting antenna arrays. Equal magnitudes of 90 Hz and 150 Hz modulation are transmitted in each of these patterns, however with different relative phases. One of the patterns is symmetrical with respect to the prescribed course. An unmodulated carrier wave is transmitted with the same pattern and the combination is commonly referred to as the "carrier plus sidebands" (C + S) signal. The other signal is transmitted in an "anti-symmetrical" pattern and is referred to as the "sidebands-only" signal.

Figure 1 illustrates how these features are used to obtain the desired directional CDI. The magnitudes of the C + S and SO sideband patterns as functions of angular deviation from the course are illustrated in Figures 1a. The sideband amplitude of the C + S pattern represents 20% modulation of the carrier wave (or a "depth of modulation" of 0.2) at both 90 Hz and 150 Hz. Considering the phases of both modulations of the C + S signal to be positive, the relative phases and typical amplitudes of the two SO modulations are as shown in Figures 1b. The resultant 90 Hz and 150 Hz modulation patterns in the total ILS signal are obtained by algebraically combining the respective C + S and SO sideband patterns (Figures 1c). The evident consequence is that the depth of modulation is greater for 90Hz than for 150 Hz to the left of the course as seen from an approaching aircraft, and the opposite is true to the right of the course. This difference when properly calibrated in relation to the total modulation (90 Hz + 150 Hz) reaching the aircraft receiver gives the CDI as appears in Figure 1d.

Since the strength of C + S and SO signals fall off at the same rate with distance from the transmitting antenna, the CDI is independent of range.

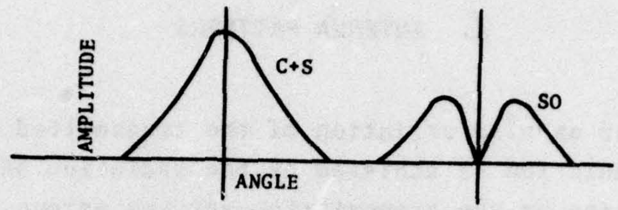


Figure 1a Sideband Pattern Magnitude

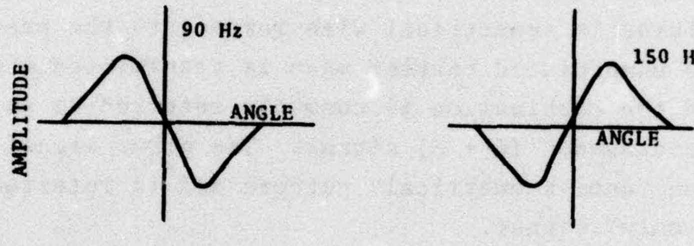


Figure 1b Relative Amplitudes and Phases In SO Pattern

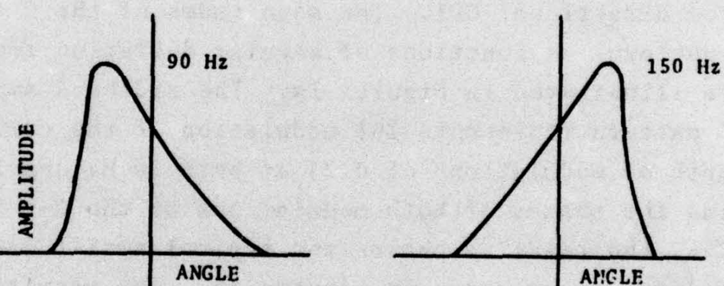


Figure 1c Resultant Modulation Patterns

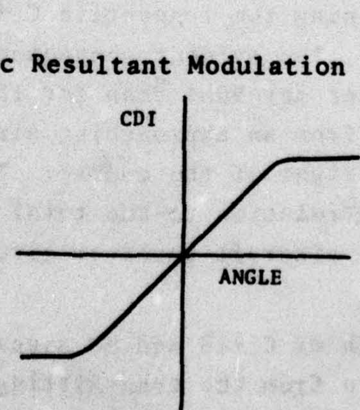


Figure 1d Course Deviation Indication (CDI)

Figure 1. Antenna Patterns Sketch

FAA standards for the ILS specify that within a certain narrow angular range about the course, the CDI should be closely proportional to the aircraft's angular deviation from course. This sector near the ideal approach is termed the "course sector" and usually extends between 1-1/2° and 3° to either side of the runway centerline. The wider sectors on either side of the course sector are called the "clearance sectors." In these sectors, which extend a minimum of 35° from the course, the CDI is required to always exceed a certain minimum magnitude. The presence of structures in the clearance sectors which scatter spurious signals into the course sector is the primary cause of derogation of the localizer CDI. Such structures are illuminated by carrier and sideband signals. The ratios of 150 Hz modulation to 90 Hz modulation in these signals are determined by the angular position of the structure with respect to the runway. In general these ratios are different from those transmitted toward the aircraft, due to the difference in angular position. The signals transmitted toward the scatterer will be reflected toward the aircraft. Thus the aircraft will receive the summations of the direct and scattered signals. Since, in general, the scattered signals will have improper ratios their effect is to distort the CDI. To combat this problem several new antenna systems have been designed. Two basic systems are used: the single antenna, and the "capture effect system."

The single antenna system radiates two patterns from one antenna array. The signal generated in the course sector is stronger than that generated in the clearance sector. However, because of the derogation effects, the signals are often not accurate enough to meet category II or III requirements and the more accurate "capture effect system" is used. This system uses one antenna array to broadcast a very narrow, powerful beam in the course sector. The second antenna array broadcasts a broader pattern, at a slightly different carrier frequency, which covers the clearance area. This system diminishes the derogation effects because of the dual frequency. The term "capture effect" has been used to describe this two-antenna array system because the airplane receiver is "captured" by the stronger transmission signal.

3. ILS SIMULATION DESCRIPTION

The ILS simulation program makes it possible for airport planners to determine what the effects of potential airport buildings on the ILS performance are going to be. Thus, for example, if a new terminal or hotel is planned, the information as to size and location of the building can be input to the program and the derogation effect of that building can be determined. Because the derogation effect of these scatterers is so important, the program can warn the planner ahead of time to change the orientation or location of the building, or it can assure him that the building would not jeopardize the airport's current FAA rating.

The output of this program is a magnetic tape of values of the CDI. Graphs are generated by a plotting routine (using the values derived from the ILSLOC program) to show the CDI in microamperes, along a flight path, for the scattering surfaces input. These generated graphs would serve the same purpose as the FAA strip charts which are generated for a certifying flight. The simulation graph differs from the actual recorded measurements due to limitations of the program which will be explained later in the text.

The ILSLOC program simulates: transmission from the various types of localizer antenna systems; the trajectory of an aircraft flight over which the CDI is to be determined; and the scattering from rectangular and cylindrical surfaces. The program permits various simulated flight paths.

The program is not an exact simulation of the certifying flight, due to certain simplifying assumptions which were made. These assumptions include:

a. A flat perfectly conducting ground plane

b. Perfectly conducting reflectors

c. Far-field scattering-- all scattering from a surface is assumed independent of all other surfaces; thus, multiple reflections from walls and near-field interactions are ignored

d. A noise-free environment

e. Relative field strengths-- the absolute field strengths involved are not calculated; thus while we can calculate the CDI's in microamperes, we do not ascertain the absolute electric-field intensities, and

f. An idealized ILS receiver model.

In addition to these assumptions the approximations of the scatterer can lose accuracy when the dimensions approach less than a few wavelengths. Since the program determines the scattering from a surface independently from all other scatterers, the shadowing of one structure on another is not included. Thus if one building is between the antenna system and another building, it will shield the second one from some of all of the ILS signal. The amount of energy reaching the second building will depend upon diffraction effects which are, in general, too complicated to analyze. It may be noted, however, that diffraction effects themselves are included as part of the physical optics approximation used.* By using rule of thumb approximations the analyst can determine roughly how much power will reach the second building. If the level is small the building may be ignored completely. If on the other hand the power level is large then the structure should probably be included as though there was no shielding effect. This will give a conservative CDI estimate (i.e., larger derogation than actual), but this will serve for most purposes. If the situation is critical, that is near category limits, then other means of analysis must be used.

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*Chin, G., L. Jordon, D. Kahn, and S. Morin, TSC, "Instrument Landing System Scattering," FAA-RD-72-137, AD754517 (Dec. 1972).

4. TEST CASE FOR THE ILSLOC COMPUTER PROGRAM

To illustrate how the computer program is operated a very simple test case (with only 2 scatters) has been created and run. For this simulated airport the program computed the course width as 4.01 degrees. Both antenna arrays were set at an elevation of 13 feet above the ground plane. The clearance antenna array was used as the origin for the coordinate system. An 80 x 100 x 60 ft hangar and 75 x 110 ft cylinder were placed on opposite sides of the 9,350 ft runway. In this case the threshold is 10,000 ft from the course antenna. (See illustration--Figure 2.) Based on the size and locations of these two buildings, the model predicted the CDI on the runway centerline and for a clearance run at 10,000 ft range.

Using this model for input values, the following section presents a detailed follow through of the main program steps.

The Mode Card

The first input is the mode card. This card contains information on the type of localizer antenna used, the frequency of the ILS, the length of the runway, and the height of the antenna. The mode card format is shown immediately following Figure 2. In order to use the mode card, it is important that the user understand the coordinate system used. The x-axis is along the centerline of the runway, the threshold being in the positive direction. The z-axis is vertical, positive z being in the up direction. The y-axis completes a right-hand coordinate system; so that when one is standing at the origin facing in the x-direction, positive y is to the left. The origin is used as a reference to define the location of scatterers, antenna system components, and flight path sample points. The antennas are located along the x-axis, they need not be at the origin. As in our test case, it is usually convenient to place the course antenna at the origin.

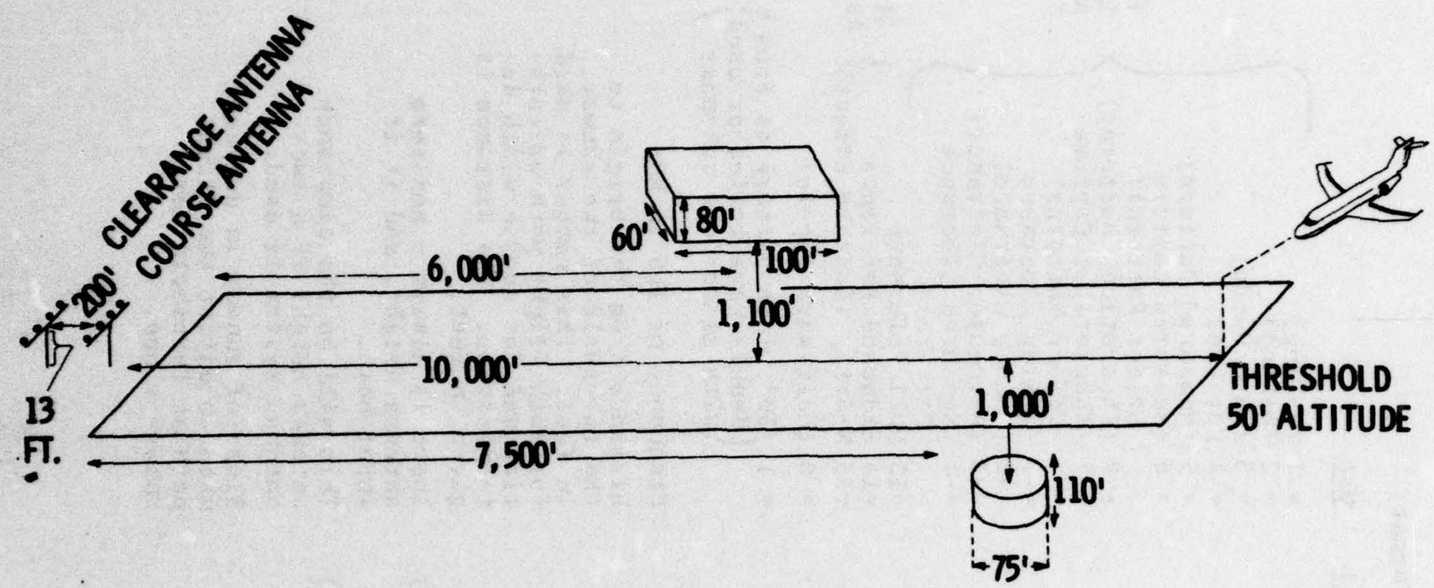


Figure 2. Simulation Airport

Model Card Format:

Col.	Symbol	Use	
1-2	Mode	= 1 (V-Ring) = 2 (8-Loop) = 3 (Wave Guide) = 4 Not Used = 5 (Measured Pattern) = 6 (Measured Capture Effect Patterns) = 7 (Theoretical Patterns) = 8 (Theoretical Capture Effect Patterns) =-1 (V-Ring Clearance =-2 (8-Loop Clearance) =-3 (Waveguide Clearance) =-4 (Measured Clearance Patterns)	Indicates Localizer Antenna Type
		=13 Null Reference =14 Sideband Reference =15 N-Array (Capture Effect)	Glide Slope Antennas
3-4	IET	= 0 (Half-wave dipole) = 1 (30° width pattern as from double wave reflector used with glideslope antennas)	Antenna Element Pattern
11-20	FRQ	Frequency of ILS in MHz	
21-30	XTH	Distance from the origin to the threshold of the runway, in feet. This number is used for both flight path orientation and for course width determination. The distance is given in feet.	
31-40	ZA(1)	There is always a non-zero antenna height, and it is input here.	
41-50	ZA(2)	This will be the clearance antenna height if a two-antenna system is used.	
51-60	SLP	Slope of runway in degrees used to adjust the flight path at threshold for runway slope.	

Modes 1, 2, and 3 provide for standard localizer antenna types. These antennas are predetermined, the only variable being course width, the adjustment of which is controlled by the course width card.

When any antenna type other than mode 1, 2, or 3 is used, additional antenna description cards must be included. Mode 5 permits the input of a measured pattern for special cases on theoretical studies. When this mode is selected additional pattern cards are required. One pattern card must be used for each measurement. The angles must be given in ascending order. A maximum of 50 measurements may be given; if less than 50 cards are used a termination card with an angle greater than 360 degrees must be inserted.

Format of Pattern Card(s)

Col.	Symbol	Use
1-10	ANG	Angle of measurement, in degrees
11-20	AFPP	Amplitude of sideband only pattern, in relative units
21-30	AGPP	Amplitude of carrier plus sideband pattern, in relative units.

Mode 7 allows the generation of a theoretical array pattern from assumed element contributions. The antenna is to be a linear array of elements with identical radiation patterns. Each element has an arbitrary magnitude and phase for both carrier plus sideband and sideband only currents. The arrays are assumed to be alligned parallel to the y-axis. All elements have the same height, as given in the mode card. All elements have the same x-coordinate as given on the course width card. The y-coordinate, in wavelengths, is given for each element on the element description card. There must be one card for each element in the array, to a maximum of 26 elements. The element description card has the following format:

Col.	Symbol	Use
1-10	DT	Element displacement in the y-direction given in wavelengths
11-20	CT	Carrier plus sideband amplitude, in relative units
21-30	PC	Carrier plus sideband phase, in degrees
31-40	ST	Sideband only relative amplitude
41-50	PS	Sideband only phase, in degrees.

The phase of the sideband only currents is ideally in quadrature to the carrier plus the sideband currents. This 90-degree shift is added by the program. Thus a "PS" inputted as zero degrees is internally converted to 90 degrees out of phase with the sideband portion of the carrier plus sideband. To indicate termination when there are less than 26 elements used, an element card is placed with a carrier plus sideband phase value (PC) of more than 500.

The next step for this mode must be the input of the horizontal radiation pattern for the individual element. This pattern will be used for each of the elements previously described. The input is the relative signal strength measured every 10° starting at 0 and proceeding until 180°. This is total of 19 amplitudes; the values are read in, in records of 8F10.4 format, for a total of 3 records. This gives the pattern for angles from 0 to 180° and since the pattern is assumed to be symmetric the value for the negative angle will be the same as a positive one of equal magnitude.

There are two methods of inputing capture effect system descriptions. The most general way is to input each antenna separately. When using this method the clearance antenna must be input first. This input will follow the same steps as a single antenna system except that the mode number will be a negative. The negative mode card and the pattern or element cards (if any) must be followed by another mode card. This mode for the course antenna must be positive, and followed by the necessary pattern or element cards.

There are two cases for the second method of inputing antenna descriptions. The first case is used if both course and clearance antennas are to be given as measured patterns; a single mode 6 card is used followed by two sets of pattern cards: the first set is for the course antenna and the second set for the clearance antenna. In the second case, for a capture effect system which uses two theoretical array antennas, a mode 8 is used. This card is followed by the course antenna element description cards and the element radiation cards; a second set of array description cards is used in the clearance antenna.

In the above localizer antenna cases, IET has no effect on the simulated individual element patterns and may be input as zero.

FRQ is set to the frequency (in MHz) of the carrier for the antennas system.

XTH is the distance (in feet) from the orgin to the runway threshold. The flight path is set to cross the threshold at an altitude of ZUP (as given on flight path card).

ZA(1) (course) and ZA(2) (clearance) are the heights in feet of the antennae.

SLP is the slope of the runway in degrees. It is used with XTH in setting up the flight path. The ground plane assumed for the signal scattering is not tilted.

Modes 13, 14, and 15 are used for glide slope antennas. Although this program is intended for localizer simulation, it may be also used to study the effects of buildings on the glide slope system. The simulation will assume a perfect flat horizontal and infinite ground plane. If a glide slope antenna is chosen on the mode card, the next card must be as follows:

Col	Symbol	Use
1-10	YA	Antenna Offset (in feet)
11-20	TGS	Glide path angle (in degrees)

YA is the antennae offset (Y-coordinate) in feet. Positive is to the left from the origin facing the threshold. If the magnitude of YA is less than 300, YA will be defaulted to 1500, the sign depending on the sign of YA input. TGS is the intended glide path angle in degrees.

The measured pattern of a capture effect localizer is used in our test case:

Mode Card:

Col.		
	1-2	6
	11-20	110.
	21-30	10000.
	31-40	13.
	41-50	13.

Pattern Cards: See attached Figure 3 for test case listing.

The antenna description cards are followed by the course width card. The format for this card is:

Col.	Symbol	Use
1-10	XXA(1)	Course array x-coordinate, in feet
11-20	XXA(2)	Clearance array x-coordinate, in feet
31-40	CW	Course width in degrees
41-50	CLS	Clearance signal strength relative to the course signal.

If CW is greater than 3° this value is used as the course width and the signal strengths of the course antenna are automatically adjusted to produce this value.

If CW is less than 3° the course width will be set to the FAA specification for a threshold to antenna distance, given by XTH, and the signal levels will be set accordingly.

CLS is the ratio of clearance signal strength to course signal strength.

-45.	-.012	0.006
-42.	-.020	0.014
-40.	-.014	0.020
-38.	0.000	0.020
-35.	0.018	0.000
-32.	0.008	-.025
-30.	-.010	-.020
-28.	-.011	0.000
-27.	-.008	0.010
-26.	0.000	0.017
-25.	0.011	0.019
-23.	0.020	0.000
-20.	0.000	-.039
-19.	-.010	-.041
-18.	-.015	-.035
-16.	0.000	0.000
-14.	0.016	0.024
-13.	0.015	0.035
-12.	0.000	0.050
-9.	-.180	0.140
-5.	-.535	0.535
-4.	-.535	0.660
-1.	-.165	0.996
0.	0.000	1.000
1.	0.165	0.996
4.	0.535	0.660
5.	0.535	0.535
9.	0.180	0.140
12.	0.000	0.050
13.	-.015	0.035
14.	-.016	0.024
16.	0.000	0.000
18.	0.015	-.035
19.	0.010	-.041
20.	0.000	-.039
23.	-.020	0.000
25.	-.011	0.019
26.	0.000	0.017
27.	0.008	0.010
28.	0.011	0.000
30.	0.010	-.020
32.	-.008	-.025
35.	-.018	0.000
38.	0.000	0.020
40.	0.014	0.020
42.	0.020	0.014
45.	0.012	0.006
1000.		

Figure 3. Pattern Card Test Case Listing

-60.	0.000	0.000
-55.	-.085	0.018
-54.	-.096	0.019
-51.	-.145	0.008
-50.	-.160	0.002
-49.	-.175	0.005
-45.	-.245	0.050
-33.	-.411	0.400
-32.	-.414	0.430
-30.	-.426	0.475
-27.	-.464	0.497
-26.	-.475	0.499
-25.	-.490	0.497
-22.	-.545	0.486
-21.	-.565	0.485
-20.	-.585	0.486
-19.	-.602	0.490
-15.	-.676	0.540
-14.	-.680	0.560
-13.	-.680	0.585
-12.	-.675	0.620
-9.	-.610	0.730
-2.	-.160	0.980
0.	0.000	1.000
2.	0.160	0.980
9.	0.610	0.730
12.	0.675	0.620
13.	0.680	0.585
14.	0.680	0.560
15.	0.676	0.540
19.	0.602	0.490
20.	0.585	0.486
21.	0.565	0.485
22.	0.545	0.486
25.	0.490	0.497
26.	0.475	0.499
27.	0.464	0.497
30.	0.426	0.475
32.	0.414	0.430
33.	0.411	0.400
45.	0.245	0.050
49.	0.175	0.005
50.	0.160	0.002
51.	0.145	0.008
54.	0.096	0.019
55.	0.085	0.018
60.	0.000	0.000
1000.		

Figure 3. Pattern Card Test Case Listing (Cont'd)

The test case course width card would read:

1-10	0
11-20	-200
31-40	0 0
41-50	0.315

The label card follows the course width card. This card is put on the output tape ahead of the CDI records for this flight. It serves as an identifying record and is the label placed on the graph. Columns 180 are used. In our test case this card reads: THIS IS A DEMONSTRATION CASE OF STRAIGHT LINE FLIGHT.

The program calculates the CDI at a point in space: for convenience, the program will permit calculation for a series of points. This set of points represents samples of a simulated flight path.

The program allows two types of flight paths. A straight line flight and a circular orbit. The flight path card has one of the following formats:

<u>Straight Line Flight</u>

Col.	Symbol	Use
1-10	XMIN	Starting distance from origin, in feet
11-20	XMAX	Ending distance from origin, in feet
21-30	DXR	Spacing between sample points, in feet
31-40	PHIR	Angle of approach, in degrees
41-50	PSIR	Glide angle, in degrees
61-70	ZUP	Height of aircraft at threshold, in feet.

XMIN is the x-coordinate of the starting location of the aircraft and XMAX is the x-coordinate of the ending location. The sample points are spaced along a straight line so that the difference in x-coordinates between successive samples is DXR.

The sign of the DXR will be set by the program so that the flight goes from XMIN to XMAX regardless of flight direction. If the DXR value would require more than 500 points the program will adjust the magnitude of DXR to give only 500 points. In some cases a flight will require more than 500 points. If this is necessary the flight must be broken up into smaller segments of not more than 500 points each. The procedure for doing this is explained in the control card section. The flight path is oriented in space so that an extension of the path crosses the threshold at the altitude of ZUP and intersects the z-axis. PHIR is the angle between the flight path and the vertical plane through the runway centerline. It is zero for a flight path along the centerline of the runway and is positive for an incoming flight (XMIN greater than XMAX) with decreasing y-displacement. PSIR is the glide angle between the flight path and the horizontal plane. It is zero for level flight and positive for a normal landing approach. The flight path is a straight line as described above except when the x-component is less than XTH, that is if the aircraft is on the antenna side of the threshold. In that case the aircraft altitude will be set up to ZUP.

Thus the values used in the test case would read:

<u>Col</u>.		
	1-10	40000
	11-20	20000
	21-30	-40
	31-40	0
	41-50	2 5
	51-60	50

The arc flight is a series of points at a constant height of ZUP and at a constant horizontal distance from origin of R. MIND is the starting angle for the arc, that is, the line of sight from the origin to the point makes a horizontal angle of MIND degree with the x-axis. The sample points are spaced at equal angles of DXR until the termination angle of MIND is reached. As in the straight line flight the sign of DXR will be adjusted appropriately. Likewise the magnitude of DXR will be set to yield not more than 500 points. Column 74 must be set to 1 to indicate a circular arc.

Circular Orbit Case

Col.	Symbol	Use
1-10	MIND	Starting angle, in degrees
11-20	MAXD	Ending angle, in degrees
21-30	DXR	Angular spacing between samples, in degrees
51-60	R	Radius of orbit, in feet
61-70	ZUP	Height of orbit, in feet
74	ICF	Must be set to 1 to indicate orbit case.

Following the flight path card must be the velocity card in the following format:

Col.	Symbol	Use
1-10	VEL	Velocity of aircraft, in feet/sec. This is used for the Doppler Effect on the receiver. The sign of the velocity will be made to agree with the directional motion from DXR. Test case assumes velocity of 200 ft/sec.

At this point we have described the antenna system and the trajectory of the aircraft; the derogating surfaces in proximity to the ILS must now be described. The program will simulate scattering from rectangular or cylindrical surfaces. We will now describe the method of inputting scatterers to simulate derogating structures.

The next card describes either the scatterer(s) or output and control. The usage is determined by the value of the ID field in columns 1 to 2. An ID of -1, 1, or 2 is used for scatterers, while the other values are used for control.

Col.	Symbol	Use
1-2	ID	Must be 1 for rectangle
3-8	XW(1)	x-coordinate of reference point, in feet
9-14	XW(2)	y-coordinate
15-20	XW(3)	z-coordinate
26-30	ALPHA	Angle between base and x-axis, in degrees
31-35	DELTA	Angle of tilt, in degrees
36-45	WW	Width of rectangle, in feet
46-55	HW	Height along rectangle, in feet.

The scatterer is a rectangle with the reference point at the middle of the base. The rectangle is assumed to be of infinite conductivity and zero thickness. It also has only one side. This can be thought of as the front surface of a metal wall. A wall with zero x-, y-, and z-coordinates and an alpha of zero is located at the origin with surface of the wall facing in the negative y direction (Figure 4, case I). A positive increase in alpha rotates the wall about the z-axis in a counterclockwise direction when viewed from above. Thus an alpha of 90 degrees faces the wall in the positive x-direction (Figure 4, case II). Alpha is the angle between the vertical projection of the base of the wall in the xy-plane and the x-axis, measured in degrees. Delta is the angle between the surface of the wall and the vertical direction, in degrees. A delta of zero is a wall perpendicular to the ground and a decrease in delta rotates the wall about the baseline in a direction so that a delta of minus ninety is a horizontal wall facing down (Figure 4, case III). WW is the width, in feet, of the wall measured along its base and HW is the height measured along the surface at right angles to the base. If the wall is

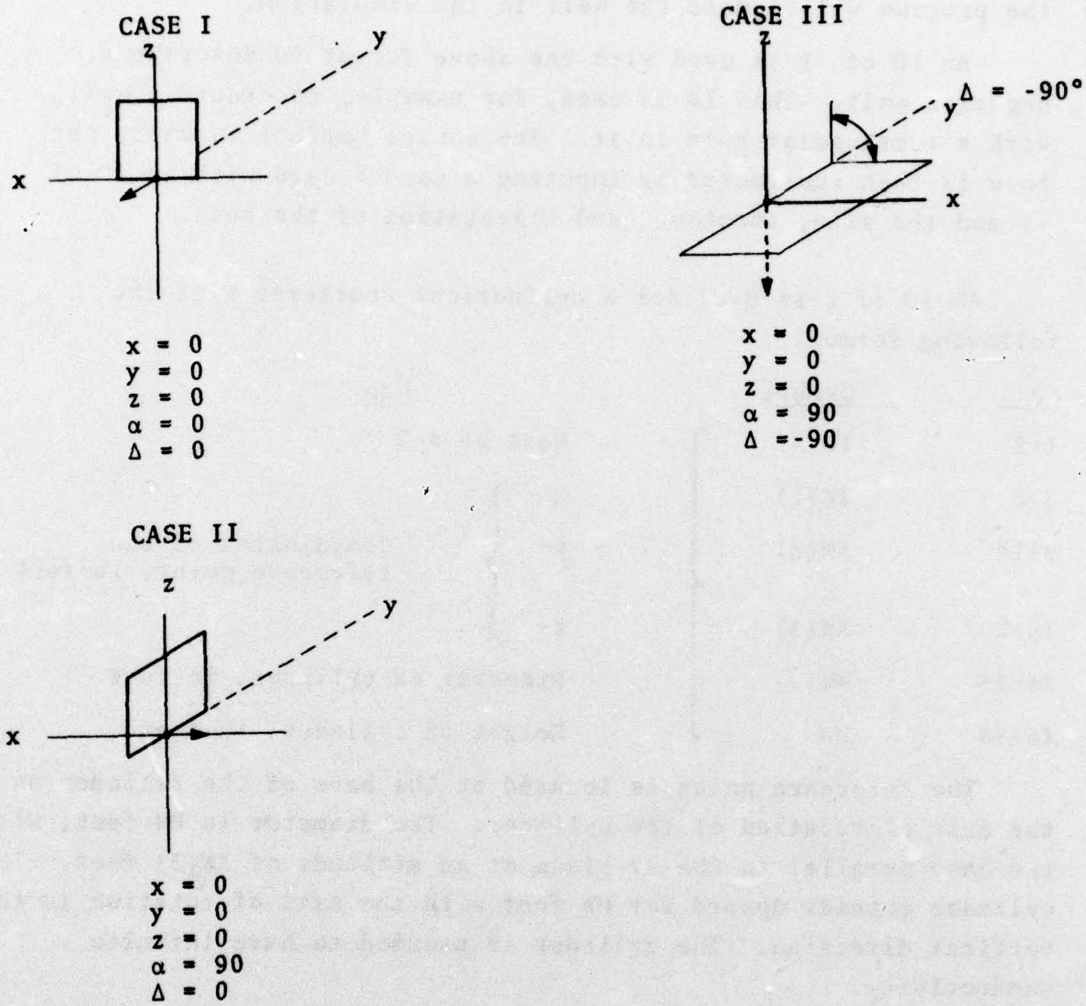


Figure 4. Illustration of Orientation Nomenclature for Rectangular Surface

oriented in such a fashion that the line of sight from the antenna to the wall passes through the back and not the front of the wall, the program will ignore the wall in the simulation.

An ID of -1 is used with the above format to describe a negative wall. This ID is used, for example, to create a wall with a rectangular hole in it. The entire surface is used; the hole is then subtracted by inputing a second card with an ID of -1 and the size, location, and orientation of the hole.

An ID of 2 is used for a cylindrical scatterer with the following format:

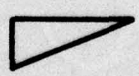
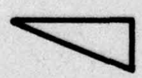
Col.	Symbol	Use
1-2	ID	Must be a 2
3-8	XW(1)	x- coordinates of the reference point, in feet
9-14	XW(2)	y- coordinates of the reference point, in feet
15-20	XW(3)	z- coordinates of the reference point, in feet
36-45	WW	Diameter of cylinder, in feet
46-55	HW	Height of cylinder, in feet.

The reference point is located at the base of the cylinder on the axis of rotation of the cylinder. The diameter is WW feet, with the base parallel to the xy-plane at an altitude of XW(3) feet. The cylinder extends upward for HW feet with the axis of rotation in the vertical direction. The cylinder is assumed to have infinite conductivity.

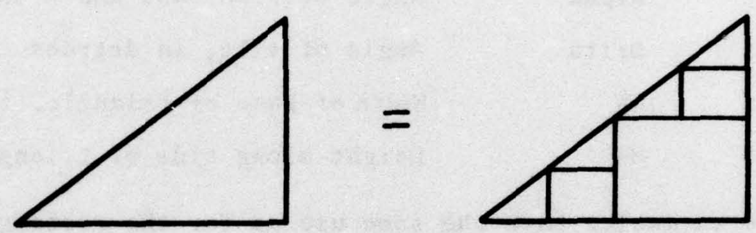
An ID of 3 or -3 is used for triangular scatters with the following format:

Col.	Symbol	Use	
1-2	ID	Must be 3 or -3	
3-8	xw(1)	X-	
9-14	xw(2)	Y-	Coordinates of the reference point, in feet.
15-20	xw(3)	z-	
26-30	Alpha	Angle between base and x-axis, in degrees	
31-35	Delta	Angle of tilt, in degrees	
36-45	WW	Width of base of triangle, in feet	
46-55	HW	Height along side of triangle, in feet.	

The variables have the same use as for the rectangular scatterer, with the exception of HW 4 WW. The magnitudes of WW & HW determine the size of the triangles, the signs of HW 4 WW are used to determine the orientation of the hypotenuse. The convention is as follows:

Triangle Orientation	Sign of HW	Sign of WW
	+	+
	+	−
	−	−
	−	+

If the size of the triangle exceeds the limits imposed by the Fresnel approximation the scatterer will be omitted and an error message given in the output. If this happens and one wishes to include scattering from this surface, the triangle must be broken up into triangular and rectangular pieces, for example:



The values for IH and IV will indicate the number of pieces horizontally and vertically the triangle must be broken up into.

After an ID of 1,-1, 2, 3, or -3, the program will calculate the electric field at the surface of the scatterer. This will be calculated from the signal from the transmission antenna array and from the ground reflection of the transmitted signal. Then, for each receiver point along the flight path, the program will calculate the electric field at that location from the scattered signal: from both the scatterer and reflected from the ground. Thus, the signal is received from four paths: (a) transmission antenna to scatterer to receiver, (b) antenna to ground to scatterer to receiver, (c) antenna to scatterer to ground to receiver, and (d) antenna to ground to scatterer to ground to receiver. This signal is decomposed into complex components induced in the receiving antenna at the different carrier and sideband frequencies. The program then loops back to read in another ID card, permitting the summation of the effects of many scatters. This allows the simulation of complex structures by breaking them up into cylinders and rectangles.

In the test case, we have only inputed three scattering surfaces. This was done because only two sides of the hangar and the cylinder are illuminated. The values for the scatterer cards read:

Col.	First card	Second card	Third card
1-2	1	1	2
3-8	6000	5950	7500
9-14	1100	1130	-1000
15-20	0	0	0
26-30	10	-80	0
31-35			
36-45	100	60	75
46-55	80	80	110

After all the scatters have been input, a control card is inserted to terminate the run. The control card format is:

Col.	Symbol	Use
1-2	ID	not -1, 1, or 2.

When a control card is read in, the program will add the direct, and ground reflected, signal from the transmission antenna to the scattered signal summations, thus giving the total received signal. The program then calculates the CDI that would be seen at each receiver point, and outputs the label, a header record describing the flight path and the values of the CDI on output tape. If the ID is equal to zero the program also outputs additional records for the strengths of sideband and carrier signals from course and clearance (if any) antenna arrays. The field summations are then cleared for the next run.

The program, having finished the previous run, now proceeds with the next input. The next run is generated by looping back to a point in the input stream, determined by the value on the control card.

Once an input sequence has begun the inputs following in the standard order must be given. The user must also keep in mind that all values on cards given before that entry point, in the previous run are still in effect. The following order is standard:

MODE CARD
(measured pattern for modes 5 and 6 or current description for modes 7 and 8)
(second mode card and patterns of currents if first mode was negative)
COURSE WIDTH CARD
LABEL CARD
FLIGHT PATH CARD
VELOCITY CARD
(set of scatterer cards)
CONTROL CARD.

The value of the ID on the control card guides the looping in the following manner:

Value of ID	Next card to be read in
0	MODE
3-10	SCATTERER
11-15	LABEL
16-20	MODE
21-50	COURSE WIDTH
>50	WILL CAUSE THE PROGRAM TO TERMINATE AFTER OUTPUTTING THE LAST CDI.

The looping permits the repetition of a run with changes in some or all of the variables. For example, ID values 3 through 10 permit a run with the same antenna system and flight path as the previous case, but with a new set of scatterer inputs.

ID values 11 to 15 permit a new flight path description and scatterer set to be input. This looping method can also be used for flights that would require more than 500 points. For reliable simulation, the spacing between receiver points (DXR) should be small enough so that the change in CDI between successive points is not more than ~20% of the peak value. Thus for long flights the flight path must be broken up into shorter segments. If the number of segments of this path does not exceed 4, the plotting program will connect them on a single graph. The control for this joining is the ID number. If the flight path finishes with an ID of 11 to 13, the graph of the next flight will continue the line of the graph. A long flight may be broken up into as many as four segments: with three segments terminating in 11 to 13 and a fourth, and final segment, terminating in 14 or 15. The flight segments must appear in the order in which they are to be flown, so that the XMIN of one section is the XMAX of the previous section. For each segment the programmer must re-input the same scatterers. If only one segment is to be plotted the control card should read 14 or 15.

ID's 16 through 20 start inputing at the mode card, thus allowing a completely new run.

An ID of 21 through 50 uses the same antenna description, but starts the inputing at the course width card. This permits the course width, clearance strength and antenna location to be varied.

The program is terminated after an ID greater than 50 is encountered. The direct signal will be added, and the CDI will be outputed before the program stops. The program will also stop if an end of file is encountered while the program is attempting to read any input card, or if certain of the variables are of improper value. In these cases the program terminates immediately, without outputing the last case.

The input of the test case flight path was done in four segments. The first segment is from 40,000 to 20,000 feet, the second segment is from 20,000 to 12,500 ft, the third segment is from 12,500 to 11,000 ft and the last is from 11,000 to 10,000 ft. An additional case for a simulated clearance flight by a circular orbit has also been included. The input cards for these test case flights are shown in Figure 5.

```
  THIS IS A DEMONSTRATION CASE OF STRAIGHT LINE FLIGHT
 40000.    20000.       -40.                    2.5          50.
200.
 16000. 1100.            10.       100.       80.
 15950. 1130.           -80.        60.       80.
 27500. -1000.  0.        0.    0.  75.        110.
13
  THIS IS A DEMONSTRATION CASE OF STRAIGHT LINE FLIGHT
 20000.    12500.       -15.                    2.5          50.
200.
 16000. 1100.            10.       100.       80.
 15950. 1130.           -80.        60.       80.
 27500. -1000.  0.        0.    0.  75.        110.
13
  THIS IS A DEMONSTRATION CASE OF STRAIGHT LINE FLIGHT
 12500.    11000.       -3.                     2.5          50.
200.
 16000. 1100.            10.       100.       80.

 15950. 1130.           -80.        60.       80.
 27500. -1000.  0.        0.    0.  75.        110.
13
  THIS IS A DEMONSTRATION CASE OF STRAIGHT LINE FLIGHT
 11000.    10000.       -2.                     2.5          50.
200.
 16000. 1100.            10.       100.       80.
 15950. 1130.           -80.        60.       80.
 27500. -1000.  0.        0.    0.  75.        110.
15

     THIS IS ORBIT CASE WITH SIGNAL STENGTHS
  180.      180.      0.72                          10000.     50.
 200.
  16000. 1100.            10.       100.       80.
  15950. 1130.           -80.        60.       80.
  27500. -1000.  0.        0.    0.  75.        110.
```

Figure 5. Flight Case Inputs

APPENDIX A

MAIN PROGRAM LISTING
INCLUDING COMMENTS EXPLAINING
THE PROGRAM

```
C      ILS SINGLE REFLECTION INTERFERENCE PROGRAM  ILSS
C THIS PROGRAM SIMULATES THE EFFECTS OF RECTANGULAR
C AND CYLINDRICAL SCATTERERS ON LOCALIZER AND GLIDE SLOPE
C ILS SIGNALS. THIS PROGRAM IS AN EXTENSION OF THE ILSLOC PROGRAM
C WHICH TREATED LOCALIZER SIGNAL SCATTERING BY BUILDINGS.
C THESE COMMENTS SERVE AS THE PROGRAM DESCRIPTION
C FOR THE USER.  A USER'S MANUAL HAS BEEN WRITTEN AND
C THIS COMMENTARY IS WRITTEN ASSUMING THE USER HAS READ IT.
C
C
C
C ILBL IS USED TO IDENTIFY THE SIGNAL STRENGH OUTPUTS  AS
C TO TYPE AND SOURCE.  THE FIRST CHARACTER IS  'S' FOR
C SIDEBAND ONLY SIGNALS OR  'C' FOR CARRIER PLUS SIDEBAND.
C THE SECOND PAIR ARE 'CR' FOR COURSE ANTENNA OR 'CL' FOR
C CLEARANCE.
C
      DIMENSION ILBL(5)
C
C
C
      DIMENSION MEMO(14),DF(501)
      COMPLEX BESF,FAC,CE
      COMPLEX EP,EE,EM,EC,ZE(4),ZD(1),EMR,FPP,GPP,FPM,GPM,
     2         CS(25,2),SD(25,2)
      COMPLEX ZJM,ZJP,ZJPC(2),ZJMC(2)
      COMPLEX  ZP(500),ZPC(500,2),ZM(500),ZMC(500,2)
      COMPLEX CD,IC,CLAM,LK,CEXPT
      DIMENSION XXRY(500,4)
      DIMENSION VCD(500,2),VPD(500,2),VMD(500,2)
      DIMENSION  XW(3),XWB(3)
      DIMENSION AN(3)
      DIMENSION AFOO(9),PHS(9)
      DIMENSION XY(10)
      REAL LAMBDA
      LOGICAL IMAGE
      COMMON/CD/ ARAD(50),AFPP(50),AGPP(50),BRAD(50),BFPP(50),BGPP(50)
      COMMON /AB/ ZJM,ZJP,ZJPC,ZJMC
      COMMON     ZP,ZPC,ZM,ZMC,VCD,VPD,VMD
      COMMON /VAR/ SM,SNCUT,SNCUD,SNCUC(2),VPC(2),VMC(2)
      COMMON /SUB/ MODE,ICP,ICM,IET,FRQ,LAMBDA,PI,RACD,PHI(3),PSI(3),NEL
     1,XTH,SLP, XXA(3),YA(3),ZA(3),RA(3),TGS,BT,SIG,CB,AK
      COMMON /ANT/ LOC,FPP,FPM,GPP,GPM,EWR(4,4),CNA(2),AS,CLS,DE(25,2),
     .                CS,SD,ET(20,2),ND(2),DUMXXX(40)
      EQUIVALENCE (ZP(1),ZD(1)),(XXRY(1,1),ZP(1))
      DATA ILBL/4HC CR,4HS CR,4HC CL,4HS CL,4H CDI/
      DATA RAD/57.2957795/
C
C
C THE OUPUT OF THE SIMULATION IS ON UNIT 8.  A TAPE WITH
C WRITE RING SHOULD BE PLACED THEREON.
C
      REWIND 8
```

```
C
C
C NC IS THE COUNT OF THE CASE BEING SIMULATED IT'S VALUE IS WRITTEN
C ON THE TAPE WITH THE OUTPUT RECORD.  THIS WOULD ALLOW
C SEARCHING FOR A PARTICULAR CASE BY NUMBER.
C
      NC=0
C
C THESE CONSTANTS ARE FILTER FACTORS FOR THE ASSUMED MODULATION
C FILTERS.
C
      TA=1./15.
      PTA = PI*TA
      W60T = 60.*PTA
      W90T = 90.*PTA
      W150T = 150.*PTA
C
C
C
C THIS IS THE STARTING POINT FOR A SIMULATION.  IT IS ALSO
C ENTERED FOR A RESTART FOLLOWING AN ID OF 8 OR 16 TC 20.
C
    1 ICP=0
      IMAGE = .TRUE.
C
C NEL IS THE NUMBER OF ANTENNAE IN THE SYSTEM.  DEFAULT
C CONDITION IS ONE ANTENNA
C
      NEL = 1
C
C
C EWR IS A COMPLEX MATRIX CONTAINING THE SIDEBAND ELECTRIC FIELD
C DESCRIPTION PRODUCED BY THE ANTENNA SURROUTINE.  EWR(I,J)
C IS THE FIELD FOR THE 'I'TH ANTENNA.  AND THE 'J' VALUES
C HAVE THE FOLLOWING SIGNIFIGANCE:
C         J          USAGE
C         1          SIDEBAND PORTION OF CARRIER PLUS SIDEBAND
C                     FOR THE COURSE SECTION OF THIS ANTENNA
C         2          SIDEBAND ONLY FOR THE COURSE
C         3          SIDEBAND PORTION OF CARRIER PLUS SIDEBAND
C                     FOR THE CLEARANCE SECTION
C         4          SIDEBAND ONLY FOR THE CLEARANCE
C
C  THIS SURROUTINE CALL IS USED TO CLEAR EWR BEFORE
C STARTING THE SIMULATION
C
      CALL CLEAR(EWR,16)
C
    2 CONTINUE
C
C
C THIS IS THE INPUT FOR THE MODE CARD, THE VARIABLES HAVE
C THE FOLLOWING USES.
```

```
C
C         SYMBOL  USE
C         MODE    ANTENNA TYPE
C         =1      V-RING COURSE
C         =2      8-LOOP COURSE
C         =3      WAVEGUIDE COURSE
C         =4      NOT USED
C         =5      MEASURED COURSE PATTERN
C         =6      MEASURED COURSE AND CLEARANCE PATTERNS
C         =7      THEORETCAL COURSE ARRAY
C         =8      THEORETICAL COURSE AND CLEARANCE ARRAY
C         =-1     V-RING CLEARANCE
C         =-2     8-LOOP CLEARANCE
C         =-3     WAVEGUIDE CLEARANCE
C         =-5     MEASURED CLEARANCE PATTERN
C         =-7     THEORETICAL CLEARANCE ARRAY
C
C GLIDE SLOPE ANTENNA CODES
C          13     NULL REFERENCE
C          14     SIDEBAND REFERENCE
C          15     M ARRAY ( CAPTURE EFFECT ).
C GS ELEMENT PATTERN CODES
C   IET =  0      HALF WAVE DIPOLE
C          1      30 DEG PATTERN
CC
C         FRQ     FREQUENCY OF TRANSMISSION
C         XTH     DISTANCE TO THRESHOLD
C         ZA(I)   'I'TH ANTENNA HEIGHT
C
C ORIGIN IS AT THE CENTER OF COORDINATE SYSTEM.
C X-AXIS IS ALONG RUNWAY
C Z-AXIS IS STRAIGHT UP
C Y-AXIS COMPLETES A RIGHT HANDED SYSTEM
C
      READ (5,1001,END=50) MODE,IET,FRQ,XTH,ZA,SLP
C
C
C THIS IS THE INITIALIZATION SECTION.  LAMBDA IS THE WAVELENGTH
C IN FEET AND AK IS THE PHASE SHIFT/DISTANCE IN RADIANS/FOOT,
C YA IS THE Y-COORDINATE OF THE ANTENNAE.  THIS IS ASSUMED TO
C BE ZERO IN ALL LOCALIZER CASES.
C
      LAMBDA=11800./FRQ/12.
      AK=2.*PI/LAMBDA
      YA(1)=0.0
      YA(2) = 0.0
      Z4 = 0.
C
C
C THIS IS A TEST FOR INVALID ANTENNA TYPE.  THE PROGRAM ABORTS IN CASE
C OF ERROR.  THIS IS USUALLY CAUSED BY OMISSION OF OTHER CARDS
C WHICH CAUSE SOMETHING OTHER THAN A MODE CARD TO BE READ AT
C THIS POINT.
```

```
C
      IF( MODE .LT. -7) GO TO 98
      IF( MODE .EQ. 0) GO TO 98
      IF( MODE .LT. 11 ) GO TO 3
C
C CP AND CM ARE THE AMOUNTS OF MODULATION ON THE CARRIER
C FOR THE CARRIER PLUS SIDEBAND.  CP IS THE COURSE MODULATION
C AND CM THE CLEARANCE.
C
      SM = 057.14
      CP = 0.4
      CM = 0.45
C
C  TGS = COMMISSIONED GLIDE PATH ANGLE STATED IN DEGREES..
C
      READ (5,1000,END=58) YA,TGS
      GO TO 4
C
    3 CP = 0.2
      CM = 0.2
      SM = 307.
C
C THIS IS TEST FOR NEGATIVE MODE  INDICATING CLEARANCE ANTENNA.
C IF MODE IS POSITIVE FLOW IS TO STATEMENT 4
C
      IF( MODE .GT. 0 ) GO TO 4
C
C ICP IS THE ANTENNA TYPE FOR THE CLEARANCE ANTENNA
C
      ICP = - MODE
C
C
C IF THERE IS A CLEARANCE ANTENNA THEN THE NUMBER OF ANTENNAE
C IS SET TO 2.
C
      NEL = 2
C
C
C IF THE CLEARENCE ANTENNA IS SPECIFIED BY A MEASURED PATTERN IT IS
C NOW READ IN BY SUBROUTINE PATTRN.
C
      IF( ICP .EQ. 5 ) CALL PATTRN(BRAD,RFPP,BGPP)
C
C
C IF THE CLEARENCE ANTENNA IS SPECIFIED BY ARRAY PARAMETERS THE INPUT
C DATA FOR  THE ARRAY IS NOW READ IN BY  CRRNTS.
C
      IF(ICP .EQ. 7) CALL CRRNTS (DE(1,2),CS(1,2),SO(1,2),ET(1,2),NO(2))
C
C
C THE FLOW IS NOW BACK TO STATEMENT 2 TO READ IN
C MODE CARD FOR COURSE ANTENNA.
C
```

```
      GO TO 2
C
C
C THIS IS THE INPUT SECTION FOR THE COURSE ANTENNA IF PATTERNS OR
C ARRAY DESCRIPTION MUST BE GIVEN, OTHERWISE FLOW IS TC THE
C INITIALIZATION SECTION.
C
    4 IF( MODE .LT. 5 ) GO TO 6
C
C
C THIS STATEMENT CONTROLS THE INPUT METHOD, PATTERN CR ARRAY,
C ACCORDING TO MODE TYPE.
C
      IF (MODE .GT. 6) GO TO 5
      CALL PATTRN(ARAD,AFPP,AGPP)
C
C
C THIS IS TO INPUT THE SECOND PATTERN FOR CLEARANCE ANTENNA IF
C MODE IS 6.
C
      IF( MODE .EQ. 5) GO TO 6
      CALL PATTRN(BRAD,BFPP,BGPP)
C
C THE NUMBER OF ANTENNAE AND THE ICP TYPE ARE SET. THEN FLOW IS TO
C INITIALIZATION.
C
      NEL = 2
      MODE=5
      ICP = 5
      GO TO 6
C
C
C THIS IS THE INPUT FOR COURSE ARRAY DATA.
C
    5 CALL CRRNTS (DE,CS,SO,ET,NO(1))
C
C
C THIS TEST IS FOR CLEARANCE ARRAY IF MODE
C IS TYPE 8
C
      IF ( MODE .EQ. 7) GO TO 6
      CALL CRRNTS (DE(1,2),CS(1,2),SO(1,2),ET(1,2),NC(2))
      MODE=7
      ICP=7
      NEL=2
C
C
C THIS IS THE COURSE WIDTH INPUT.
C XXA(1) IS THE X-COORDINATE OF THE COURSE ANTENNA
C XXA(2) IS THE X-COORDINATE OF THE CLEARANCE ANTENNA
C CW IS THE COURSE WIDTH
C CLS IS THE RATIO OF CLEARANCE TO COURSE SIGNAL STRENGTH.
C
```

```
      6 READ (5,1000,END=50) XXA,CW,CLS
C
C
C SET THE DEFAULT CONDITION ON CLS OF 1.
C
        IF( CLS .LE. 0.0 )  CLS = 1.0
C
C
C CWA(I) IS THE COURSE WIDTH ADJUSTMENT ON THE (I)TH ANTENNA
C IT SETS THE SIDEBAND TO CARRIER RATIO. THE CLEARANCE ANTENNA
C (CWA(2)) IS ALWAYS 1.0 .  THE COURSE WIDTH IS ADJUSTED
C BY VARING THE COURSE ANTENNA (CWA(1)).
C
        CWA(1) = 1.0
        CWA(2)=1.0
C
        IF( MODE .GT. 10 ) GO TO 12
C
C THE PROGRAM WILL NOW CALCULATE THE CDI FOR 2.5 DEGREE COURSE
C OFFSET.  THIS IS USED TO NORMALIZE THE SIDEBAND LEVEL TO
C ACHIEVE THE DESIRED COURSE WIDTH.  LOC IS THE TYPE OF ANTENNA
C USED BY THE ANTENNA SUBROUTINE. PSI(1) IS THE ANGULAR ALTITUDE
C OF THE REFERENCE POINT AND PHI(1) IS THE AZIMUTH OF THE POINT.
C
        PSI(1) = 5.E-03
        PHI(1) = 2.5*RADD
        LOC = MODE
C
C
C THE MODE IS USED TO DETERMINE WHICH ANTENNA SUBROUTINE TO CALL.
C CSP IS THE STANDARD ANTENNA ROUTINE. IT COVERS THE VARING
C 8-LOOP AND WAVEGUIDE.  LNAR IS THE ARRAY ANTENNA SUBROUTINE.
C ANTP IS THE MEASURED PATTERN SUBROUTINE. THE SUBROUTINE WILL
C RETURN FPP AND GPP FOR THE POINT AT PHI,PSI AND UNIT RANGE.
C FPP IS THE SIDEBAND ONLY LEVEL.  GPP IS THE SIDEBAND LEVEL
C FOR THE CARRIER PLUS SIDEBAND.  AFTER THE RETURN, FLOW IS TO
C STATEMENT 9.
C
        IF (MODE .GE. 7) GO TO 8
        IF(MODE .GE. 5) GO TO 7
        CALL CSP
        GO TO 9
      7 CALL ANTP (FPP,GPP,ARAD,AFPP,AGPP)
        GO TO 9
      8 CALL LNAR ( FPP,GPP,PHI,DE,CS,SO,ET,ND)
        GO TO 9
C
C
C THE SIGNAL LEVELS ARE IN FPP AND GPP.  TEMP IS THE APPARENT
C COURSE WIDTH WITH CWA'S OF 1.0.
C
      9 TEMP= 1.0375/REAL(FPP/GPP)
C
```

```
C
C THE COURSE WIDTH READ IN IS USED IF IT IS LARGER THAN 3 DEGREES
C OTHERWISE THE STANDARD VALUE BY FAA SPECIFICATIONS IS
C DETERMINED AND THIS VALUE USED.  THE COURSE WIDTH IS LIMITED
C TO A RANGE OF 3 TO 6 DEGREES.
C
      IF( CW - 3.0 ) 10,10,11
   10 CW = 2.*ATAN(250./XTH ) * RAD
      IF( CW .LT. 3.0 ) CW = 3.0
      IF(CW .GT. 6.0) CW=6.0
C
C
C THE CWA(1) IS ADJUSTED TO PRODUCE THE DESIRED COURSE WIDTH.
C
   11 CWA(1) = TEMP/CW
C
      GO TO 13
C
   12 IF( CW .LE. 0.0 ) CW = 1.4
      CALL GSCAL(CW)
   13 CONTINUE
C
C THE VALUES, READ IN AND CALCULATED, FOR THE ANTENNA SYSTEM(S)
C ARE OUTPUT ON THE LINE PRINTER (ASSUMED TO BE UNIT 6)
C
      WRITE(6,1003) MODE,ICP,PRO,XTH,ZA,XXA,CW
      WRITE(6,1000) TEMP,CWA
      WRITE(6,1002) CLS
C
C THIS IS THE LOOP BACK POINT FOR NEW FLIGHT PATH. IC'S 11 TO 15.
C MEMO IS THE LABEL FOR HEADER RECORDS AND GRAPHS.
C INPUT DATA FOR FLIGHT PATH,
C         XMIN    STARTING POINT
C         XMAX    ENDING POINT
C         DXR     SAMPLE POINT SPACING
C         PHIR    ANGLE OF APPROACH
C         PSIR    GLIDE ANGLE
C         R       RADIUS OF ORBIT
C         ZUP     ALTITUDE AT THRESHOLD OR OF ORBIT
C         ICF     FLAG 0 FOR STRAIGHT LINE, 1 FOR ORBIT
C
   14 CONTINUE
      READ (5,1005,END=50) MEMO
      WRITE(6,1004) MEMO
      READ (5,1006,END=50) XMIN,XMAX,DXR,PHIR,PSIR,R,ZUP,ICF
C
C
C THE SIGN OF DXR IS ADJUSTED FOR FLIGHT FROM XMIN TO XMAX.
C
      DXR=SIGN(DXR,(XMAX-XMIN))
C
C
C THE VELOCITY OF THE AIRCRAFT IS INPUT.
```

```
C
      READ (5,1006,END=90) VEL
      WRITE (6,1007) VEL
C
C THE SIGN OF THE VELOCITY IS SET TO AGREE WITH THAT OF DXR.
C
      VEL=SIGN(VEL,DXR)
C
C
C THE NUMBER OF RECEIVER POINTS IS DETERMINED.  IF THIS IS
C LESS THAN 502 FLOW PROCEEDS TO STATEMENT 16, OTHERWISE THE
C MAGNITUDE OF DXR IS INCREASED TO GIVE ONLY 501 POINTS.
C
      NR =IFIX( (XMAX-XMIN)/DXR + 1.)
      IF(NR .LT. 1) GO TO 15
      IF(NR-501) 16,16,15
   15 WRITE (6,1008)
      DXR=(XMAX-XMIN)/500.
      IF(ABS(DXR) .LT. 1.E-5) GO TO 90
      NR = 501
   16 CONTINUE
C
C
C THE FLIGHT PATH DESCRIPTION IS OUTPUT.  THE FORMAT BEING DETERMINED
C BY THE TYPE OF FLIGHT.  IN THE CASE OF STRAIGHT LINE THE
C NECESSARY CONSTANTS FOR DOPPLER EFFECTS AND POSITION ARE
C DETERMINED.
C AFTER OUTPUT FLOW IS TO STATEMENT 19.
C
      IF (ICP) 18,18,17
   17 WRITE (6,1019) XMIN,XMAX,DXR,R,ZUP,ICP
      GO TO 19
   18 CONTINUE
      WRITE (6,1009) XMIN,XMAX,DXR,PHIR,PSIR,XTH,ZUP
      PHIR=PHIR/RAD
      PSIR=PSIR/RAD
      SPSI = SIN(PSIR)
      TANGR=SPSI/COS(PSIR)
      COSPIR=COS(PHIR)
      SINPIR=SIN(PHIR)
      VX=VEL*COS(PSIR)*COS(PHIR)
      VY=VEL*COS(PSIR)*SIN(PHIR)
      VZ=VEL*SIN(PSIR)
   19 CONTINUE
C
C
C THIS IS THE LOOP BACK POINT TO START A NEW SIMULATION WITH
C PREVIOUS ANTENNA SYSTEM AND FLIGHT PATH.  THE COMPLEX FIELD
C SUMMATION MATRICIES ARE CLEARED, THE CASE NUMBER IS
C INCREMENTED BY ONE AND THE LINEPRINTER HEADERS ARE WRITTEN.
C
   20 CONTINUE
      CALL CLEAR(ZP,4900)
```

```
      NC = NC + 1
      WRITE (6,1010)
      WRITE (6,1011)
C
C
C XY IS AN ARRAY OF DATA ON THE ANTENNA AND FLIGHT PATH AND IS
C OUTPUT AS PART OF THE HEADER RECORD ON THE OUTPUT TAPE.
C
      XY(1) = PHIR
      XY(2) = PSIR
      XY(3) = ZUP
      XY(4) = FLOAT(NC)
      XY(5) = VEL
      XY(6) = FLOAT(MODE)
      XY(7) = FLOAT(ICP)
      XY(9) = DXR
      XY(8) = XMIN
C
C
C THIS IS THE INPUT FOR A NEW SCATTERER OR CONTROL CARD.  THE
C FORMAT AND USAGE OF THE VARIABLES WILL BE FOUND IN THE USER'S MANUAL.
C
   21 READ (5,1012,END=50) ID,XN(1),XN(2),XN(3),ALPHA,DELTA,WN,HN
C
C
C A NEGATIVE ID IS USED ON A SCATTERER TO CAUSE THE FIELDS TO
C BE SUBTRACTED FROM THE SUM.  THUS IDA IS USED TO DETERMINE
C THE TYPE OF SCATTERER AND THE SIGN OF ID IS USED FOR THE
C SIGN DTERMINATION OF THE FIELDS.
C
      IDA=IABS(ID)
C
C
C THE RECEIVER POINT LOCATION VARIABLES ARE INITIALIZED.  XR IS
C THE X-COORDINATE OF THE LOCATION, ZR IS THE Z-COORDINATE
C AND CDEG IS THE AZIMUTH.  THE USE OF THESE VARIABLES IS CONTROLLED
C BY THE VALUE OF ICP.
C
C
C
      IF (ICP) 23,23,22
   22 CDEG=XMIN-DXR
      ZR=ZUP
      GO TO 24
   23 XR=XMIN-DXR
   24 CONTINUE
C
C
C
C IF IDA IS NOT 1, 2, OR 3 THEN THIS CARD IS A CONTROL CARD
C AND FLOW PASSES TO STATEMENT 43 TO OUTPUT THE CDI AND FOR
C LOOPING CONTROL.
C
```

```
      IF(IDA .GT. 3) GO TO 43
      IF(IDA .EQ. 0) GO TO 43
C
C
C THIS SECTION SETS CERTAIN VARIABLES FOR THE CYLINDER CASE.
C AKA IS A CONSTANT USED IN THE SCATTERERING AND DELTA IS SET TO
C ZERO FOR A VERTICAL CYLINDER.
C
      IF(IDA .NE. 2) GO TO 29
      DELTA=0.
      AKA=WW*AK/2.
   29 CONTINUE
C
C
C THE INPUT ANGLES ARE CONVERTED TO RADIANS AND
C THEIR SINES AND COSINES ARE CALCULATED.
C
      ALPHA=ALPHA/RAD
      DELTA=DELTA/RAD
      COSD=COS(DELTA)
      SIND=SIN(DELTA)
      COSA=COS(ALPHA)
      SINA=SIN(ALPHA)
C
C
C BECAUSE OF CERTAIN APPROXIMATIONS MADE IN THE ANALYSIS
C THERE IS A LIMIT ON THE SIZE OF THE SCATTERERS THAT MAY
C BE SIMULATED.  TO AVOID THIS PROBLEM AS MUCH AS
C POSSIBLE, FOR THE RECTANGULAR SURFACE,
C THE PROGRAM WILL BREAK UP TOO LARGE A WALL INTO
C SMALLER PIECES.  TO AVOID PROBLEMS WITH OTHER TYPES
C OF SCATTERERS THE VARIABLES INVOLVED ARE SET TO DEFAULT
C VALUES AND THE BREAKING UP SECTION IS SKIPPED.
C
      IH=1
      IV=1
      DH=0.
      DV=0.
      DZ=0.
      DHZ=P.
      DVZ=P.
      IF(IDA .NE. 1) WRITE (6,1013)
     . ID,XW(1),XW(2),XW(3),ALPHA,DELTA,WW,HW
      GO TO (62,27,62) IDA
C
C
C TEMP IS THE MAXIMUM DISTANCE FROM THE REFERENCE POINT ON THE
C WALL THAT WILL GIVE A REASONABLE ERROR IN THE APPROXIMATION.
C
   62 TEMP=SQRT(LAMBDA*SQRT((XXA(1)-XW(1))**2+(YA(1)-XW(2))**2))/5.
C
C
C IH IS THE NUMBER OF PIECES HORIZONTALLY INTO WHICH THE WALL MUST BE
```

```
C DIVIDED,
C
      IH=IFIX(WW/2./TEMP)+1
C
C
C IV IS THE THE NUMBER OF PIECES VERTICALLY.
C
      IV=IFIX(HH/2./TEMP)+1
C
C
      WRITE(6,1013) ID,XW(1),XW(2),XW(3),ALPHA,DELTA,WW,HH,IH,IV
      IF( IDA .EQ. 3 ) GO TO 26
C WW AND HH ARE SET TO NEW VALUES, THESE ARE THE SIZES OF THE
C PIECES.  DX AND DY ARE THE CHANGE IN X- AND Y-COORDINATES BETWEEN
C PIECES IN THE HORIZONTAL ROWS.   DZ IS THE CHANGE IN ELEVATION
C BETWEEN ROWS VERTICALLY.  DXZ AND DYZ ARE THE CHANGE IN X AND Y
C BETWEEN ROWS.  THIS CHANGE OCCURS ONLY IN TILTED WALLS (SIND
C NOT EQUAL TO ZERO).
C
      AI=IH
      WW=WW/AI
      TEMP=WW*(AI-1.)/2.
      DX=ABS (COSA*WW)
      XW(1)=XW(1)-ABS(COSA*TEMP)
      DY=SIGN(SINA*WW,SINA*COSA)
      XW(2)=XW(2)-SIGN(SINA*TEMP,SINA*COSA)
      HH=HH/FLOAT(IV)
   26 DZ=COSD*HH
      DXZ=-SIND*HH*SINA
      DYZ=SIND*HH*COSA
      CLAM=CMPLX(0.,1./LAMBDA)
      IF( IDA .NE. 3 ) GO TO 27
      IF( (IH .EQ. 1 ) .AND. ( IV .EQ. 1 ) ) GO TO 27
      WRITE (6,1019)
      GO TO 21
C
C
C XW IS THE COORDINATE VECTOR USED FOR THE LOCATION OF THE
C REFERENCE POINT OF EACH PIECE OF THE WALL.  XW0 IS USED
C AS ORIGIN OF THE WALL.  AS EACH PIECE IS USED FOR THE
C SCATTERING  XW IS INCREMENTED.  XW0 IS USED TO RESET XW
C FOR LOOPING ON ROWS.
C
   27 XW0(1)=XW(1)-DX-DXZ/2.
      XW0(2)=XW(2)-DY-DYZ/2.
      XW0(3)=XW(3)-DZ/2.
C
C
C THIS LOOP IS FOR THE ROWS
C
      DO 42 IB=1,IV
      XW0(1)=XW0(1)+DXZ
      XW0(2)=XW0(2)+DYZ
```

```
      XMP(3)=XM0(3)+DZ
      XM(1)=XMP(1)
      XM(2)=XMP(2)
      XM(3)=XMP(3)
C
C
C THIS LOOP IS WITHIN EACH ROW AND IS FOR HORIZONTALLY SEPARATED
C PIECES.
C
      DO 41 IA=1,IN
C
C
C XM IS THE COORDINATE VECTOR OF THE REFERENCE POINT ON THE
C PIECE BEING SIMULATTED.
C
      XM(1)=XM(1)+DX
      XM(2)=XM(2)+DY
C
C
C SUBROUTINE FLC IS USED TO CALCULATE THE FIELDS GENERATED BY THE
C ANTENNAE SYSTEM AT THE REFERENCE POINT.   AFTER THE CALL
C THE FIELDS AT THE REFERENCE POINT FOR ALL ANTENNAE ARE  IN
C EMP.
C
      CALL FLC(XM(1),XM(2),XM(3))
C
C THIS LOOP IS ON THE ANTENNAE.  FOR EACH PIECE THE PROGRAM
C CALCULATES THE SCATTERED FIELD FROM ALL ANTENNAE.
C IEL IS THE NUMBER OF THE ANTENNA BEING SIMULATED.
C
C
      DO 40 IEL=1,NEL
C
C
C XA,YA,ZA ARE THE X-,Y- AND Z- COORDINATES OF THE
C ANTENNA.
C
      XA = XXA(IEL)
      ZA=ZA(IEL)
      IF( (XM(1).LT.XA) .AND. (MODE.GT. 10) )  GO TO 34
C
C
C THIS SECTION INITIALIZES THE RECEIVER POINT
C LOCATION VARIABLES.  IR IS THE NUMBER OF THE RECEIVER POINT.
C
      IR=0
      IF(ICF.EQ.0) GO TO 29
      XRCS = XMIN - DXR
      GO TO 30
   29 XXR = XMIN - DXR
   30 CONTINUE
      IF(MODE.GT.0) ZZ = ZA(IEL)
C
```

```
C
C DH IS THE HORIZONTAL DISTANCE FROM THE ANTENNA TO THE
C REFERENCE POINT.
C R1 IS THE DISTANCE FROM THE ANTENNA TO THE REFERENCE
C POINT.
C
C

      DH = SQRT((XN(1)-XA)**2 + (XN(2)-YA(IEL))**2)
      R1=SQRT((XN(1)-XA)**2+(XN(2)-YA(IEL))**2+(XN(3)-HA)**2)
C
C THETA IS THE ANGLE BETWEEN THE HORIZONTAL PLANE
C AND THE LINE BETWEEN THE ANTENNA AND THE REFERENCE
C POINT ON THE SCATTERER.  CTH AND STH ARE THE COSINE
C AND THE SINE OF THETA RESPECTIVELY.
C
      CTH=DH/R1
      STH=(XN(3)-HA)/R1
C
C DD AND CEXPT ARE USED IN THE SECTION WHICH
C COMPUTES THE GAIN FOR THE SCATTERING.  SINCE THEY DO
C NOT DEPEND ON THE LOCATION OF THE RECEIVER POINT,
C THEY ARE COMPUTED HERE.
C
C IF CEXPT = 0 THE ANTENNA IMAGE IS TREATED AS A SEPARATE ELEMENT.
      DD=CTH*SIND*COSG+STH*COSD
      CEXPT = (0.0,0.0)
      IF( IMAGE ) CEXPT=CEXP(CMPLX(0.,2.*AK*HA*XN(3)/DH))
C
C
C AN IS A VECTOR WHOSE COORDINATES ARE THE DIRECTION COSINES
C FROM THE REFERENCE POINT ON THE SURFACE  OF THE SCATTERER TO
C THE ANTENNA.  THE REFERENCE SYSTEM USED IS ALIGNED WITH
C THE SIDES OF THE RECTANGLE AND THE THIRD AXIS IS
C THE OUTWARD NORMAL.  IN THE CASE OF THE CYLINDER THE
C NORMAL IS ASSUMED TO LIE IN A HORIZONTAL PLANE AND
C TO POINT AT THE ANTENNA.
C
      IF(IDA .NE. 2) GO TO 32
      AN(1)=(XA-XN(1))/DH
      AN(2)=(YA(IEL)-XN(2))/DH
      AN(3)=0.
      GO TO 33
   32 CONTINUE
      AN(1)=SINA
      AN(2)=-COSA
      AN(3)=0.
   33 CONTINUE
C
C
C THE HORIZONTAL ANGLE BETWEEN THE NORMAL TO THE SURFACE AND
C THE LINE OF SIGHT TO THE ANTENNA IS GAMMA.  SING AND COSG
C ARE THE SINE AND COSINE OF GAMMA.
```

```
C
      COSG=(-AN(1)*(XW(1)-XA)-AN(2)*(XW(2)-YA(IEL)))/DW
      SING = (-AN(2)*(XW(1)-XA) + AN(1)*(XW(2)-YA(IEL)))/DW
C
C
C IF THE COSG IS NEGATIVE THEN THE LINE OF SIGHT IS
C THRU THE BACK OF THE SCATTERER AND THE ILLUMINATION OF
C THE FRONT SURFACE IS ASSUMED TO BE OF ZERO INTENSITY
C AND THE FIELD FROM THIS SCATTERING IS IGNORED.
C
      IF (COSG) 34,34,35
   34 WRITE (6,1017) IA,IB,IEL
      GO TO 40
   35 CONTINUE
C
C
C THIS IS THE LOOP BACK POINT FOR THE RECEIVER POINTS.
C FOR EACH PIECE OF SCATTERER AND FOR EACH ANTENNA
C THE PROGRAM CALCULATES ALL THE FIELDS AT ALL THE
C RECEIVER POINTS BEFORE GOING ON TO THE NEXT PIECE
C OR ANTENNA.  XR,YR, AND ZR ARE THE COORDINATES
C OF THE RECEIVER LOCATION, VX,VY AND VZ ARE THE
C VELOCITIES IN THOSE DIRECTIONS.  THE LOCATION
C IS DETERMINED BY SLIGHTLY DIFFERENT METHODS DEPENDING
C ON THE FLIGHT TYPE.  THE VALUE OF IGF IS THE CONTROL.
C IR IS THE RECEIVER POINT NUMBER AND IS USED TO
C DETERMINE WHERE THE FIELDS FROM THE SCATTERING
C ARE TO BE SUMMED.
C
   36 CONTINUE
      IF(ICF .LE. 0) GO TO 37
      CDEG=CDEG+DXR
      IF( (CDEG-XMAX)*DXR .GE. 0.) GO TO 40
      XR=R*COS(CDEG/RAD)
      YR=R*SIN(CDEG/RAD)
      VX = - VEL*YR/R
      VY =   VEL*XR/R
      VZ = 0.0
      GO TO 39
   37 CONTINUE
      RXR=RXR+DXR
      IF( (RXR-XMAX)*DXR .GE. 0.) GO TO 40
      XR=RXR*COSPIR
      YR=RXR*SINPIR
      TEMP=SQRT(RXR*RXR+.25*XTH*XTH-XTH*XR)-XTH*.5
      IF(TEMP .LT. 0.) GO TO 38
      ZR=ZUP+TANBR*TEMP
      VZ = VEL*SPSI
      GO TO 39
   38 VZ = 0.0
      ZR=ZUP
   39 CONTINUE
      IF(IR .GT. 499) GO TO 40
```

```
      IR=IR+1
C
C
C RN IS THE DISTANCE FROM THE RECEIVER POINT TO THE
C SCATTERER REFERENCE POINT.
C
      RN=SQRT((XR-XN(1))**2+(YR-XN(2))**2+(ZR-XN(3))**2)
C
C
C RR IS THE HORIZONTAL DISTANCE FROM THE RECEIVER TO THE
C REFERENCE POINT.
C
      RR=SQRT((XR-XN(1))**2+(YR-XN(2))**2)
C
C
C BETA IS THE HORIZONTAL ANGLE BETWEEN THE SURFACE NORMAL AND
C THE LINE OF SIGHT TO THE RECEIVER POINT.  SINB AND COSB
C ARE THE SINE AND COSINE OF BETA.
C
      COSB=(AN(1)*(XR-XN(1))+AN(2)*(YR-XN(2)))/RR
      SINB=(-AN(2)*(XR-XN(1))+AN(1)*(YR-XN(2)))/RR
C
C
C DR IS THE DISTANCE FROM THE ANTENNA TO THE
C RECEIVER POINT.
C
      DR = SQRT((XR-XA)**2 + (YR-YA(IEL))**2 + (ZR-ZZ)**2 )
C
C
C THIS SECTION EVALUATES THE SCATTERING FROM THE SURFACE.
C THE COMPLEX VARIABLE 'FAC' REPRESENTS THE GAIN FACTOR
C FROM THE REFERENCE POINT ON THE SURFACE TO THE
C RECEIVER POINT.
C
C
C
C PHID AND PHIJD ARE THE RELATIVE FREQUENCY SHIFTS DUE TO DOPPLER
C EFFECT FROM THE AIRCRAFT VELOCITY.
C
      PHID = AK*(VX*(XR-XA) + VY*(YR-YA(IEL)) + VZ*(ZR-ZZ))/DR
      PHIJD = AK*(VX*(XR-XN(1))+VY*(YR-XN(2))+VZ*(ZR-XN(3)))/RN
C
C
C THESE CONSTANTS ARE THE GAIN FACTORS FOR THE VARIOUS CROSSTALK
C CASES.
C
      UT=(PHIJD-PHID)*TA/2.
      SNCUC(1) = SINC(UT+W8*T)**2
      SNCUC(2) = SINC(UT+W15*T)**2
      SNCUT = SINC(UT)
      SNCUD = SINC(UT+W8*T)
C
C
```

```
C THE GAIN FOR THE ACTUAL SCATTERING IS COMPUTED BELCW.
C THERE ARE FOUR TYPES OF TRIANGLES. THEY ARE ENCODEG
C BY THE USE OF MINUS SIGNS ON THEIR WIDTHS
C AND HEIGHTS.  THE CASES ARE AS FOLLOWS:
C
C
C     ORIENTATION OF THE RIGHT ANGLE              SIGN HEIGHT    SIGN WIDTH
C
C          LOWER RIGHT                                 +              +
C          UPPER LEFT                                  -              -
C          LOWER LEFT                                  +              -
C          UPPER RIGHT                                 -              +
C
C
C
   20 FAC=CMPLX(0.,0.)
      IF (IDA.EQ.3) LK=SIGN(1.,WW*HH)*CMPLX(0.,HH/AK)
      RP=RW
      SE2=(ZR-XW(3))/RP
      DO 65 M=1,2
      CE2=RR/RP
      AP=CTH*SING-CE2*SIND
      BP=BH*CE2*COSB*SIND-SE2*COSD
      BPP=BP*2.*HA*COSD/DH
      IF (IDA.EQ.3) GO TO 61
      IC=WW*(WW*SINC(AK*BP*HH/2.) -CEXPT*WW*SINC(AK*BPP*HH/2.))
      IF( IDA .EQ. 1 ) IC = IC*SINC(AK*AP*WW/2.)
      IF( IDA .EQ. 2 ) IC = IC*BESF(AKA,COSB,SINB)/2.
      GO TO 63
   61 W=AK*(CTH*SING-CE2*SINB)
      WP=W*(AK*BPP*HH)/WW
      W=W*(AK*BP*HH)/WW
      IC=LK*(SINC(AK*AP*WW/2.)*(CEXP(CMPLX(0.,-AK*BP*HH/2.))/BP
     A   -CEXPT*CEXP(CMPLX(0.,-AK*BPP*HH/2.))/BPP)
     .   -SINC(W*WW/2.)/RP*CEXPT*SINC(WP*WW/2.)/BPP)
   63 CB=CLAM*CEXP(CMPLX(0.,AK*RP))*IC/RP
      FAC=-CE2*(CTH*COSD*COSG-STH*SIND*(COSB*COSG-SINB*SING))*CB-FAC
      IF (M.EQ.2)  GO TO 65
      RP=SQRT(RR*RR+(XW(3)+ZR)**2)
      SE2=-(ZR+XW(3))/RP
   65 CONTINUE
C
C
C IF ID IS NEGATIVE THE GAIN IS TAKEN IN THE OPPOSITE
C SENSE.
C
   35 IF( ID .LT. 0) FAC=-FAC
C
C
C THE GAIN IS MULTIPLIED BY THE SIGNALS AT THE REFERENCE
C POINT TO GIVE THE SIGNALS AT THE RECEIVER.  THESE SIGNALS ARE COMPLEX
C MAGNITUDFS.  EP IS THE SIDEBAND PORTION OF THE CARRIER
```

```
C PLUS SIDEBAND FOR THE COURSE ANTENNA AND EE THE SIDEBAND
C ONLY.  EM IS THE SIDEBAND PORTION OF THE CARRIER PLUS SIDEBAND
C FOR THE CLEARANCE AND EC THE SIDEBAND ONLY.
C
      EP = FAC*EWR(IEL,1)
      EE = FAC*EWR(IEL,2)
      EM = FAC*EWR(IEL,3)
      EC = FAC*EWR(IEL,4)
C
C
C THESE ARE THE COMPLEX PHASORS FOR THE SIGNALS AT THE RECEIVER
C POINT  FOR THE DIFFERENT ANTENNAE AND FREQUENCIES.
C THEY HAVE THE FOLLOWING SIGNIFIGANCE.
C          SYMBOL  USAGE
C          ZJP     CARRIER FROM THE COURSE ANTENNA
C          ZJPC(1) 90 HZ SIDEBAND FOR COURSE
C          ZJPC(2) 150 HZ SIDEBAND FOR COURSE
C          ZJM     CARRIER FROM CLEARANCE
C          ZJMC(1) 90 HZ FROM CLEARANCE
C          ZJMC(2) 150 HZ FROM CLEARANCE
C
      ZJP = EP/CMPLX(EP,0.0)
      ZJPC(1) = EP - EC
      ZJPC(2) = EP + EC
      ZJM = EM/CMPLX(EM,0.0)
      ZJMC(1) = EM - EC
      ZJMC(2) = EM + EC
C
C
C SUBROUTINE VARCAL ADDS THE FIELDS TO THE FIELDS
C ACCUMULATED FOR THE 'IR'TH RECEIVER POINT.
C
      CALL VARCAL (IR)
C
C
C THE PROGRAM LOOPS BACK TO THE NEXT RECEIVER POINT.
C
      GO TO 36
   40 CONTINUE
   41 CONTINUE
   42 CONTINUE
C
C
C THIS IS THE TRANSFER BACK TO PICK UP THE
C NEXT SCATTERER OR CONTROL CARD.
C
      GO TO 21
C
C
C  AT THIS POINT THE PROGRAM HAS ACCUMULATED THE SCATTERED FIELDS
C AND HAS READ IN A CONTROL CARD TERMINATING THE RUN.
C THE PROGRAM WILL ADD IN THE DIRECT UNSCATTERED FIELD, BOTH
C DIRECTLY FROM THE ANTENNA AND REFLECTED FROM THE GROUND.
```

```
C THEN THE APPROPRIATE RECORDS WILL BE OUTPUT.
C
   43 CONTINUE
      IR=0
      SNCUT = 1.0
      SNCUO = 0.0
      SNCUC(1) = 0.
      SNCUC(2) = 0.
C
C
C FROM THIS STATEMENT THROUGH JUST BEFORE STATEMENT 51 IS
C THE LOOP ON RECEIVER POINT.  THE LOOPING IS DONE THE SAME
C AS THE SECTION FOLLOWING STATEMENT 39.
C
   44 IF(ICF .GT. 0) GO TO 46
      RXR =RXR + DXR
      IF( (RXR-XMAX)*DXR .GE. 0. ) GO TO 51
      XR=RXR*COSPIR
      YR=RXR*SINPIR
      TEMP=SQRT(RXR*RXR+.25*XTH*XTH-XTH*XR)-XTH*.5
      IF(TEMP .LT. 0.) GO TO 45
      ZR=ZUP+TANBR*TEMP
      VZ = VEL*SPSI
      GO TO 47
   45 VZ = 0.0
      ZR = ZUP
      GO TO 47
   46 CDEG = CDEG + DXR
      IF((CDEG-XMAX)*DXR .GE. 0. ) GO TO 51
      TEMP = CDEG/RAD
      XR = R*COS(TEMP)
      YR = R*SIN(TEMP)
   47 IR=IR+1
      CALL CLEAR(ZE,4)
C
C
C THIS CALL TO FLC CAUSES THE CALCULATION OF THE FIELD LEVELS
C AT THE RECEIVER POINT.
C
      CALL FLC(XR,YR,ZR)
C
C
C THIS IS THE LOOP FOR THE DIFFERENT ANTENNAE.  IEL IS THE
C ANTENNA NUMBER.  NEL IS TOTAL NUMBER OF ANTENNAE BEING
C USED.
C
      DO 49 IEL=1,NEL
C
C THIS SECTION CALCULATES THE FIELDS FOR THE VARIOUS SIGNALS
C AT THE RECEIVER POINT.
C
      WA = ZA(IEL)
      XA = XXA(IEL)
```

```
      RD=SQRT(RA(IEL)**2+(ZR-HA)**2)
       CE=CMPLX(RD/RA(IEL),0.)
      RD=2.*AK*HA*ZR/RD
      IF( IMAGE ) CE=CE*CMPLX(1.-COS(RD),-SIN(RD))
      DO 50 J = 1,4
      EWR(IEL,J)=EWR(IEL,J)*CE
   50 E(J)=E(J)+EWR(IEL,J)
      EJP = EWR(IEL,1)/CMPLX(CP,0.0)
      EJPC(1) = EWR(IEL,1) - EWR(IEL,2)
      EJPC(2) = EWR(IEL,1) + EWR(IEL,2)
      EJM = EWR(IEL,3)/CMPLX(CM,0.0)
      EJMC(1) = EWR(IEL,3) - EWR(IEL,4)
      EJMC(2) = EWR(IEL,3) + EWR(IEL,4)
C
C
C THIS CALL TO VARCAL ADDS THE FIELDS TO THE ONES ACCUMULATED
C FROM THE SCATTERERS.
C
      CALL VARCAL (IR)
   49 CONTINUE
C
C
C DETEC TAKES THE COMPLEX FIELD PHASORS AND EVALUATES
C THE COURSE DEVIATION INDICATION (CDI).  IR IS THE RECEIVER POINT
C NUMBER AND IS USED IN THE SUBROUTINE TO SELECT WHICH FIELDS
C ARE TO BE USED.  DF(IR) IS THE LOCATION IN THE ARRAY WHERE
C THE CDI IS TO BE PLACED.
C
      CALL DETEC (IR,DF(IR))
      IF(IR .GT. 499) GO TO 51
      GO TO 44
   51 CONTINUE
      XY(IR)=FLOAT(IR)
      WRITE(6,1010) ID,NC,IR,ICF
C
C
C THIS SECTION OUTPUTS THE CDI ON UNIT 8.  THE OUTPUT IS A LABEL
C RECORD (MEMO). TWO RECORDS OF FLIGHT AND ANTENNA DESCRIPTION,
C AND THE CDI RECORDS.
C
      IF(ID .EQ. 0) MEMO(13)=ILBL(5)
      WRITE (8,1005) MEMO
      WRITE(8,1014) XY,ID,NC,ICF
      WRITE(8,1016) (DF(I),I=1,IR)
C
C IF THE ID IS NOT 0 THE FLOW IS TO STATEMENT 57 TO PROCESS
C THE ID VALUE FROM THE CONTROL CARD.  OTHERWISE THE SIGNAL
C STRENGTHS ARE OUTPUT.
C
      IF( ID .NE. 0 ) GO TO 57
C
C
C IX IS THE NUMBER OF SIGNAL TYPES THAT ARE TO BE OUTPUT.  TWO
```

```
C FOR SIMPLE ANTENNA SYSTEMS, FOUR FOR CAPTURE EFFECT.
C
      IX=4
      IF((NEL .EQ. 1).OR.((MODE.GT. 10).AND. (MODE.LT. 19)) ) IX=2
C
C
C THESE LOOPS CALCULATE THE SIGNAL STRENGTHS.  THE VALUES ARE
C PLACED IN XXRY(I,J),  WHERE I IS THE RECEIVER POINT NUMBER AND
C J HAS THE FOLLOWING USAGE+
C        J        USAGE
C        1        CARRIER LEVEL FOR COURSE ANTENNA
C        2        SIDEBAND LEVEL FOR COURSE ANTENNA
C        3        CARRIER LEVEL FOR CLEARANCE
C        4        SIDEBAND LEVEL FOR CLEARANCE
C XXRY OCCUPIES THE SAME LOCATION IN CORE AS ZP AND ZM,
C
      DO 52 I=1,IR
   52 XXRY(I,1)=CABS(ZP(I))*CP
      DO 53 I=1,IR
   53 XXRY(I,2)=CABS(ZPC(I,1)-ZPC(I,2))/2.
      DO 54 I=1,IR
   54 XXRY(I,3)=CABS(ZM(I))*CM
      DO 55 I=1,IR
   55 XXRY(I,4)=CABS(ZMC(I,1)-ZMC(I,2))/2.
C
C
C THIS LOOP OUTPUTS THE APPROPRIATE NUMBER OF SIGNALS ON UNIT 8,
C THE LABEL RECORD FOR EACH CASE IS ALTERED SLIGHTLY AS EXPLAINED
C IN THE DATA STATEMENT FOR ILBL,
C
      DO 56 J = 1,IX
      MEMO(13)=ILBL(J)
      WRITE(8,1009) MEMO
      WRITE(8,1014) XY,ID,NC,ICF
   56 WRITE(8,1016) (XXRY(I,J),I=1,IR)
C
C
C THIS SECTION CONTROLS THE FLOW OF THE PROGRAM AFTER THE OUPUT
C FOR THE CASE IS FINISHED.  THE CONTROL IS BY THE VALUE OF THE
C ID READ IN ON THE LAST CONTROL CARD,  THIS ABSOLUTE
C VALUE OF ID IS IN IDA,  DEPENDING ON THE VALUE OF IDA THE
C PROGRAM LOOPS BACK AND READS IN THE NEXT DATA CARD FOR THE
C NEXTCASE TO BE RUN,  THE VALUE WILL CAUSE THE TRANSFER IN
C THE FOLLOWING+
C        IDA      NEXT TYPE OF CARD READ
C        0        MODE
C        1-10     SCATTERER
C        11-15    LABEL
C        16-20    MODE
C        21-50    COURSE WIDTH
C
   57 CONTINUE
      IF(IDA .EQ. 0) GO TO 1
```

```
      IF(IDA .LE. 10) GO TO 20
      IF(IDA .LE. 15) GO TO 14
      IF(IDA .LE. 20) GO TO 1
      IF(IDA .LE. 90) GO TO 6
   50 CONTINUE
      END FILE 8
      REWIND 8
      STOP
 1000 FORMAT (8F10.3)
 1001 FORMAT(2I2,6X,7F10.3)
 1002 FORMAT(9X,4HEL3=,F9.4)
 1003 FORMAT(9H0MODE =  2I4/10H FRQ =     F7.2/
     1   9H XTH =       F9.2/ 8H ZA =     3F9.2/
     2 8H XA =     3F9.2/14H COURSE WIDTH  F7.2,8H DEGREES   )
 1004 FORMAT (3X,13A5,A2)
 1005 FORMAT (13A5,A2)
 1006 FORMAT (7F10.0,2X,3I2)
 1007 FORMAT(4H0 VEL=,E11.4)
 1008 FORMAT(20H OVER 900 RECEIVER POINTS !
 1009 FORMAT(6H0XMIN=,E11.4,7H  XMAX=,E11.4,7H  DXR=,E11.4,7H  PHIR=,E11
     X.4,7H  PSIR=,E11.4,6H  XTH=,E11.4,5H SUP=,E11.4)
 1010 FORMAT(16H0 STRUCTURE DATA)
 1011 FORMAT(50H ID          XW             YW             ZW        ALPHA
     X,4HDELTA ,8X,23H  WW             HW        ,5X,1HH
     X,5X,13H V  SECTIONS  )
 1012 FORMAT (I2,3F0.0,5X,2F5.0,3F10.0)
 1013 FORMAT (I3,1X,7E12.4,5X,I3,4X,I3)
 1014 FORMAT(1X,7F10.9,/ 3F10.0,I10,10X,2I10)
 1015 FORMAT(6H0MINO=,E11.4,7H  MAXO=,E11.4,7H  DDEG=,E11.4,4H  R=,
     XE11.4,7H  SUP=,E11.4,7H   ICF=,I2)
 1016 FORMAT( 7E13.8 )
 1017 FORMAT(27H SURFACE IS NOT ILLUMINATED  ,
     X5H   H=,I2,5H   V=,I2,6H  IEL=,I2)
 1018 FORMAT (2X,3HID= ,I3,5X,3HNC= ,I3,5X,3HIR= ,I3,5X,4HICF= ,I2,//)
 1019 FORMAT (' *** ABOVE TRIANGLE TOO LARGE.  SCATTERER ',
     1 'OMITTED ***')
      END
```

CONSTANTS

0	1794210421°4	1	000000000020	2	216500600000	3	204000000000	4	212034443000
5	177631463146	6	177714631463	7	176631463146	10	171307334121	11	[illegible]
12	201946314631	13	211764000000	14	160517426542	15	000000010024	16	[illegible]
17	201400000000	20	000000000000	21	000000000000	22	000000000004		

COMMON

ARAD	/CD	/+0	AFPP	/CD	/+62	AGPP	/CD	/+144	BRAD	/CD	/+226	BFPP	/CD	/+310
BGPP	/CD	/+372	BJM	/AB	/+0	BJP	/AB	/+2	BJPC	/AB	/+4	BJMC	/AB	/+10
BP	/.COMM.	/+0	BPC	/.COMM.	/+1750	ZM	/.COMM.	/+3670	ZMC	/.COMM.	/+7640	VCD	/.COMM.	/+13560
VPD	/.COMM.	/+15530	VMD	/.COMM.	/+17500	SM	/VAR	/+0	SNCUT	/VAR	/+1	SNCUD	/VAR	/+2
SNCUC	/VAR	/+3	VPC	/VAR	/+5	VMC	/VAR	/+7	MODE	/SUB	/+0	ICP	/SUB	/+1
ICM	/SUB	/+2	IET	/SUB	/+3	FRQ	/SUB	/+4	LAMBDA	/SUB	/+5	PI	/SUB	/+6

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RADD   /SUB  /+7     PHI    /SUB  /+10    PSI    /SUB  /+13    NEL    /SUB  /+16    XTN    /SUB  /+17
SLP    /SUB  /+20    XXA    /SUB  /+21    YA     /SUB  /+24    ZA     /SUB  /+27    RA     /SUB  /+32
TGS    /SUB  /+35    BT     /SUB  /+36    SIG    /SUB  /+37    DB     /SUB  /+40    AK     /SUB  /+41
LOC    /ANT  /+0     FPP    /ANT  /+1     FPM    /ANT  /+3     GPP    /ANT  /+5     GPM    /ANT  /+7
EWR    /ANT  /+11    CWA    /ANT  /+51    AS     /ANT  /+53    CLS    /ANT  /+54    DE     /ANT  /+55
CS     /ANT  /+137   ZO     /ANT  /+303   ET     /ANT  /+447   ND     /ANT  /+517   DUMXXX /ANT  /+521
ZD     /.COMM./+0    XXRV   /.COMM./+0

SUBPROGRAMS

FORSE.  .JOFF   TPFCN.  CLEAR   END.    PATTRN  CRRNTS  CSP     ANTP    LNAR    REAL    CFD.2   ATAN    SOCAL   SIGN
IFIX    ABS     SIN     COS     FLOAT   IABS    SQRT    CMPLX   FLC     CEXP    SINC    CFM.8   CFM.4   CFMM.8  DEXP
CFD.8   CFM.2   VARCAL  CFMM.2  DETEC   CABS    EXIT    FLOUT.  FLIRT.  INTO.   INTI.   ALPHO.  ALPHI.

SCALARS

RAD     3793         NC      3794         TA      3795         PTA     3796         PI      6
HSGT    3797         HSGT    3760         H1SGT   3761         ICP     1            IMAGE   3762
NEL     16           MODE    P            IET     3            FRQ     4            XTN     17
SLP     20           LAMBDA  5            AK      41           ZS      3763         SM      8
CP      3764         CM      3765         TGS     35           CW      3766         CLS     54
RADD    7            LOC     P            FPP     1            GPP     5            TEMP    3767
XMIN    3770         XMAX    3771         DXR     3772         PHIR    3773         PSIR    3774
R       3775         SUP     3776         ICF     3777         VEL     4000         WR      4001
SPSI    4002         TANSR   4003         COSPIR  4004         SINPIR  4005         VX      4006
VY      4007         VZ      4010         IO      4011         ALPHA   4012         DELTA   4013
WW      4014         HW      4015         IDA     4016         CDEG    4017         ZR      4020
RXR     4021         AKA     4022         COSD    4023         SIND    4024         COSA    4025
SINA    4026         IH      4027         IV      4030         DX      4031         DV      4032
DZ      4033         DXB     4034         DYZ     4035         AI      4036         CLAM    4037
IB      4041         IA      4042         IEL     4043         XA      4044         HA      4045
IR      4046         DW      4047         R1      4050         CTN     4051         STN     4052
BB      4053         COSG    4054         CEXPT   4055         SING    4057         XR      4060
YR      4061         RW      4062         RR      4063         COSB    4064         SINB    4065
DR      4066         PHID    4067         PHIJO   4070         UT      4071         SNOUT   1
SNCUD   2            FAC     4072         LK      4074         RP      4076         SEZ     4077
H       4100         CEZ     4101         AP      4102         BP      4103         DPP     4104
IC      4105         W       4107         WP      4110         CB      4111         EP      4113
EE      4115         EN      4117         EG      4121         ZJP     2            ZJM     0
RD      4123         CE      4124         J       4126         I       4127         IX      4130
ICM     2            BT      36           SIG     37           DB      40           FPM     3
GPM     7            AS      53

ARRAYS

ILBL    4131         MEMO    4136         DF      4154         ZE      5141         ZO      0
CS      137          ZO      303          ZJPC    4            ZJMC    10           ZP      0
ZPC     1750         ZM      5470         ZMC     7640         XXRY    0            VOD     12560
VPD     15530        VMD     17500        XW      5151         XWB     5154         AN      5157
AFOO    5162         PHS     5173         XY      5204         ARAD    0            AFPP    62
AGPP    144          BRAD    226          AFPP    310          BGPP    372          SNOUC   3
VPC     5            VMC     7            PHI     10           PSI     13           XXA     21
VA      24           ZA      27           RA      32           EWR     11           CWA     51
```

	DE	98		ET	447		ND	517		DUMXXX	921	
AB	38											
ABS	300	993	994									
AFDD	33											
AFPP	37	227	300									
AGPP	37	227	300									
AI	990	991	992									
AK	41	170	408	604	702	703	812	821	822	820	826	827
	997											
AKA	408	823										
ALPHA	447	495	499	500	510	541						
AN	32	676	677	678	681	682	683	691	692	762	763	
ANY	43											
ANTP	300											
AP	817	822	828									
ARAD	37	227	300									
AS	43											
ATAN	326											
BB	662	818										
BESP	23	823										
BFPP	37	201	234									
BGPP	37	201	234									
BP	818	819	821	827	828							
BPP	819	821	826	828								
BRAD	37	201	234									
BT	41											
CABS	1025	1027	1029	1031								
CB	28	831	832									
CD	37											
CDES	466	631	721	722	723	724	929	930	931			
CE	23	956	958	960								
CER	816	817	818	829	832							
CEXP	664	820	831									
CEXPT	28	663	664	821	828							
CLAN	28	961	831									
CLEAR	100	424	939									
CLS	43	266	271	346								
CM	171	179	873	969	1029							
CMPLX	561	664	811	812	828	831	870	873	956	958	962	965
COS	409	410	412	413	497	499	723	932	958			
COSA	499	993	994	995	996	960	682					
COSB	762	810	823	832								
COSD	497	998	662	818	819	832						
COSG	662	691	700	832								
COSPIN	418	732	919									
CP	170	178	870	962	1025							
CRNNYS	207	247	254									
CS	24	43	207	247	254	318						
CSP	306											
CTW	693	662	817	829	832							
CW	266	325	326	327	328	333	337	338	344			
CWA	43	279	288	333	349							
DD	41											
DE	43	207	247	294	318							

DELTA	447	487	496	497	498	519	541							
DETEC	903													
DF	22	903	908											
DR	700	702												
DUMMXX	43													
DV	645	653	664	676	677	691	692	819						
DX	314	353	374	399										
DXR	363	368	378	385	389	390	402	415	448	466	469	631	633	721
	722	730	731	817	918	929	928							
DXS	317	350	374	382										
DY	315	355	375	400										
DYS	316	360	375	383										
DZ	316	350	376	384										
EC	24	856	874	875										
EE	24	854	871	872										
EM	24	859	873	874	875									
EP	24	853	870	871	872									
ET	43	207	247	294	318									
EWR	24	43	100	853	854	855	856	960	961	962	963	964	965	966
	967													
FAC	22	811	832	842	852	854	855	856						
FLC	600	941												
FLOAT	436	438	439	997	907									
FPM	24	43												
FPP	24	43	300	310	317									
FRQ	41	141	149	344										
GPM	24	43												
GPP	24	43	300	310	317									
GSCAL	338													
HA	622	646	694	664	819	953	959	997						
HH	447	519	538	541	557	550	559	560	812	821	826	827	828	
I	990	1024	1025	1026	1027	1028	1029	1030	1031	1042				
IA	993	701												
IABS	495													
IB	901	701												
IC	20	821	822	823	828	831								
ICF	363	401	402	465	638	720	916	900	997	1041				
ICH	41													
ICP	41	76	102	201	207	241	256	344	439					
ID	447	499	519	541	843	900	995	997	1004	1041				
IDA	495	470	479	486	519	921	542	562	675	812	820	822	823	1040
	1061	1062	1063	1064										
IEL	615	621	622	635	645	646	677	691	692	701	769	702	853	896
	855	856	940	953	954	955	956	960	961	962	963	964	965	966
	967													
IET	41	141												
IFIA	305	533	930											
IN	512	533	541	550	563	593								
ILBL	18	46	995	1039										
IMAGE	36	77	664	990										
IR	620	742	743	881	985	934	973	983	984	987	988	998	1024	1026
	1020	1030	1042											
IV	513	530	541	557	563	581								

IX	1010	1011	1030											
J	959	960	961	1038	1039	1042								
LAMBDA	35	41	149	150	927	951								
LX	20	812	828											
LBAR	316													
LOC	43	292												
N	815	833												
NENO	22	361	362	995	996	1039	1040							
MOD	41	141	161	162	163	165	169	220	226	233	240	252	259	282
	292	384	385	344	438	623	635	1011						
NC	60	425	436	988	997	1041								
NO	43	207	247	294	318									
NXL	41	82	195	239	297	615	940	1011						
NR	385	386	387	391										
PATION	201	227	234											
PHI	41	291	318											
PHID	782	789												
PHIJD	783	789												
PHIR	363	405	406	410	411	412	413	422						
PHS	33													
PI	41	46	150											
PSI	41	290												
PSIR	363	405	407	408	409	412	413	414	434					
PTA	66	67	68	69										
R	363	402	723	724	725	720	932	933						
R1	646	653	654											
RA	41	955	956											
RAD	47	326	406	487	495	496	723	724	931					
RADD	41	291												
RD	955	956	957	958										
REAL	317													
RP	813	814	816	831	834	835								
RR	755	762	763	816	834									
RU	749	783	813											
RXR	469	632	730	731	732	733	734	917	918	919	920	921		
SE2	814	818	835											
SIG	41													
SIGN	360	370	955	956	812									
SIN	400	411	413	414	490	500	724	933	958					
SINA	900	955	956	959	681									
SINM	763	817	823	825	832									
SINC	790	791	792	793	821	822	828							
SINU	498	959	960	662	818	832								
SINS	692	817	825	832										
SINPIR	411	733	920											
SLP	41	141												
SN	40	169	180											
SNCVC	40	790	791	988	989									
SNCVD	40	793	987											
SNCVT	40	792	986											
SO	24	43	207	247	254	318								
SPSI	400	409	737	924										
SQRT	927	645	646	734	749	755	769	834	921	958				

STM	654	662	838											
SUO	41													
TA	45	46	280											
TANDR	409	736	923											
TEMP	317	333	345	527	533	536	552	554	556	734	735	736	921	922
	923	931	932	933										
TSS	41	175												
UT	700	790	791	792	793									
VAR	46													
VARCAL	801	973												
VBD	30	39												
VEL	373	374	378	412	413	414	437	725	726	737	924			
VMC	40													
VMO	30	39												
VPC	40													
VPO	30	39												
VX	412	725	782	783										
VY	413	726	782	783										
VZ	414	727	737	738	782	783	924	926						
W	825	826	827	828										
W1SPT	69	791												
WOD1	67	793												
WOD2	68	790												
WP	826	828												
WW	447	488	519	533	541	551	552	553	555	812	821	822	826	827
	828													
XA	621	622	645	646	676	681	692	769	782	954				
XMAX	363	368	385	389	482	485	722	731	918	938				
XMIN	362	368	385	389	482	485	441	466	469	631	633			
XR	725	726	732	734	749	755	762	763	769	782	783	919	921	932
	941													
XTN	41	141	326	344	409	734	921							
XW	31	447	519	527	541	554	556	574	575	578	585	586	587	599
	600	608	623	645	646	654	664	676	677	691	692	749	795	762
	763	783	814	834	835									
XWO	31	574	575	576	582	583	584	585	586	587				
XZA	41	266	344	527	621	954								
XZRY	29	45	1025	1027	1029	1031	1042							
XY	34	433	434	435	436	437	438	439	440	441	987	997	1041	
YA	41	151	152	175	527	645	646	677	691	692	769	782		
YR	724	725	733	749	755	762	763	769	782	783	920	933	941	
ZA	41	141	344	622	635	953								
ZD	24	45												
ZE	24	939	961											
ZJM	26	38	873	968										
ZJMC	26	38	874	875	966	967								
ZJP	26	38	870	962										
ZJPC	26	38	871	872	963	964								
ZM	27	39	1029											
ZMC	27	39	1031											
ZP	27	38	48	424	1028									
ZPC	27	39	1027											
ZR	467	736	748	749	769	782	783	814	834	835	923	927	941	958
	957													
ZUP	363	482	485	435	467	736	748	923	927					
ZZ	153	635	769	788										

1P	76	1060	1063								
2P	102	213									
3P	103	178									
4P	105	220									
5P	226	247									
6P	176	228	233	242	293	266	1064				
7P	305	300									
8P	304	310									
9P	307	309	311	317							
10P	325	326									
11P	325	333									
12P	282	337									
13P	335	339									
14P	360	1062									
15P	386	387	388								
16P	387	392									
17P	401	402									
18P	401	404									
19P	403	415									
20P	423	1061									
21P	447	505	525								
22P	465	466									
23P	465	469									
24P	466	478									
25P	486	489									
26P	542	550									
27P	521	562	563	574							
28P	611										
29P	630	633									
30P	632	634									
31P	643										
32P	675	680									
33P	679	684									
34P	623	705	791								
35P	700	703									
36P	719	806									
37P	728	729									
38P	735	739									
39P	720	738	741								
40P	615	702	722	731	742	887					
41P	593	888									
42P	901	889									
43P	478	479	904								
44P	916	905									
45P	922	920									
46P	916	929									
47P	925	928	934								
49P	948	974									
50P	959	961									
51P	918	930	904	906							
52P	1024	1025									
53P	1026	1027									
54P	1028	1029									
55P	1030	1031									
56P	1030	1042									
57P	1054	1059									
58P	141	161	162	175	266	361	363	373	398	447	1065
61P	820	825									
62P	521	527									
63P	824	831									
64P	815	833	836								
1000P	179	266	345	1069							
1001P	141	1070									
1002P	346	1071									
1003P	344	1072									
1004P	362	1073									
1005P	361	996	1040	1076							
1006P	363	373	1077								

1007P	374	1078	
1008P	398	1079	
1009P	405	1080	
1010P	426	1082	
1011P	427	1083	
1012P	447	1086	
1013P	519	941	1087
1014P	997	1041	1088
1015P	402	1089	
1016P	990	1042	1091
1017P	701	1092	
1018P	900	1094	
1019P	904	1095	

```
C
C
C THIS SUBROUTINE IS USED TO ZERO OUT THE CONTENTS OF
C VARIOUS MATRACIES.
C
      SUBROUTINE CLEAR (X,N)
      COMPLEX X(1)
      DO 1 I = 1,N
    1 X(I) = (0.,0.)
      RETURN
      END

CONSTANTS

0        000000000000     1        000000000000

GLOBAL DUMMIES

X        34               N        35

SCALARS

CLEAR    36               I        37               N        35

ARRAYS

X        34

  12        8     9
CLEAR       6
I           8     9
N           6     8
X           6     7     9
```

```
1        C
2        C  SCALAR PRODUCT OF VECTORS A AND B
3              FUNCTION  SP( A, B )
4              DIMENSION A(3), B(3)
5              SP = A(1)*B(1)+A(2)*B(2)+A(3)*B(3)
6              RETURN
7              END

    GLOBAL DUMMIES

    A        44                B        45

    SCALARS

    SP       46

    ARRAYS

    A        44                B        45
A            3        4        5
B            3        4        5
SP           3        5
```

```
C
C
C     THIS ROUTINE CONVERTS PLANE POLAR COORDINATES TO PLANE RECTANGULAR CO-
C     ORDINATES.
C
      SUBROUTINE P2R ( X, Y, R, T )
      COMPLEX Z
      Z = R*CEXP(CMPLX(0.0,T))
      X = REAL( Z )
      Y = AIMAG( Z )
      RETURN
      END

   CONSTANTS

   0       00000000000PB

   GLOBAL DUMMIES

   X       S1          Y       S2          R       S3          T       S4

   SUBPROGRAMS

   CEXP    CMPLX   CFM.S   REAL    AIMAG

   SCALARS

   P2R     S7          Z       60          R       S3          T       S4          X       S1
   Y       S2

AIMAG      10
CEXP       8
CMPLX      8
P2R        6
R          6       8
REAL       9
T          6       8
X          6       9
Y          6       10
Z          7       8       9       10
```

```
C
      SUBROUTINE SSCAL(CW)
      REAL LAMBDA
      COMPLEX FPP,GPP,E,C(90),S(90),CJA,CJB,FPM,GPM,CMP,GP,FP
      COMMON /ANT/ LOC,FPP(2),GPP(2),E(4,4),CMA(2),AS(2),D(50),C,S,
     2                ET(20,2),ND(2)
      COMMON /SUB/ MODE,ICP,ICM,IET,FRQ,LAMBDA,PI,RADD,PHI(3),PSI(3),NEL
     1,XTH,SLP, XA(3),YA(3),ZA(3),RAA(3),TGS,BT,SIG,CB,AK
      COMMON /WG/ TM(3,2),BM(3,2),CJA(30),CJB(30)
      DIMENSION RM(3)
      EQUIVALENCE  (FPM,FPP(2)), (GPM,GPP(2)), (CLS,AS(2))
      NAMELIST /SCAL/ MODE,IET,XTH,SLP,TGS,BT,SIG,BM,TM,CMM,CMA,XA,YA,ZA
     1 ,ICP,ICM,FRQ,LAMBDA,PI,H1,FPP,GPP,X,S,AS,E
      DATA FR /0.5 /
      TTS(X) = SIN(X*RADD)/COS(X*RADD) - SLP
      ICP = MODE
      ICM = MODE
      CMM=CM
      CMA(1) = 1.0
      CMA(2) = 1.0
      IF( XA(1).GT.(XTH-3000.) ) GO TO 20
      IF( MODE .GT. 12 ) GO TO 2
      ZA(1) = AMAX1( 35.0,ZA(1) )
      H1 = ZA(1)
      GO TO 3
    2 H1 = 0.
    3 XA(1) = XTH - ( 50. - H1 )/TTS(TGS)
   20 IF( ABS(YA(1)) .GT. 300. ) GO TO 30
      IF( MODE - 12 ) 22,22,23
   22 YA(1) = SIGN(750.,YA(1))
      GO TO 30
   23 YA(1) = SIGN(500.,YA(1))
   30 IF( ZA(1) .GT. 5. ) GO TO 40
      IF( MODE .GT. 12 ) GO TO 32
      ZA(1) = (XA(1) - XTH)*TTS(TGS) + 50.
      GO TO 40
   32 H1 =  0.25*LAMBDA/SIN(TGS*RADD)
      IF( MODE - 14 ) 33,34,35
C   NULL REFERENCE MODE = 13
   33 ZA(1) = H1
      ZA(2) = 2.*H1
      GO TO 40
C   SIDEBAND REFERENCE MODE  =  14
   34 ZA(1) = H1/2.
      ZA(2) = 3.0*ZA(1)
      GO TO 40
C   M - ARRAY  MODE = 15
   35 ZA(1) =  H1
      ZA(2) = 2.*H1
      ZA(3) = 3.*H1
   40 IF( MODE - 12 ) 50,60,70
   50 CONTINUE
   60 IF( ABS(SIG) .GT. 1.0E-05 ) GO TO 61
```

```
      SIG = ATAN2((XA(1)-XTH)*TTS(TGS)*90.,-ZA(1),-YA(1))/RADD
   61 XA(2) = XA(1)
      YA(2) = YA(1)
      ZA(2) = -ZA(1)
      CALL P2R( BM(1,1),BM(3,1),1.0,TGS*RADD)
      BM(2,1) = 0.
      CALL P2R( TM(1,1),TM(2,1),1.0,-SIG*RADD)
      TM(3,1) = BM(1,1)*TM(1,1)
      TM(1,1) = -BM(3,1)*TM(1,1)
      RM(2) = 0.0
      CALL P2R( RM(1),RM(3),1.0,(TGS-0.5*FR*CW)*RADD)
      CALL CUG( FPP(1),GPP(1),RM,TM,BM )
      CALL P2R( RM(1),RM(3),1.0,TGS*RADD )
      CALL CUG( FPM,GPM,RM,TM,BM )
      DM0 = REAL( FPM/GPM )
      DM1 = REAL( FPP(1)/GPP(1) )
      BT = TGS - 0.5*FR*CW*DM0/( DM1 - DM0 )
      CALL P2R( BM(1,1),BM(3,1),1.0,BT*RADD )
      CWA(1) = 0.210*FR/( DM1 - DM0 )
      CWA(2) = CWA(1)
      BM(1,2) = BM(1,1)
      BM(2,2) = BM(2,1)
      BM(3,2) = -BM(3,1)
      CALL P2R( TM(1,1),TM(2,1),1.0,-SIG*RADD)
      TM(3,1) = BM(1,1)*TM(1,1)
      TM(1,1) = -BM(3,1)*TM(1,1)
      TM(1,2) = TM(1,1)
      TM(2,2) = TM(2,1)
      TM(3,2) = -TM(3,1)
C     CLS MAY BE USED AS AN EXTERNAL CONTROL OF COMPENSATOR AMPLITUDE HERE.
      CALL CUG( FPP(1),GPP,RM,TM(1,2),BM(1,2))
      CMP = 0.5*(0.0,1.0)*CLS*FPP(1)/SIN(AK*SP(RM,TM(1,2))*D(20))
      S(20) = CMP
      S(1)  = -CMP
      GO TO 90
   70 XA(2) = XA(1)
      XA(3) = XA(1)
      IF ( MODE .EQ. 19 )  GO TO 71
      NEL = 2
      GO TO 72
   71 NEL = 3
C     OFFSET ADJUSTMENTS FOR PROXIMITY
C
   72 RA = SORT( ZA(1)*ZA(1) +YA(1)*YA(1) )
      YA(2) = SIGN(SORT(RA*RA-ZA(2)*ZA(2)),YA(1))
      IF( NEL .EQ. 3 ) YA(3) = SIGN(SORT(RA*RA-ZA(3)*ZA(3)),YA(1))
C     THIS SECTION CALIBRATES THE COURSE WIDTH OF IMAGE TYPE ARRAYS TO THE VALUE
C     SPECIFIED BY CW.
      CALL P2R( X,0.,1.0E+04,(TGS+0.5*FR*CW)*RADD )
      CALL FLC( X + XA(1), 0., 2 )
      GP = (0.,0.)
      FP = (0.,0.)
      DO 73 I = 1,NEL
```

```
      RD = 2.*AK*ZA(I)*Z/X
      CE = ( 1.-CEXP(CMPLX(0.,RD)))
      GP = GP + E(I,1)*CE
   73 FP = FP + E(I,2)*CE
      CHA(1) = .210*FR/ABS(REAL(FP/GP))
   99 WRITE (6,GCAL)
      RETURN
      END

CONSTANTS

0    214567000000   1    204430000000   2    211474000000   3    212047000000   4    211744000000
5    160517426542   6    201400000000   7    176676359442   10   000000000000   11   201400000000
12   216470400000   13   000000000000   14   000000000000   15   201400000000   16   000000000000

GLOBAL DUMMIES

CN     1110

COMMON

LOC  /ANT /+0    PPP    /ANT /+1    GPP  /ANT /+5    E    /ANT /+11   CHA  /ANT /+21
AS   /ANT /+53   D      /ANT /+99   C    /ANT /+137  S    /ANT /+303  ET   /ANT /+447
NO   /ANT /+817  MODE   /SUB /+0    ICP  /SUB /+1    ICM  /SUB /+2    IET  /SUB /+3
FRQ  /SUB /+4    LAMBDA /SUB /+5    PI   /SUB /+6    RADO /SUB /+7    PHI  /SUB /+10
PSI  /SUB /+13   NEL    /SUB /+16   XTN  /SUB /+17   SLP  /SUB /+20   XA   /SUB /+21
YA   /SUB /+24   BA     /SUB /+27   RAA  /SUB /+32   TGS  /SUB /+35   BT   /SUB /+36
SIS  /SUB /+37   DB     /SUB /+40   AK   /SUB /+41   TN   /NG  /+0    BN   /NG  /+6
CJA  /NG  /+14   CJB    /NG  /+110  FPN  /ANT /+8    GPN  /ANT /+7    CLS  /ANT /+94

SUBPROGRAMS

ALLIO.  SIN    COS     AMAX1  ABS  SIGN  ATAN2  P2R  GNG  REAL  CFD,2  SP  CFM,2  SQRT  FLC
CEXP    CMPLX  NNLST.

SCALARS

GSCAL  1116     MODE  0     IET     3     XTN   17     SLP  20
TGS    35       BT    36    SIS     37    CNN   1117   ICP  1
ICM    2        FRQ   4     LAMBDA  5     PI    6      N1   1120
X      1121     S     1122  FR      1123  RADO  7      CN   1110
FPN    3        GPN   7     DNB     1124  DN1   1125   CMP  1126
CLS    94       AK    41    NEL     16    RA    1130   GP   1131
FP     1133     I     1135  RD      1136  CE    1137   LOG  0
DB     40

ARRAYS

C     137       S     303   FPP   1     GPP   5     E    11
CHA   21        AS    53    D     99    ET    447   NO   817
PHI   10        PSI   13    XA    21    YA    24    BA   27
RAA   32        TN    0     BN    6     CJA   14    CJB  110
RN    1140
```

```
C
C THIS SUBROUTINE IS USED TO INPUT DATA FOR CALCULATING THEORECTICAL
C PATTERNS FOR ARRAY TYPE ANTENNAE.
C
      SUBROUTINE CRRNTS( D, C, S, ET, NE )
      DIMENSION ET(19),D(1)
       COMPLEX C(1),S(1)
      COMMON /SUB/ MODE,ICP,ICM,ICT,FRQ,LAMBDA,PI,RADD,PHI(3),PSI(3),NEL
     1,XTH,SLP, XXA(3),YA(3),ZA(3),RA(3),TSS,ST,SIG,CB
      I = 1
C
C
C THIS IS THE INPUT FOR THE ELEMENT LOCATION AND CURRENT DESCRIPTION
C DT IS THE ELEMENT DISPLACEMENT IN THE Y-DIRECTION, MEASURED
C        IN WAVELENGTHS.
C CT IS THE CARRIER PLUS SIDEBAND AMPLITUDE, IN RELATIVE UNITS
C PC IS THE CARRIER PLUS SIDEBAND PHASE, IN DEGREES
C ST IS THE SIDEBAND ONLY AMPLITUDE, IN RELATIVE UNITS
C PS IS THE SIDEBAND ONLY PHASE, IN DEGREES
C
    1 READ (5,1000) DT, CT, PC, ST, PS
C
C THIS TEST IS TO SEE IF THE END OF THE ELEMENT CARDS HAS BEEN
C REACHED.  IF THE CARRIER PHASE IS GREATER THAN 900 FLOW
C IS TO THE ELEMENT PATTERN SECTION.
C
      IF( PC .GT. 900.) GO TO 2
C
C THIS IS THE 90 DEGREE PHASE SHIFT FOR THE QUADRATURE OF
C THE SIDEBAND ONLY TO THE SIDEBAND IN THE CARRIER PLUS SIDEBAND.
C
      PS = PS+90.0
      WRITE (6,1000) DT,CT,PC,ST,PS
      D(I) = DT*2.*PI
      C(I)=CT*CEXP(CMPLX(0.,PC*RADD))
      S(I) = ST*CEXP(CMPLX(0.,PS*RADD))
      I = I + 1
C
C
C THIS STATEMENT LOOPS BACK FOR THE NEXT ELEMENT IF THE TOTAL
C NUMBER OF ELEMENTS DOES NOT EXCEED THE AVAILABLE SPACE.
      IF( I .LT. 26) GO TO 1
C
C
C THIS SECTION READS IN THE PATTERN FOR THE ELMENTS. NE IS THE
C NUMBER OF ELEMENTS.  ALL ELEMENTS ARE ASSUMED TO HAVE THE SAME
C PATTERNS.
C
    2  NE = I - 1
C
C
C ET WILL CONTAIN THE ELEMENT PATTERN.  THE VALUES ARE IN
C RELATIVE AMPLITUDES.  ET(1) IS THE VALUE AT ZERO DEGREES AND
```

```
C SUCCESSIVE VALUES ARE AT 10 DEGREE SPACING UP TO 180.  THUS
C THERE ARE 19 POINTS GIVEN. THE PATTERN IS SYMETRIC ABOUT
C THE ZERO DEGREE POINT.
C
      READ (5,1000) ET
      WRITE(6,1000) ET
      RETURN
 1000 FORMAT( 8F10.4 )
      END

CONSTANTS

0       000000000000

GLOBAL DUMMIES

D       156             C       157             S       160             ET      161

COMMON

MODE    /SUB    /+0     ICP     /SUB    /+1     ICM     /SUB    /+2     IET     /SUB    /+3
LAMBDA  /SUB    /+5     PI      /SUB    /+6     RADD    /SUB    /+7     PHI     /SUB    /+10
NEL     /SUB    /+16    XTN     /SUB    /+17    SLP     /SUB    /+20    XXA     /SUB    /+21
ZA      /SUB    /+27    RA      /SUB    /+32    TGS     /SUB    /+35    BT      /SUB    /+36
DB      /SUB    /+40

SUBPROGRAMS

CEXP    CMPLX   CFM.R   FLOUT.  FLIRT.

SCALARS

CRRNTS  166             I       167             DT      170             CT      171
ST      173             PS      174             PI      6               RADD    7
MODE    0               ICP     1               ICM     2               IET     3
LAMBDA  5               NEL     16              XTN     17              SLP     20
RT      34              SIG     37              DB      40

ARRAYS

ET      161             D       156             C       157             S       160
PSI     13              XXA     21              VA      24              ZA      27

BT        0
C         5      7      35
CEXP      35     34
CMPLX     35     36
CRRNTS    5
CT        21     33     35
D         5      6      36
DB        0
DT        21     33     34
ET        5      6      58     59
FRO       0
I         10     34     35     36     37     42     49
ICM       0
ICP       0
IET       0
LAMBDA    0
MODS      0                                             1P     21     42
NE        5      49                                     2P     27     49
NEL       0                                          1000P     21     33     58     59     61
PC        21     27     33     35
PHI       0
PI        0      34
PS        21     32     33     36
PSI       0
RA        0
RADD      0      35     36
S         5      7      36
SIG       0
SLP       0
ST        21     33     36
SUB       0
TGS       0
XTN       0
XXA       0
YA        0
ZA        0
```

```
C
C
C THIS SUBROUTINE INPUTS THE ANTENNA PATTERNS FOR THE MEASURED
C PATTERN ANTENNA BASES.
C
      SUBROUTINE PATTRN ( ARAD, AFPP, AGPP )
      DIMENSION ARAD(90), AFPP(90), AGPP(90)
      DATA  RAD /  57.2957795  /
      IX = 1
    1 READ(5,1000) ANG, AFPP(IX), AGPP(IX)
      AFPP(IX)=AFPP(IX)*100000.
      AGPP(IX)=AGPP(IX)*103400.
      ARAD(IX)=ANG     /RAD
      IX=IX+1
      IF( IX .GE. 91) GO TO 2
      IF( ANG .LT. 361.) GO TO 1
      IF( IX .LE. 2) GO TO 4
    2 WRITE (6,1001)
      WRITE (6,1002)
      IY=IX-2
      DO 3 I=1,IY
      ANG=ARAD(I)*RAD+.0001
    3 WRITE (6,1003) ANG,AFPP(I),AGPP(I)
      GO TO 5
    5 RETURN
    4 WRITE (6,1004)
      END FILE 6
      STOP
 1000 FORMAT(8F10.0)
 1001 FORMAT(28H ANTENNA PATTERN MEASUREMENT)
 1002 FORMAT(34H ANGLE READ    SIDEBAND     CARRIER)
 1003 FORMAT (3E12.4)
 1004 FORMAT(33H MEASURED ANTENNA PATTERN MISSING )
      END

CONSTANTS

P       22149690000P0    1      221024540000    2      160517426942

GLOBAL DUMMIES

ARAD    172             AFPP    173             AGPP    174

SUBPROGRAMS

TPFCN,  EXIT     FLOUT,  FLIRT.

SCALARS

PATTRN  175             RAD     176             IX      177             ANG     200
I       202

ARRAYS
```

	ARAD	172		AFPP	173		ASPP	174	
AFPP	6	7	10	11	23				
ASPP	6	7	10	12	23				
ANG	10	13	14	22	23				
ARAU	6	7	13	22					
I	21	22	23						
IX	9	10	11	12	13	14	15	17	20
2Y	20	21							
PATTRN	6								
RAD	8	13	22						
1P	10	16							
2P	15	18							
3P	21	23							
4P	17	26							
5P	24	28							
1000P	10	29							
1001P	18	30							
1002P	19	31							
1003P	23	32							
1004P	26	33							

```
C
C
C THIS SUBROUTINE SIMULATES THE BEHAVIOR OF THE ILS RECEIVER
C SYSTEM.  FOR THE IR'TH RECEIVER POINT IT CALCULATES THE DDI
C THAT WOULD BE OBSERVED WITH THE FIELD LEVELS IN EP,EP
C EPC AND EMC.
C
      SUBROUTINE DETEC (IR,CDI)
      DOUBLE PRECISION GGGG
      REAL N
      COMPLEX  EP(900),EPC(900,2),
     2         EM(900),EMC(900,2)
      DIMENSION VCD(900,2),VPD(900,2),VMD(900,2)
      DIMENSION V(2),GGGG(26)
      COMMON EP,EPC,EM,EMC,VCD,VPD,VMD
      COMMON /VAR/ SM,SNCUT,SNCUD,SNCUC(2),VPC(2),VMC(2)
      DATA NG /5/
      DATA GGGG/ .1000D+1,-.25000000D+00,
     1-.46875000000000D-01,-.19531250000000D-01,-.10681152343750D-01,
     1-.67291259765625D-02,-.46262741088867D-02,-.33752918243408D-02,
     1-.25710582733154D-02,-.20234906673431D-02,-.16339644230902D-02,
     1-.13470112[illegible]D-02,-.11290[illegible]D-02,-.9[illegible]D-03,
     1-.82710[illegible]D-03,-.71969437114[illegible]D-03,-.63[illegible]D-03,
     1-.5[illegible]D-03,-.49[illegible]D-03,-.44[illegible]D-03,
     1-.4030[illegible]D-03,-.36532[illegible]D-03,-.33267[illegible]D-03,
     1-.3042[illegible]D-03,-.27926[illegible]D-03,-.257[illegible]D-03/
      CALL DTC(EP(IR),VP,VPC)
      CALL DTC(EM(IR),VM,VMC)
      BK2 = 4.0*VP*VM/(VP+VM)**2
      UW = VM/VP
      IF( UW .EQ. 0.) GO TO 2
      N = NG
      N1 = N + 1.
      CC = 0.0
      CP = 0.0
      CM = 0.0
    1 IF( N1 .LE. 0 ) GO TO 3
      G = GGGG(N1)
      CC = CC*BK2 + G
      CP = CP*BK2 + G*(1.+N*(UW-1.))
      CM = CM*BK2 + G*(1.+N*(1./UW-1.))
      N1 = N1 - 1
      N=N-1
      GO TO 1
    2 CC= 1.0
      CP = 1.0
      CM = 0.0
    3 DO 4  I = 1,2
      VD2I = CP*CP*VPD(IR,I) + CM*CM*VMD(IR,I) + CC*CC*VCD(IR,I)
      VCI = CP*VPC(I) + CM*VMC(I)
    4 V(I) = SQRT( VCI*VCI  + VD2I )
      CDI = SN*(V(2)-V(1))/(V(2)+V(1))
      RETURN
```

```
94              END

    CONSTANTS

    3       20140000007070

    GLOBAL DUMMIES

    IR      214             CDI     215

    COMMON

    ZP      /.COMM./+0      ZPC     /.COMM./+1750   ZM      /.COMM./+5670   ZMC     /.COMM./+7640   VCD     /.COMM./+13560
    VPD     /.COMM./+15530  VMD     /.COMM./+17500  SM      /VAR   /+0      SNCUT   /VAR   /+1      SNCUD   /VAR   /+2
    SNCUC   /VAR   /+3      VPC     /VAR   /+5      VMC     /VAR   /+7

    SUBPROGRAMS

    DTC     FLOAT   IFIX    SQRT

    SCALARS

    DETEC   217             NG      220             IR      214             VP      221             VM      222
    BS2     223             UN      224             N       225             N1      226             CG      227
    CP      230             CM      231             G       232             I       233             VD2I    234
    VCI     235             CDI     215             SM      0               SNCUT   1               SNCUD   2

    ARRAYS

    ZP      0               ZPC     1750            ZM      5670            ZMC     7640            VCD     13560
    VPD     15530           VMD     17500           V       236             GOOD    240             SNCUC   3
    VPC     5               VMC     7

BS2         29      39      40      41
CC          34      39      45      49
CDI         6       52
CM          36      41      47      49      50
CP          35      40      46      49      50
DETEC       0
DTC         27      20
G           30      39      40      41
GOOD        1       14      18      30
I           40      49      50      51
IR          0       27      20      49
N           10      32      33      40      41      43
N1          33      37      30      42      43
NG          17      32
SM          16      52
SNCVC       16
SNCVD       16
SNCVT       16
SQRT        51
UN          30      31      40      41
V           14      51      52
VAR         16
VCD         13      15      49
VCI         50      51
VD2I        49      51
VM          20      29      30
VMC         16      20      50
VMD         13      15      49
VP          27      29      30
VPC         16      27      50
VPD         13      15      49
ZM          11      15      20
ZMC         11      15
ZP          11      15      27
ZPC         11      15
        1P  37      44
        2P  31      45
        3P  32      40
        4P  40      51
```

```
      C
      C
      C THIS SUBROUTINE SIMULATES THE EFFECTS OF PHASE SHIFT BETWEEN
      C CARRIER AND SIDEBANDS ON DETECTED 90 AND 150 HZ AMPLITUDE.
      C
            SUBROUTINE DTC ( ZN,VN, VNC )
            COMPLEX ZN, ZH
            DIMENSION ZN(900,1),VNC(1)
            VN = CABS(ZN(1,1))
            ZH = 1.0
            IF( VN .GT. 0. ) ZH = CONJG(ZN(1,1))/VN
            DO 1  I = 1,2
          1 VNC(I) = ZH*ZN(1,I+1)
            RETURN
            END

   CONSTANTS

   F        201400000000     1        400000000000

   GLOBAL DUMMIES

   ZN       73           VN       74             VNC      75

   SUBPROGRAMS

   CABS     CONJG    CFP.9    CFM.2

   SCALARS

   DTC      76           VN       74             ZH       77             I       101

   ARRAYS

   ZN       73           VNC      75
CABS        9
CONJG       11
DTC         6
I           12       13
VN          6        9        11
VNC         6        8        13
ZH          7        10       11       13
ZN          6        7        8        9        11       13
   1P       12       13
```

```
C
C THIS SUBROUTINE ADDS THE FIELDS IN ZJP, ZJM, ZJPC, AND ZJMC
C TO THE SUMMATIONS IN ZPC, ZMC, VCD, VPD AND VMD.  THE ARRAYS
C CONTAIN THE COMPLEX SUMS FOR EACH RECEIVER POINT.  THE SYMBOLS
C HAVE THE FOLLOWING USAGE.
C       SYMBOL  USAGE
C       ZP      CARRIER FROM COURSE ANTENNA
C       ZM      CARRIER FROM CLEARANCE
C       ZPC(IR,1)       90 HZ SIDEBAND FROM COURSE
C       ZPC(IR,2)       150 HZ SIDEBAND FROM COURSE
C       ZMC(IR,1)       90 HZ SIDEBAND FROM CLEARANCE
C       ZMC(IR,2)       150 HZ SIDEBAND FROM CLEARANCE
C       VCD(IR,1)       *
C       VCD(IR,2)       *
C       VPD(IR,1)       * THESE ARE INTERNAL VARIABLES USED FOR
C       VPD(IR,2)       * DOPPLER EFFECTS.  THEY HAVE NO DIRECT
C       VMD(IR,1)       * PHYSICAL MEANING.
C       VMD(IR,2)       *
C
C SNCUT IS THE GAIN FACTOR FROM THE DIFFERENCE OF THE SCATTERED
C SIGNAL FROM THE DIRECT SIGNAL FREQUENCY.  THIS FREQUENCY
C SHIFT IS CAUSED BY THE DIFFERENT VELOCITIES OF THE AIRCRAFT
C RELATIVE TO THE ILS ANTENNA AND THE SCATTERERS. SNCUC(1) IS
C THE GAIN OF THE CROSS TALK FROM THE CARRIER THROUGH THE 90 HZ
C FILTER.  SNCUC(2) IS THE CROSS TALK AT 150 HZ.
C SNCUD IS THE CROSS TALK FACTOR BETWEEN THE 90 HZ AND 150 HZ
C SIGNALS FROM THE DOPPLER SHIFT.
C
      SUBROUTINE VARCAL (IR)
      COMPLEX Z
      COMPLEX  ZP(500),ZPC(500,2),
     2         ZM(500),ZMC(500,2)
      DIMENSION VCD(500,2),VPD(500,2),VMD(500,2)
      COMMON    ZP,ZPC,ZM,ZMC,VCD,VPD,VMD
      COMMON /VAR/ SM,SNCUT,SNCUD,SNCUC(2)
      COMPLEX ZJM,ZJP,ZJPC(2),ZJMC(2)
      COMMON /AB/ ZJM,ZJP,ZJPC,ZJMC
      CABZ(Z) = REAL(Z*CONJG(Z))
      ZP(IR) = ZP(IR) + ZJP
      ZM(IR) = ZM(IR) + ZJM
      DO 1 I=1, 2
      ZPC(IR,I) = ZPC(IR,I) + ZJPC(I)*SNCUT
      ZMC(IR,I) = ZMC(IR,I) + ZJMC(I)*SNCUT
      VCD(IR,I) = VCD(IR,I) + (CABZ(ZJP   ) + CABZ(ZJM   ))*SNCUC(I)
      J=3-I
      SNCUD2 = SNCUD*SNCUD
      VPD(IR,J) = VPD(IR,J) + CABZ(ZJPC(I)) *SNCUD2
    1 VMD(IR,J) = VMD(IR,J) + CABZ(ZJMC(I)) *SNCUD2
      RETURN
      END

GLOBAL DUMMIES
```

```
IR      219

COMMON

ZP      /,COMM,/+0         ZPC     /,COMM,/+1790      ZM      /,COMM,/+5670      ZMC     /,COMM,/+7640      VCD     /,COMM,/+13960
VPD     /,COMM,/+15930     VHD     /,COMM,/+17900     SN      /VAR    /+0        SNCUT   /VAR    /+1        SNCUD   /VAR    /+2
SNCUC   /VAR    /+3        ZJM     /AB     /+0        ZJP     /AB     /+2        ZJPC    /AB     /+4        ZJMC    /AB     /+10

SUBPROGRAMS

REAL    CONJG   CFY.0   CFM.2

SCALARS

VARCAL  221                IR      219                ZJP     2                  ZJM     6                  I       222
SNCUT   1                  J       223                SNCUD2  224                SNCUD   2                  SN      0

ARRAYS

ZP      0                  ZPC     1790               ZM      5670               ZMC     7640               VCD     13960
VPD     15930              VHD     17900              SNCUC   3                  ZJPC    4                  ZJMC    10
AB        37
CABZ      30      44      47      40
CONJG     30
I         41      42      43      44      45      47      48
IR        29      39      40      42      43      44      47      40
J         45      47      40
REAL      30
SN        35
SNCUC     35      44
SNCUD     35      46
SNCUD2    46      47      40
SNCUT     35      42      43
VAR       35
VARCAL    29
VCD       33      34      44
VHD       33      34      40
VPD       33      34      47
Z         30      38
ZJM       36      37      40      44
ZJMC      36      37      43      40
ZJP       36      37      39      44
ZJPC      36      37      42      47
ZM        31      34      40
ZMC       31      34      43
ZP        31      34      39
ZPC       31      34      42

   1P     41      40
```

```
C
C
C THIS SUBROUTINE CALCULATES THE ELECTRIC FIELDS FOR THE
C SIDEBANDS AT LOCATION (X1,Y,Z).  ARRAY E IS THE SAME AS
C ARRAY EMP IN THE MAIN PROGRAM.
C
      SUBROUTINE FLC(X1,Y1,Z)
      COMPLEX E,F,FPP,GPP,C(25,2),S(25,2),CJA,CJB
      COMMON/CO/ ARAD(50),AFPP(50),AGPP(50),BRAD(50),BFPP(50),BGPP(50)
      COMMON /SUB/ LC(3),IET,FRQ,MANDA,PI,RADD,PHI,P(2),PSI,TT(2),NEL,
     1 XTH,SLP, XXA(3),YA(3),HA(3),RA(3),TGS,GT,SIG,CO,AK
      COMMON /ANT/ LOC,FPP(2),GPP(2),E(4,4),CHA(2),AS(2),D(25,2),C,S,
     2              ET(20,2),MNO(2),GC(4,3,4)
      COMMON /MG/ TH(3,2),BH(3,2),CJA(30),CJP(30)
      DIMENSION RH(3)
      JA = 1
C
C
C THIS IS THE LOOP ON ANTENNA NUMBER.
C
      DO 11 J=1,NEL
      CALL CLEAR (FPP,4)
C
C
C LOC IS THE TYPE FOR ANTENNA 'J'
C
      LOC = LC(J)
C
C X IS THE DISTANCE FROM THE ANTENNA TO THE POINT.
C
      X = X1 - XXA(J)
      Y = Y1 - YA(J)
      R=SQRT(X**2+Y**2+(Z-HA(J))**2)
      RA(J) = R
      IF ( LOC .GT. 10 ) GO TO 2
      PHI=ATAN2(Y,X)
      PSI = ATAN2(Z-HA(J),X)
      JA=1+150*(J-1)
      IF( LOC .LT. 4) CALL CSP
      IF(LOC .EQ. 5) CALL ANTP(FPP(J),GPP(J),ARAD(JA),AFPP(JA),AGPP(JA))
      IF(LOC .EQ. 7) CALL LNAR(FPP(J),GPP(J),PHI,D(1,J),C(1,J),
     *S(1,J),ET(1,J),MNO(J))
      GO TO 10
    2 CONTINUE
      RH(1) = X/R
      RH(2) = Y/R
      RH(3) = (Z-HA(J))/R
      IF( LOC .GT. 12 ) GO TO 3
      CALL CWG( FPP, GPP, RH, TH(1,J), BH(1,J) )
      GO TO 10
    3 CALL GSA ( GC(1,J,LOC-12),RH,IET )
   10 CON3 = AK*R
C
```

```
      C
      C F IS THE COMPLEX GAIN FACTOR FOR THE TRANSMISSION LOSS FROM THE
      C ANTENNA TO THE POINT.
      C
            F = CEXP(CMPLX(0.,CON3))/R
            DO 11 JC=1,2
            JB=2*JC-1
      C
      C
      C GPP IS THE SIGNAL LEVEL FOR THE SIDEBAND PORTION OF THE CARRIER
      C PLUS SIDEBAND.
      C
            GPP(JC)= GPP(JC)*AS(JC)
      C
      C
      C FPP IS THE COMPLEX PHASOR FOR THE SIDEBAND ONLY.
      C
            FPP(JC)=FPP(JC)*CHA(JC)*AS(JC)
            E(J,JB)=GPP(JC)*F
         11 E(J,JB+1)= FPP(JC)*F
            RETURN
            END

CONSTANTS

9       0000/000004   1        000000000000

GLOBAL DUMMIES

X1      354           Y1       355              Z       356

COMMON

ARAD    /CD    /+0      AFPP   /CD    /+62    AGPP   /CD    /+144    BRAD   /CD    /+226   BFPP   /CD    /+310
BGPP    /CD    /+372    LC     /SUB   /+0     IET    /SUB   /+3      FRQ    /SUB   /+4     WAMDA  /SUB   /+5
PI      /SUB   /+6      RADD   /SUB   /+7     PHI    /SUB   /+10     P      /SUB   /+11    PSI    /SUB   /+13
TT      /SUB   /+14     NEL    /SUB   /+16    XTN    /SUB   /+17     SLP    /SUB   /+20    XXA    /SUB   /+21
VA      /SUB   /+24     HA     /SUB   /+27    QA     /SUB   /+32     TGS    /SUB   /+35    BT     /SUB   /+36
SIG     /SUB   /+37     DD     /SUB   /+40    AK     /SUB   /+41     LOC    /ANT   /+0     FPP    /ANT   /+1
GPP     /ANT   /+5      E      /ANT   /+11    CHA    /ANT   /+51     AS     /ANT   /+53    D      /ANT   /+55
C       /ANT   /+137    S      /ANT   /+303   ET     /ANT   /+447    ND     /ANT   /+517   GC     /ANT   /+561
TM      /NG    /+0      BM     /NG    /+0     CJA    /NG    /+14     CJB    /NG    /+110

SUBPROGRAMS

CLEAR   SQRT   ATAN2   CSP   ANTP   LNAR   GNG   GSA   CEXP   CMPLX   CFD.0   CFMM.2   CFM.2

SCALARS

FLC     361           JA       362              J       363           NEL     16            LOC     0
X       364           X1       354              Y       365           Y1      355           R       366
Z       356           PHI      10               PSI     13            IET     3             CON3    367
AK      41            F        370              JC      372           JB      373           FRQ     4
```

WANDA	5	PI	6	RADD	7	XTH	17	SLP	20
TGS	35	BT	36	SIG	37	DB	40		

ARRAYS

C	137	S	383	ARAD	8	AFPP	62	AGPP	144
BRAD	226	BFPP	310	BGPP	372	LC	8	P	11
TT	14	XXA	21	VA	24	HA	27	RA	32
FPP	1	GPP	5	F	11	CNA	51	AS	53
?	59	ET	447	ND	517	GC	521	TN	8
BN	6	CJA	14	CJB	110	RN	374		

AFPP	9	40												
AGPP	9	40												
AK	10	52												
ANT	12													
ANTP	48													
ARAD	9	40												
AS	12	66	71											
ATAN2	36	37												
BFPP	8													
BGPP	9													
BN	14	49												
BRAD	9													
BT	10													
C	8	12	41											
CD	9													
CEXP	50													
CJA	8	14												
CJB	8	14												
CLEAR	22													
CMPLX	50													
CONJ	52	58												
CSP	39													
CNA	12	71												
D	12	41												
DB	10													
E	8	12	72	73										
ET	12	41												
F	8	56	72	73										
FLC	7													
FPP	8	12	22	40	41	49	71	73						
FRO	10													
GC	12	51												
GPP	8	12	40	41	42	66	72							
GSA	51													
GNG	49													
HA	10	33	37	47										
IET	10	51												
J	21	27	31	32	33	34	37	38	40	41	47	49	51	72
	73													
JA	16	38	40											
JB	60	72	73											
JC	59	68	66	71	72	73								
LC	10	27												
LNAM	41													
LOC	12	27	35	39	40	41	48	51						
ND	12	41												
NEL	10	21												
P	10													
PHI	10	36	41											
PI	10													
PSI	10	37												
R	33	34	45	46	47	52	58							
RA	10	34												
RADD	10													
RN	15	45	46	47	49	51								
S	8	12	41											
SIG	10													
SLP	10													
SQRT	33													
SUB	10													
TGS	10													
TN	14	49												
TT	10													
WANDA	10													
WG	14													
X	31	33	36	37	45									
X1	7	31												
XTH	10													
XXA	10	31												
Y	32	33	36	46										
Y1	7	32												
YA	10	32												
Z	7	33	37	47										
2P	35	44												
3P	40	51												
12P	43	50	52											
11P	21	59	73											

```
C
C  THIS IS THE WAVEGUIDE FAR FIELD ANGULAR PATTERN ROUTINE.
C  UNIT VECTORS ARE USED TO DENOTE THE SIGNIFICANT DIRECTIONS :
C      R  :  DIRECTION OF OBSERVATION
C      B  :  BROADSIDE DIRECTION
C      T  :  TANGENT  DIRECTION
      SUBROUTINE GWG( FPP, GPP, R, T, B )
      COMPLEX FPP,GPP, C(50),S(50), FP,GP, E
      COMMON /ANT/ LOC,FP(2),GP(2),E(4,4),CHA(2),AS(2),D(50),C,S,
     2             ET(20,2),NDO(2),GC(4,3,4)
      DIMENSION R(3), B(3), T(3)
      ND = 20
      SIPH = SP( R,T )
      EPP = SP( R,B )
      IF ( T(3) .LT. 0.0 ) EPP = -EPP
      FPP = (0.0,0.0)
      GPP=(0.0,0.0)
      DO 1 J=1,ND
      GPP = GPP + C(J)*CEXP(CMPLX(0.,-D(J)*SIPH))
    1 FPP = FPP + S(J)*CEXP(CMPLX(0.,-D(J)*SIPH))
      GPP = EPP*GPP
      FPP = EPP*FPP
      RETURN
      END
```

CONSTANTS

```
0       000000002000     1       P000P0000000
```

GLOBAL DUMMIES

FPP	151	GPP	153	R	155	T	156	B	157

COMMON

LOC	/ANT	/+0	FP	/ANT	/+1	GP	/ANT	/+5	E	/ANT	/+11	CHA	/ANT	/+91
AS	/ANT	/+93	D	/ANT	/+55	C	/ANT	/+137	S	/ANT	/+303	ET	/ANT	/+447
NDO	/ANT	/+517	GC	/ANT	/+521									

SUBPROGRAMS

```
SP      CEXP     CMPLX     CFM.2     CFMM.2
```

SCALARS

GWG	163	ND	164	SIPH	165	EPP	166	FPP	151
GPP	153	J	167	LOC	0				

ARRAYS

C	137	S	303	FP	1	GP	5	E	11
CHA	91	AS	93	D	55	ET	447	NDO	517
GC	521	R	155	B	157	T	156		

ANT	9				
AS	9				
B	7	11	14		
C	8	9	19		
CEXP	19	20			
CMPLX	19	20			
CMA	9				
D	9	19	20		
E	8	9			
EPP	14	15	21	22	
ET	9				
FP	8	9			
FPP	7	8	16	20	22
GC	9				
GP	8	9			
GPP	7	8	17	19	21
GWG	7				
J	18	19	20		
LOC	9				
ND	12	18			
NOD	9				
R	7	11	13	14	
S	8	9	20		
SIPH	13	19	20		
SP	13	14			
T	7	11	13	15	
1P	18	20			

```
C
C  THIS SUBROUTINE CALCULATES THE FAR FIELD AMPLITUDES EMANATING FROM
C  INDIVIDUAL GLIDE SLOPE ELEMENTS.THE RELATIVE AMPLITUDES FOR THE VAR.
C  IOUS SIDEBAND COMPONENTS ARE TRANSMITTED TO THE SUBROUTINE BY THE
C  ARRAY G, THE ELEMENT PATTERN IS SELECTED BY THE INDEX IE
C
      SUBROUTINE GSA ( G, R, IE )
      COMPLEX FPP,GPP, C(50),S(50), GP, E
      COMMON /ANT/ LOC,GP(4),E(4,4),CHA(2),AS(2),D(50),C,S,
     2              ET(20,2),ND(2),GC(4,3,4)
      DIMENSION G(4), R(3)
      IF ( IE .EQ. 0 ) F = SQRT( 1. - R(2)**2 )
      IF(IE .EQ. 1 ) F=(SINC(4.*ATAN2(R(2),SQRT(R(1)**2+R(3)**2))))**1.5
      DO 1 I = 1,4
    1 GP(I) = F*G(I)
C     GP(1) = CHA(1)*GP(1)
      RETURN
      END
```

```
GLOBAL DUMMIES

G     76            R     77            IE    100

COMMON

LOC   /ANT   /+0    GP    /ANT   /+1    E     /ANT   /+11   CHA   /ANT   /+91   AS    /ANT   /+93
D     /ANT   /+95   C     /ANT   /+137  S     /ANT   /+303  ET    /ANT   /+447  ND    /ANT   /+517
GC    /ANT   /+521

SUBPROGRAMS

SQRT  SINC   ATAN2  EXP3.0

SCALARS

GSA   104           IE    100           F     105           I     106           LOC   0

ARRAYS

C     137           S     303           GP    1             E     11            CHA   91
AS    93            D     95            ET    447           ND    517           GC    521
G     76            R     77

ANT      9
AS       9
ATAN2   13
C        8    9
CHA      9
D        9
E        8    9
ET       9
F       12   13   15
FPP      8
G        7   11   15
GC       9
GP       8    9   15
GPP      8
GSA      7
I       14   15
IE       7   12   13
LOC      9
ND       9
R        7   11   12   13
S        8    9
SINC    13
SQRT    12   13
   1P   14   15
```

```
C
C THIS SUBROUTINE GIVES FPP AND GPP AT ANGLE PHI BY SUMMING THE SIGNALS
C FROM THE ND ELEMENTS IN THE ARRAY.  THE PATTERN FOR THE
C ELEMENTS IS IN ET.  THE RELATIVE CARRIER PLUS SIDEBANDS AND
C SIDEBAND ONLY SIGNALS FED TO THE ELEMENTS ARE IN C AND S.
C
      SUBROUTINE LNAR (FPP,GPP,PHI,D,C,S,ET,ND)
      COMPLEX  FPP,GPP,C,S
       DIMENSION D(1),C(1),S(1),ET(1)
      SIPH=SIN(PHI)
      TEMP=ABS(PHI)/.1745329
      I=TEMP+1.
      A=I-1
      R=TEMP-A
      EPP=R*(ET(I+1)-ET(I))+ET(I)
      FPP=(0.,0.,0.,0)
      GPP=(0.,0.,0.,0)
      DO 1 J=1,ND
      GPP = GPP + C(J)*CEXP(CMPLX(0.,-D(J)*SIPH))
    1 FPP = FPP + S(J)*CEXP(CMPLX(0.,-D(J)*SIPH))
      GPP = EPP*GPP
      FPP = EPP*FPP
      RETURN
      END

CONSTANTS

 0     17694534300S   1      00000900000   2      0000F900000

GLOBAL DUMMIES

 FPP   173            GPP    175           PHI    177           D      200          C      201
 S     202            ET     203           ND     204

SUBPROGRAMS

 SIN   ABS    IFIX    FLOAT  CEXP   CMPLX  CFM,7  CFMM,2

SCALARS

 LNAR  210            SIPH   211           PHI    177           TEMP   212          I      213
 A     214            R      215           EPP    216           FPP    173          GPP    175
 J     217            ND     204

ARRAYS

 D     200            C      201           S      202           ET     203

A          14    15
ABS        12
C           8     9    10    20
CEXP       20    21
CMPLX      20    21
D           8    19    20    21
EPP        16    22    23
ET          8    10    16
FPP         8     9    17    21    23
GPP         8     9    18    20    22
I          13    14    16
J          19    20    21
LNAR        8
ND          8    19
PHI         8    11    12
R          15    16
S           8     9    10    21
SIN        11
SIPH       11    20    21
TEMP       12    13    15
    1P     19    21
```

```
C
C
C THIS ANTENNA SUBROUTINE GIVES FPP AND GPP FOR ANGLE PHI BY
C INTERPOLATION IN TABLES ANT AND ACP.  ANGLE PHI IS IN
C RADIANS.  THE SUBROUTINE WILL INTERPOLATE BETWEEN VALUES
C BRACKETTING TPHI.  IF PHI IS OUTSIDE THE RANGE OF THE TABLE
C THEN EXTRAPOLATION FROM THE LAST TWO VALUES WILL BE USED.
C
      SUBROUTINE ANTP (FPP,GPP,ANG,ANT,ACP)
      DIMENSION ANG(90), ANT(90), ACP(90)
      COMMON /SUB/ LC(4),FRQ,WANDA,PI,RADD,PHI,P(2),PSI,T(2),NAR,XTH,
     1 XXA(3),YA,MA(3),RA(3)
      DO 1 I=2,90
      K=I
      IF(ANG(I) .GE. 6.3) GO TO 5
      IF(ANG(I)-PHI) 1,3,2
    1 CONTINUE
    2 FPP=ANT(K-1)+(ANT(K)-ANT(K-1))*(PHI -ANG(K-1))/(ANG(K)-ANG(K-1))
      GPP=ACP(K-1)+(ACP(K)-ACP(K-1))*(PHI -ANG(K-1))/(ANG(K)-ANG(K-1))
      GO TO 4
    3 FPP=ANT(K)
      GPP=ACP(K)
    4 RETURN
    5 K=K-1
      GO TO 2
      END

 CONSTANTS

 P        203623146314

 GLOBAL DUMMIES

 FPP    116        GPP    117        ANG    120        ANT    121        ACP    122

 COMMON

 LC     /SUB  /+0   FRQ   /SUB  /+4   WANDA  /SUB  /+5   PI     /SUB  /+6   RADD   /SUB  /+7
 PHI    /SUB  /+10  P     /SUB  /+11  PSI    /SUB  /+13  T      /SUB  /+14  NAR    /SUB  /+16
 XTH    /SUB  /+17  XXA   /SUB  /+20  YA     /SUB  /+23  MA     /SUB  /+24  RA     /SUB  /+27

 SCALARS

 ANTP   123        I      124        K      125        PHI    10         FPP    116
 GPP    117        FRQ    4          WANDA  5          PI     6          RADD   7
 PSI    13         NAR    16         XTH    17         YA     23

 ARRAYS

 ANG    120        ANT    121        ACP    122        LC     0          P      11
 T      14         XXA    20         MA     24         RA     27

ACP        9    10    19    22
ANG        9    10    15    16    18    19
ANT        9    10    18    21
ANTP       9
FPP        9    18    21
FRQ       11
GPP        9    19    22
MA        11
I         13    14    15    16
K         14    18    19    21    22    24                1P    13    16    17
LC        11                                              2P    16    18    25
NAR       11                                              3P    16    21
P         11                                              4P    20    23
PHI       11    16    18    19                            5P    15    24
PI        11
PSI       11
RA        11
RADD      11
SUB       11
T         11
WANDA     11
XTH       11
XXA       11
YA        11
```

```
C
C
C THIS ANTENNA SUBROUTINE WILL EVALUATE FPP AND GPP FOR THE
C STANDARD ANTENNAE.  THE VALUE OF LOC WILL DETERMINE THE TYPE
C OF ANTENNA USED.  THE SIGNALS WILL BE CALCULATED AT ANGLE PHI.
C
      SUBROUTINE CBP
      REAL LAMDA
      COMMON /SUB/ LC(4),FRQ,LAMDA,PI,RADO,PHI,P(2),PSI,T(2),NAR,XTH
      COMMON /ANT/ LOC,FPP,XF,FPM,YF,GPP,XG,GPM,YG,E(4,4)
      DIMENSION C(10),S(10),D(10),ET(20)
      SIP=SIN(PHI)
      GO TO (1,4,6),LOC
C
C
C THIS IS THE V-RING ANTENNA
C
    1 CR=2.221
      C(1)=1.000
      C(2)=0.946
      C(3)=0.385
      C(4)=0.279
      C(5)=0.214
      C(6)=0.175
      C(7)=0.140
      D(1)=180.9
      D(2)=497.4
      D(3)=784.0
      D(4)=1120.
      D(5)=1440.
      D(6)=1760.
      D(7)=2080.
      DO 2 J=1,7
    2 D(J)=D(J)*RADO
      ET(1)=1.00
      ET(2)=0.99
      ET(3)=0.97
      ET(4)=0.92
      ET(5)=0.84
      ET(6)=0.73
      ET(7)=0.62
      ET(8)=0.48
      ET(9)=0.33
      ET(10)=0.22
      ET(11)=0.15
      ET(12)=0.13
      ET(13)=0.18
      ET(14)=0.23
      ET(15)=0.30
      ET(16)=0.34
      ET(17)=0.38
      ET(18)=0.39
      ET(19)=0.40
```

```
      TEMP=ABS(PHI)/.1745329
      I=TEMP+1.
      A=I-1
      B=TEMP-A
      EPP=B*(ET(I+1)-ET(I))+ET(I)
      FPP=0.0
      EPP=C0*EPP
      DO 3 J=1,7
      CSPH=COS(D(J)*SIPH)
      SNPH=SIN(D(J)*SIPH)
      EPP = EPP + 2.*EPP*C(J)*CSPH
    3 FPP = FPP + 2.*EPP*C(J)*SNPH
      GO TO 8
C
C
C THIS IS THE O-LOOP ANTENNA
C
    4 C(1)=1.20
      C(2)=1.00
      C(3)=0.20
      C(4)=0.30
      D(1)=99.0
      D(2)=190.0
      D(3)=[illegible]
      D(4)=[illegible]
      FPP=0.
      CSPH=2.*COS(RADD*D(1)*SIPH)
      EPP=C(1)*CSPH
      DO 5 J=2,4
      SNPH=2.*SIN(RADD*D(J)*SIPH)
    5 FPP=FPP+C(J)*SNPH
      GO TO 8
C
C
C
C THIS IS THE WAVEGUIDE ANTENNA
C
    6 C(1)=[illegible]
      C(2)=[illegible]
      C(3)=[illegible]
      C(4)=[illegible]
      C(5)=[illegible]
      C(6)=[illegible]
      C(7)=[illegible]
      C(8)=[illegible]
      C(9)=-0.16
      D(1)=0.179
      D(2)=[illegible]
      D(3)=0.776
      D(4)=[illegible]
      D(5)=1.000
      D(6)=[illegible]
      D(7)=[illegible]
```

```
      D(0)=0.770
      D(9)=0.963
      D(1)=117.
      D(2)=298.
      D(3)=947.
      D(4)=822.
      D(5)=1000.
      D(6)=1299.
      D(7)=1520.
      D(8)=1709.
      D(9)=2000.
      FPP=0.0
      GPP=0.0
      DO 7 J=1,9
      ZPP=2.*COS(RADO*D(J)*SIPH)
      SNP=2.*SIN(RADO*D(J)*SIPH)
      GPP=GPP+C(J)*CSPH
    7 FPP=FPP+S(J)*SNPH
    8 RETURN
      END
```

CONSTANTS

0	[illegible]	1	[illegible]	2	[illegible]	3	[illegible]	4	[illegible]
5	[illegible]	6	[illegible]	7	[illegible]	10	[illegible]	11	[illegible]
12	[illegible]	13	[illegible]	14	[illegible]	15	[illegible]	16	[illegible]
17	[illegible]	20	[illegible]	21	[illegible]	22	[illegible]	23	[illegible]
24	[illegible]	25	[illegible]	26	[illegible]	27	[illegible]	30	[illegible]
31	[illegible]	32	[illegible]	33	[illegible]	34	[illegible]	35	[illegible]
36	[illegible]	37	[illegible]	40	[illegible]	41	[illegible]	42	[illegible]
43	[illegible]	44	[illegible]	45	[illegible]	46	[illegible]	47	[illegible]
50	[illegible]	51	[illegible]	52	[illegible]	53	[illegible]	54	[illegible]
55	[illegible]	56	[illegible]	57	[illegible]	60	[illegible]	61	[illegible]

COMMON

LC	/SUB	/+0	FRQ	/SUB	/+4	LAMDA	/SUB	/+5	PI	/SUB	/+6	RADO	/SUB	/+7
PHI	/SUB	/+10	P	/SUB	/+11	PSI	/SUB	/+13	T	/SUB	/+14	NAR	/SUB	/+16
XTH	/SUB	/+17	LOC	/ANT	/+0	FPP	/ANT	/+1	XF	/ANT	/+2	FPH	/ANT	/+3
YF	/ANT	/+4	GPP	/ANT	/+5	XG	/ANT	/+6	GPH	/ANT	/+7	YG	/ANT	/+10
E	/ANT	/+11												

SUBPROGRAMS

SIN ABS IFIX FLOAT COS

SCALARS

CSP	906	SIPH	907	PHI	10	LOC	0	CO	910
J	911	RADO	7	TEMP	912	I	913	A	914
N	915	EPP	916	FPP	1	GPP	5	CSPH	917
SNPH	920	FRQ	4	LAMDA	9	PI	6	PSI	13
NAR	16	XTH	17	XF	2	FPH	3	YF	4

```
       XG     6          GPN    7          YG     10

       ARRAYS

       LC     J          P      11         T      14         E      11         C      981
       S      933        D      949        ET     997

A             56     57
ABS           94
ANT           10
C             11     19     20     21     22     23     24     25     64     65     71     72     73     74
              81     86     91     92     93     94     95     96     97     98     99     123
CO            10     60
COS           62     80     121
CSP           7
CSPH          62     64     80     81     121    123
D             11     26     27     28     29     30     31     32     34     62     63     75     76     77
              78     80     83     109    110    111    112    113    114    115    116    117    121    122
E             10
EPP           30     60     64     65
ET            11     35     36     37     38     39     40     41     42     43     44     45     46     47
              48     48     80     81     82     83     84
FPH           10
FPP           10     30     65     70     84     110    124
FRQ           9
GPH           10
GPP           10     60     64     81     119    123
I             33     34     38
J             33     34     61     62     63     64     65     82     83     84     120    121    122    123
              124
LANDA         8
LC            9
LOC           10     13
MAR           9
P             9
PHI           9      12     94
PI            9
PSI           9
R             57     58
RADD          9      34     80     83     121    122
S             11     100    101    102    103    104    105    106    107    108    124
SIN           12     63     83     122
SIPH          12     62     63     80     83     121    122
SNPH          63     65     93     94     122    124
SUP           9
T             9
TEMP          94     95     97
WANDA         9
XF            10
XG            10
XYN           9
YF            10
YG            10
       1P     13     18
       2P     33     34
       3P     61     65
       4P     13     71
       5P     82     84
       6P     13     91
       7P     120    124
       8P     66     85     125
```

```
C
C
C THIS FUNCTION EVALUATES THE WEIGHTED SUM OF A SERIES OF
C BESSEL FUNCTIONS.  IT IS USED TO CALCULATE THE SCATTERING
C FROM A CYLINDER.
C
      COMPLEX FUNCTION BESF(AKA,XCB,XSB)
      COMPLEX SUM
      DATA PI,EE/3.14159265,2.71828183/
      CB=XCB
      SUM=(-2.,0.,0.)
      IF(CB .LT. -.99996) GO TO 6
      SB=ABS(XSB)
      CB2=SQRT((1.+CB)/2.)
      V=2.*AKA*CB2
      VI=2./V
      SER=0.
      FN=IFIX(9.+.67*V)*2+10
      OJ=1./FN
      EJ=((1.-1./FN)**(FN-.5))*EE*V*.5*OJ*OJ
      FN=FN-1.
      DO 3 KK=1,5
      EJ=-EJ+FN*VI*OJ
      FN=FN-1.
      OJ=-OJ+FN*VI*EJ
      FN=FN-1.
3     CONTINUE
      B=ATAN2(SB,CB)
      S1=SIN((FN+2.)*B/2.)
      C1=COS((FN+2.)*B/2.)
      S2=S1*CB-C1*SB
      C2=C1*CB+S1*SB
    4 YI=FN
      ZI=FN+2.
      SER=SER+EJ*(C2/YI-C1/ZI)
      IF(FN .LT. 2.) GO TO 5
      C1=C2
      S1=S2
      TEMP=C2*CB+S2*SB
      S2=S2*CB-C2*SB
      C2=TEMP
      EJ=-EJ+FN*VI*OJ
      FN=FN-1.
      OJ=-OJ+FN*VI*EJ
      FN=FN-1.
      AM=2./(ABS(EJ)+ABS(OJ))
      EJ=EJ*AM
      OJ=OJ*AM
      SER=SER*AM
      GO TO 4
    5 AJ=-EJ+FN*VI*OJ
      ZZJ=AJ
      XXJ=OJ
```

```
      IF(ABS(AJ) .GE. ABS(DJ)) GO TO 7
      IF(V .LT. 3.) GO TO 9
      XI=3./V
      F0=.79788456+XI*(.00000156+XI*(.01659667+XI*(
     1.00017105-XI*(.00249511-XI*(.00113653-XI*.00020033)))))
      PHI=V-2.35619449+XI*(.12499612+XI*(.0000565-XI*
     1(.00637879-XI*(.00074348+XI*(.00079824-XI*.00029166)))))
      BJ=F0*COS(PHI)/SQRT(V)
      GO TO 10
    9 XI=V*V/9.
      BJ=V*(.5-XI*(.56249985-XI*(.21093573-XI*
     1(.03954289-XI*(.00443319-XI*(.00031761-XI*.00001109))))))
   10 SCAL=BJ/DJ
      DJ=BJ
      BJ=AJ*SCAL
      GO TO 8
    7 XI=3./V
      IF(V .LT. 3.) GO TO 1
      PHI=V-.78539816-XI*(.04166397+XI*(.00003954-XI*(
     ..00262573-XI*(.00054125+XI*(.00029333-XI*.00013558)))))
      F0=.79788456-XI*(.00000077+XI*(.00552740+XI*(
     ..00009512-XI*(.00137237-XI*(.00072805-XI*.00014476)))))
      BJ=F0*COS(PHI)/SQRT(V)
      GO TO 2
    1 XI=V*V/9.
      BJ=1.-XI*(2.2499997-XI*(1.2656208-XI*(.3163866-XI*(
     ..0444479-XI*(.0039444-XI*(.00021))))))
    2 SCAL=BJ/AJ
      DJ=DJ*SCAL
    8 RI=-BB*SIN(AKA*SB)/(AKA*(1.+CB))+2.*CB2*CB2*BJ
      SER=SER*SCAL
      RI=RI-2.*CB2*SER
      CI=-PI*CB2*DJ
      SUM=CMPLX(RI,CI)
    6 CONTINUE
      BESF=SUM
      RETURN
      END
```

CONSTANTS

0	579400000000	1	200000000000	2	200777763407	3	200527024365	4	200400000000
5	201400000000	6	178496447137	7	167451736362	10	170307023770	11	164546557423
12	173417726752	13	155642604610	14	200620418514	15	202455457437	16	165461647612
17	166642403726	20	166605630311	21	171642024531	22	162731751515	23	175777767671
24	204440000000	25	163721113737	26	165515823444	27	171442421130	30	174563736715
31	176657776111	32	200437777753	33	200622677324	34	164434251725	35	165463450260
36	166433612541	37	170530121603	40	162513937003	41	174925237264	42	164457492073
43	166575552356	44	167547604304	45	163616754512	46	171552174610	47	154635307772
50	164470319420	51	171472400064	52	174554074002	53	177503765945	54	201503777346
55	202437777745								

GLOBAL DUMMIES

```
AKA      665            XCB     666            XSB     667

SUBPROGRAMS

ABS      SQRT    IFIX   FLOAT   EXP3.4  ATAN2  SIN     COS     CMPLX

SCALARS

BESF     672            PI      674            EE      675            CB      676            XCB     666
SUM      677            SB      701            XSB     667            CB2     702            V       703
AKA      665            VI      704            SER     705            FN      706            OJ      707
EJ       710            KK      711            R       712            S1      713            C1      714
S2       715            C2      716            YI      717            ZI      720            TEMP    721
AM       722            AJ      723            ZZJ     724            XXJ     725            XI      726
FO       727            PHI     730            BJ      731            SCAL    732            RI      733
CI       734

ABS      13      46     54
AJ       51      52     54      60      81
AKA       7      15     83
AM       46      47     48      49
ATAN2    20
B        28      29     30
BESF      7      09
BJ       61      64     66      67      60     76      79      81      83
C1       30      31     32      35      37
C2       32      35     37      39      40     41
CB       10      12     14      20      31     32      39      40      83
CB2      14      15     43      85      86
CI       86      87
CMPLX    87
COS      38      61     76
EE        9      20
EJ       20      23     25      35      42     44      46      47      51
FN       18      19     20      21      23     24      25      26      29      30      33      34      36      42
         43      44     45      51
FO       57      61     74      76
IFIX     18
KK       22
OJ       19      20     23      25      42     44      46      48      51      53      54      66      67      82
         86
PHI      50      61     72      76
PI        9      86
RI       83      89     97
S1       29      31     32      38
S2       31      30     39      40
SB       13      20     31      32      39     40      83
SCAL     66      68     51      82      84
SER      17      35     49      84      95
SIN      29      83
SQRT     14      61     76
SUM       8      11     87      89
TEMP     39      41
V        15      16     18      20      55     56      59      61      63      64      70      71      72      76
         70
VI       16      23     25      42      44     51
XCB       7      18
XI       56      57     59      63      64     70      72      74      78      79
XSB       7      13
XXJ      53
YI       33      35
ZI       34      35
ZZJ      52

    1P   71      78
    2P   77      81
    3P   22      27
    4P   33      50
    5P   36      51
    6P   12      88
    7P   54      78
    8P   69      83
    9P   55      63
   10P   42      66
```

```
C
C
C
C THIS IS THE SINC FUNCTION.  IT IS DEFINED AS THE SINE OF
C X DIVIDED BY X.  SINC OF ZERO IS TAKEN TO BE ONE.
C
      FUNCTION SINC(X)
      XX=ABS(X)
      IF(XX .LT. .0001220703) XX=.0001
      SINC=SIN(XX)/XX
      RETURN
      END

   CONSTANTS

   0      163777777702    1      163643334272

   GLOBAL DUMMIES

   X      41

   SUBPROGRAMS

   ABS    SIN

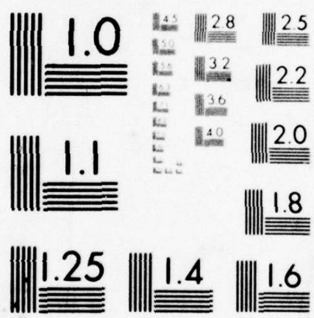
   SCALARS

   SINC   42          XX     43          X      41
ABS          8
SIN         10
SINC         7     12
X            7      8
XX           8      9     10
```

AD-A035 690 TRANSPORTATION SYSTEMS CENTER CAMBRIDGE MASS F/G 1/2
USERS'S MANUAL FOR ILSS (REVISED ILSLOC): SIMULATION FOR DEROGA--ETC(U)
DEC 76 G CHIN, L JORDAN, C KAHN, S MORIN
UNCLASSIFIED TSC-FAA-76-7 FAA-RD-76-217 NL

2 OF 2
AD A035690

END
DATE FILMED
3-77



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

```
      BLOCK DATA
      COMPLEX ZJM,ZJP,ZJPC(2),ZJMC(2)
      COMMON /AB/ ZJM,ZJP,ZJPC,ZJMC
      COMMON /SUB/DUMMY(6),PI,RADD
      COMMON /ANT/DUM(43),AS(2),DUMXX(297),GC(4,3,4)
      COMPLEX CJA(30),CJB(30)
      COMMON /WG/WGDUM(12),CJA,CJB
       DATA CJA( 2),CJB( 2)/( 0.994396E-01,-0.444292E+00),
     1( 0.732930E-01, 0.327656E+00)/
       DATA CJA( 3),CJB( 3)/( 0.193992E+00,-0.492091E+00),
     1( 0.114439E+00, 0.330059E+00)/
       DATA CJA( 4),CJB( 4)/( 0.221030E+00,-0.474087E+00),
     1( 0.165794E+00, 0.359604E+00)/
       DATA CJA( 5),CJB( 5)/( 0.384208E+00,-0.582507E+00),
     1( 0.230768E+00, 0.381230E+00)/
       DATA CJA( 6),CJB( 6)/( 0.450800E+00,-0.520400E+00),
     1( 0.310674E+00, 0.406607E+00)/
       DATA CJA( 7),CJB( 7)/( 0.515791E+00,-0.542297E+00),
     1( 0.404931E+00, 0.425217E+00)/
       DATA CJA( 8),CJB( 8)/( 0.634920E+00,-0.536363E+00),
     1( 0.510200E+00, 0.430537E+00)/
       DATA CJA( 9),CJB( 9)/( 0.740220E+00,-0.505310E+00),
     1( 0.618978E+00, 0.417856E+00)/
       DATA CJA(10),CJB(10)/( 0.850034E+00,-0.448100E+00),
     1( 0.720660E+00, 0.383074E+00)/
       DATA CJA(11),CJB(11)/( 0.924600E+00,-0.367463E+00),
     1( 0.824869E+00, 0.327759E+00)/
       DATA CJA(12),CJB(12)/( 0.972000E+00,-0.269300E+00),
     1( 0.907839E+00, 0.251112E+00)/
       DATA CJA(13),CJB(13)/( 0.986503E+00,-0.161624E+00),
     1( 0.963434E+00, 0.157079E+00)/
       DATA CJA(14),CJB(14)/( 0.973917E+00,-0.526250E-01),
     1( 0.996403E+00, 0.530674E-01)/
       DATA CJA(15),CJB(15)/( 0.931749E+00, 0.502681E-01),
     1( 0.990247E+00,-0.530717E-01)/
       DATA CJA(16),CJB(16)/( 0.863803E+00, 0.141137E+00),
     1( 0.966121E+00,-0.157001E+00)/
       DATA CJA(17),CJB(17)/( 0.781282E+00, 0.215828E+00),
     1( 0.900347E+00,-0.251213E+00)/
       DATA CJA(18),CJB(18)/( 0.684827E+00, 0.272418E+00),
     1( 0.824159E+00,-0.327751E+00)/
       DATA CJA(19),CJB(19)/( 0.584010E+00, 0.310151E+00),
     1( 0.723922E+00,-0.383734E+00)/
       DATA CJA(20),CJB(20)/( 0.487007E+00, 0.320516E+00),
     1( 0.618665E+00,-0.417957E+00)/
       DATA CJA(21),CJB(21)/( 0.383764E+00, 0.333237E+00),
     1( 0.500884E+00,-0.430658E+00)/
       DATA CJA(22),CJB(22)/( 0.300467E+00, 0.324260E+00),
     1( 0.404480E+00,-0.425227E+00)/
       DATA CJA(23),CJB(23)/( 0.234293E+00, 0.306669E+00),
     1( 0.319694E+00,-0.406606E+00)/
       DATA CJA(24),CJB(24)/( 0.172500E+00, 0.285123E+00),
     1( 0.737762E+00,-0.381212E+00)/
```

```
      DATA CJA(25),CJB(25)/( 0.123197E+00, 0.204296E+00),
     1( 0.165703E+00,-0.399902E+00)/
      DATA CJA(26),CJB(26)/( 0.046109E-01, 0.248495E+00),
     1( 0.114433E+00,-0.336041E+00)/
      DATA CJA(27),CJB(27)/( 0.939731E-01, 0.241264E+00),
     1( 0.733419E-01,-0.327697E+00)/
      DATA AS/1.0,1.2/
      DATA ZJM,ZJP,ZJPC,ZJMC /8*(0.,0.)/
      DATA PI,RADD/3.14159265,.017453292/
      DATA GC/2.,0.,.4,0.,.12,0.,0.,0.,0.,0.,0.,0.,
     1-.12,0.,.4,0.,.12,0.,0.,0.,0.,0.,0.,0.,
     2-.86,.886,.4,.886,.12,0.,-.2,0.,-.86,.886,0.,.886,
     30.,0.,0.,0.,0.,0.,0.,0.,0.,0.,0.,0./
      END

COMMON

ZJM    /AB   /+0     ZJP    /AB   /+2    ZJPC   /AB   /+4    ZJMC  /AB   /+10    DUMMY  /SUB  /+0
PI     /SUB  /+6     RADD   /SUB  /+7    DUM    /ANT  /+8    AS    /ANT  /+93    DUMXX  /ANT  /+95
GC     /ANT  /+521   WGDUM  /WG   /+8    CJA    /WG   /+14   CJB   /WG   /+110

SUBPROGRAMS

.JBFF

SCALARS

ZJM     0            ZJP     2            PI      6            RADD    7

ARRAYS

ZJPC    4            ZJMC    10           DUMMY   0            DUM     8            AS      93
DUMXX   95           GC      521          CJA     14           CJB     110          WGDUM   0

AB        3
ANT       5
AS        2    60
CJA       6     7     8    10    12    14    16    18    20    22    24    26    28    30
         32    34    36    38    40    42    44    46    48    50    52    54    56    58
CJB       6     7     8    10    12    14    16    18    20    22    24    26    28    30
         32    34    36    38    40    42    44    46    48    50    52    54    56    58
DUM       5
DUMMY     4
DUMXX     5
GC        5    63
PI        4    62
RADD      4    62
SUB       4
WG        7
WGDUM     7
ZJM       2     3    61
ZJMC      2     3    61
ZJP       2     3    61
ZJPC      2     3    61
```

APPENDIX B

DYNAMIC SIMULATION

PROGRAM DYNM LISTING

The ILSLOC program calculates the CDI at each point in space; this CDI includes the Doppler effects from the velocity of the aircraft. In the simulation, the receiver system is assumed to generate the CDI value instantaneously. In the real case, the inertia of the electrical and mechanical portions of the system limit the rate of change of the CDI. Thus the real observed CDI appears to have been low-pass filtered from the instantaneous CDI.

The program DYNM takes the output tape generated by program ILSLOC and converts it to observed CDI by simulating the effect of a low-pass filter. The variable TAU is the time constant of the effective filter.*

Note: When a flight path has been segmented, the low-pass filter will operate continuously over the entire flight path.

```
C THIS PROGRAM SIMULATES THE EFFECT OF THE  MECHANICAL AND ELECTRICAL
C INERTIA OF THE ILS RECEIVER ON THE CDI.  THIS EFFECT IS EQUIVALENT
C TO A SIMPLE R-C LOW PASS FILTER.  THE VARIABLE TAU IS THE TIME
C CONSTANT OF THE EFFECTIVE FILTER.  A TYPICAL VALUE IS .4 SECONDS.
C THE INPUT TAPE IS ON UNIT 11, THE OUTPUT ON UNIT 12.
C
C
      DIMENSION XY(10),DEF(501),MEMO(14)
      LOGICAL EOF
      DATA ILBL/4HDYNM/
      DATA TAU/0.4/
      IF(EOF(11)) GO TO 4
    1 IT=0
      DELC=0.
    2 READ(11,1000) MEMO,XY,ID,NC,ICF
      WRITE(6,1003) MEMO,XY,ID,NC,ICF
      DEFK=ABS(XY(9)/XY(5)/TAU)
      IR=IFIX(XY(10)+.1)
      READ(11,1001) (DEF(I),I=1,IR)
      IF(IT .EQ. 0) CEF2=DEF(1)
      IT=1
      DO 3 I=1,IR
      CEF2=CEF2+DELC
      DELC=(DEF(I)-CEF2)*DEFK
    3 DEF(I)=CEF2
      MEMO(13)=ILBL
      WRITE(12,1000) MEMO,XY,ID,NC,ICF
      WRITE(12,1001) (DEF(I),I=1,IR)
      IF(ID .GT. 13) GO TO 1
      IF( ID .EQ. 0) GO TO 1
      GO TO 2
    4 REWIND 11
      END FILE 12
      REWIND 12
      CALL EXIT
 1000 FORMAT(13A6,A2,/,1X,7F18.9,/,3F18.9,I10,10X,2I10)
 1001 FORMAT(7E15.8)
 1003 FORMAT(1X,13A6,A2,/,1X,7F18.9,/,3F18.9,I10,10X,2I10)
      STOP
      END
```

APPENDIX C

ILSPLT PLOTTING ROUTINE

This program has been written to generate graphs of the static and dynamic CDI's. It was written on the IBM 7094 using the CALCOMP plotting subroutines.

The first input card has the following format:

Col.	Symbol	Use
1-2	NL	Number of lines per graph
3-4	NGRFS	Number of graphs
5-7	NTAPE (1)	Input logical unit no. for first line
8-10	NTAPE (2)	Input logical unit no. for second line
11-13	NTAPE (3)	Input logical unit no. for third line.

NL permits the overlaying of two or more CDI or signal strength graphs for comparison purposes. The scaling will be set by the first graph, and the successive overlays will be plotted to the same scale. A maximum of three lines per graph will be allowed.

NGRFS sets the maximum number of graphs to be drawn. Each graph will have the same number of overlays.

NTAPE (i) gives the logical unit number used for the input of the ith line on each graph. If the value of NTAPE is negative then its absolute value will be used as its logical unit number and the tape will be rewound before input.

The second input card defines the scaling used for the graph (or graphs) described above. It has the following format:

Col.	Symbol	Use
1-10	XSC	Horizontal scale in ft/in. or deg/in.
11-20	DELX	Tick mark spacing in ft. or deg.
21-30	YMAX	Maximum y-value on vertical scale
31-40	YMIN	Minimum y-value on vertical scale
41-50	DELY	Tick mark spacing on vertical spacing in microamps for CDI or relative units.

The horizontal axis is drawn in either feet or degrees per inch as specified by XSC. The tick mark spacing along the axis is determined by DELX. The length of the axis will be adjusted to the shortest length with an integral number of tick marks that will cover the domain required by the input data. When a flight path has been segmented it is treated as a single line on the graph.

YMAX, YMIN define the range of the plotted variable: CDI or relative signal strength. The y-axis has a fixed length of seven inches. If DELY does not integrally divide the range, DELY will be adjusted to yield an integer. When the range (YMAX-YMIN) is zero, the program will automatically scale the range to the largest scale that will include the data in the length of the axis.

When multiple graphs are plotted, each graph is scaled independently.

After all NGRFS graphs have been drawn, the program will loop back to the beginning and attempt to read in a new NL card. This allows many graphs to be drawn. If the user wishes to replot data using different scales or overlaid with different sets of data, he may use the negative NTAPE to rewind the input tape.

The program will terminate after reaching an end-of-file on the card input unit.

The vertical scale on the graph is always labeled "microamperes." This is valid only for CDI graphs. All others are in relative units and this labeling should be ignored.

```
      COMMON/TEST/XMIN,DXR,NTOT,NP
      LOGICAL EOF
      DIMENSION IBUF(1000)
      DIMENSION NTAPE(3),MEMO(14),M(14)
      EQUIVALENCE (M(1),MEMO(1))
      COMMON /PDF/ DF(2000),XLEN,NSTEPS,IDEF,IDENT,DX(10),NPTS(10)
      COMMON /PRINT/ NL,XSC,DELX,YMAX,YMIN,DELY,ICF
      CALL PLOTS(IBUF,1000)
      CALL PLOT(0.0,-12.,-3)
      CALL FACTOR (0.4)
      ILBL=1
   60   CONTINUE
      IF(EOF(5)) GO TO 55
      READ(5,100) NL,NGRFS,NTAPE
      WRITE(6,100) NL,NGRFS,NTAPE
      IF(NGRFS.LE.0) NGRFS=3
100   FORMAT(2I2,3I3)
      DO 401 I=1,NL
      IF(NTAPE(I).GE.0) GO TO 401
      NTAPE(I)=-NTAPE(I)
      NU=NTAPE(I)
       REWIND NU
401   CONTINUE
      READ(5,101) XSC,DELX,YMAX,YMIN,DELY
      WRITE(6,101) XSC,DELX,YMAX,YMIN,DELY
  101 FORMAT(8F10.0)
      TEMP=AMIN1(YMIN,YMAX)
      YMAX=AMAX1(YMIN,YMAX)
      YMIN=TEMP
      TEMP=YMAX-YMIN
       IF(TEMP .NE. 0.) DELY=TEMP/(FLOAT(IFIX(TEMP/DELY+.5)))
      NPLT = 1
      NP = 1
      I = 1
      N1 = 1
      NTOT = 0
   10 NU = NTAPE(NP)
      IF(EOF(NU)) GO TO 50
      READ(NU,500) M,X0,DXR,XY,ID,IDEF,IDENT,ICF
      IF(ICF .NE. 0) ICF=1
      WRITE(6,600) MEMO,X0,DXR,XY,ID,IDEF,IDENT,ICF
      IF(ILBL .NE. 1) GO TO 70
      ILBL=0
      CALL SYMBOL(0.,0.,.14,MEMO,90.,80)
      CALL PLOT(3.,0.,-3)
70      CONTINUE
      IR =IFIX( XY+.1)
      NTOT = NTOT + IR
      IF(I.EQ.1) XMIN = X0
  500 FORMAT(13A6,A2,/,/,3F18.9,4I10)
  600 FORMAT(2X,13A6,A2,/,3F18.9,4I10)
501      FORMAT(7E15.8)
502      FORMAT(1X,7E15.8)
      READ(NU,501)(DF(J),J=N1,NTOT)
      WRITE(6,502) (DF(J),J=N1,NTOT)
```

```
      WRITE(6,1000) XMIN,IR,N1,NTOT,NP,I
 1000 FORMAT(F10.0,5I10)
      NPTS(I) = IR
      DX(I) = DXR
      IF( ID .GT. 13 ) GO TO 40
       IF(ID .EQ. 0) GO TO 40
      N1 = N1 + IR
      I = I + 1
      GO TO 10
   11 NL = NP
   40 CONTINUE
      NSTEPS = I
      IF(NP.GT.1) GO TO 41
      CALL GRAPH2(0)
      GO TO 42
41        CALL GRAPH2(1)
   42 CONTINUE
      N1 = 1
      I = 1
      NTOT = 0
      IF(NP.EQ.NL) GO TO 45
      NP = NP + 1
      GO TO 10
   45 NP = 1
      CALL PLOT(XLEN+7.,-12.,-3)
      NPLT = NPLT + 1
      ILBL=1
      IF(NPLT.GT.NGRFS) GO TO 60
      GO TO 10
   50 CONTINUE
      IF(NTOT.GT.0) GO TO 11
      CALL PLOT (XLEN+7.,-12.,-3)
      GO TO 60
   55 CONTINUE
      CALL PLOT(0.,0.,999)
      DO 400 I=1,NL
      NU=NTAPE(I)
  400   REWIND NU
      STOP
      END
```

```
      SUBROUTINE GRAPH2(ITL)
      DIMENSICN XLAB(4)
      COMMON/TEST/XO,DELTAX,NDELTA,NP
      DATA XLAB/24HDISTANCE,FT.  DEGREES     /
      DIMENSICN TYPE(8)
      DIMENSION X(3),NC(3)
      COMMCN /PDF/ DF(2000),XLEN,NSTEPS,IDEF,IDENT,DX(10),NPTS(10)
      COMMCN /PRINT/ NL,XSC,DELX,YMAX,YMIN,DELY,ICF
      DATA X /-5.,5.,5./
      DATA NC /1,5,4/
      IF(ITL .NE. 0) GO TO 1
      ELX=DELX
      IF(DELTAX.LT.0.) ELX = -ABS(DELX)
       RANGE=0.
      DO 11 I=1,NSTEPS
11     RANGE=RANGE+FLOAT(NPTS(I))*DX(I)
      TIX=IFIX(RANGE/ELX+.9)
7     XLEN = ABS(ELX/XSC*TIX)
      IF(XLEN .GT. 40.) GO TO 9
      IF(XLEN .GT. 5.) GO TO 6
    9 XSC=ABS(RANGE/20.)
      XLEN=ABS(ELX/XSC*TIX)
      WRITE(6,8) XSC
8      FORMAT(25H AXIS OUT OF RANGE SCALE=,E12.5,8H FT./IN.  /)
6     CONTINUE
      XMAX=TIX*ELX+XO
      XMIN = AMIN1(XO,XMAX)
      XMAX = AMAX1(XO,XMAX)
      ND = 2
      PWR = 0.
      CALL PLOT(0.,1.5,-3)
      AMIN=YMIN
      AMAX=YMAX
      IF(YMAX .EQ. YMIN) CALL SCLAX(7.,DF,NDELTA,AMAX,AMIN,DELY,ND,PWR)
      CALL AXIS3(0.,0.,AMAX,AMIN,DELY,7.,12HMICROAMPERES,12,ND,PWR,DELN)
      YSC = DELN
      IXLAB=2*ICF+1
      IXSC=-1
      IF(ABS(ELX) .LT. 10.) IXSC=1
      CALL AXIS3(0.,0.,XMAX,XMIN,ELX,-XLEN,XLAB(IXLAB),12 ,IXSC,0.
     .,DELN)
      XSC = DELN
      XT = XLEN/2. - 2.
      IF(AMIN*AMAX.GT.0.) GO TO 2
      IF( AMIN .EQ. 0.) GO TO 2
      ZERO=(0.-AMIN/10.**PWR)/YSC
      CALL PLOT (0.,ZERO,3)
      CALL PLOT(XLEN,ZERO,2)
2     CONTINUE
1      CONTINUE
      XI=0.
      IF(DELTAX .LT. 0.) XI=XMAX-XMIN
      J=1
      DO 5 I=1,NSTEPS
      DELTAX = DX(I)
```

```
      NX=NPTS(I)
      IF(I .LT. NSTEPS) NX=NX+1
       YM=AMIN/10.**PWR
      CALL XCLINE(XI,DELTAX,DF(J),NX,0.,XSC,YM,YSC,NC(NP))
      J=J+NPTS(I)
      XI=XI+DX(I)*FLOAT(NPTS(I))
    5 CONTINUE
      RETURN
      END
```

```
      SUBROUTINE XCLINE(XI,DX,Y,N,XM,DELX,YM,DELY,NC)
      DIMENSION Y(1),IPEN(4)
      REAL L(4,4),LL(4)
      DATA IPEN/2,3,2,3/
      DATA L/.3,.1,.3,.1,.5,3*.05,.3,3*.1,.1,.05,.1,.05/
      X = XI
    2 IC = NC - 1
      XP1 = (X-XM)/DELX
      YP1=(Y(1)-YM)/DELY
      CALL PLOT(XP1,YP1,3)
      IF(IC.LE.0) GO TO 1000
      IF(IC.GT.4) IC = 4
      K=1
      I=2
      X = X + DX
      XP2 = (X-XM)/DELX
      YP2=(Y(2)-YM)/DELY
    1 LL(K)=L(K,IC)
   10 DIFFX=XP2-XP1
      DIFFY=YP2-YP1
      DIS=SQRT(DIFFX*DIFFX+DIFFY*DIFFY)
      IF(DIS.GT.LL(K))GO TO 100
      CALL PLOT(XP2,YP2,IPEN(K))
      XP1=XP2
      YP1=YP2
      I=I+1
      IF(I.GT.N)RETURN
      X = X + DX
      XP2 = (X-XM)/DELX
      YP2=(Y(I)-YM)/DELY
      LL(K)=LL(K)-DIS
      GO TO 10
  100 RATIO=DIS/LL(K)
      XP1=XP1+DIFFX/RATIO
      YP1=YP1+DIFFY/RATIO
      CALL PLOT(XP1,YP1,IPEN(K))
      K=K+1
      IF(K.EQ.5)K=1
      GO TO 1
 1000 DO 50 I=2,N
      X = X + DX
      XP1 = (X-XM)/DELX
      YP1=(Y(I)-YM)/DELY
   50 CALL PLOT(XP1,YP1,2)
      RETURN
      END
```

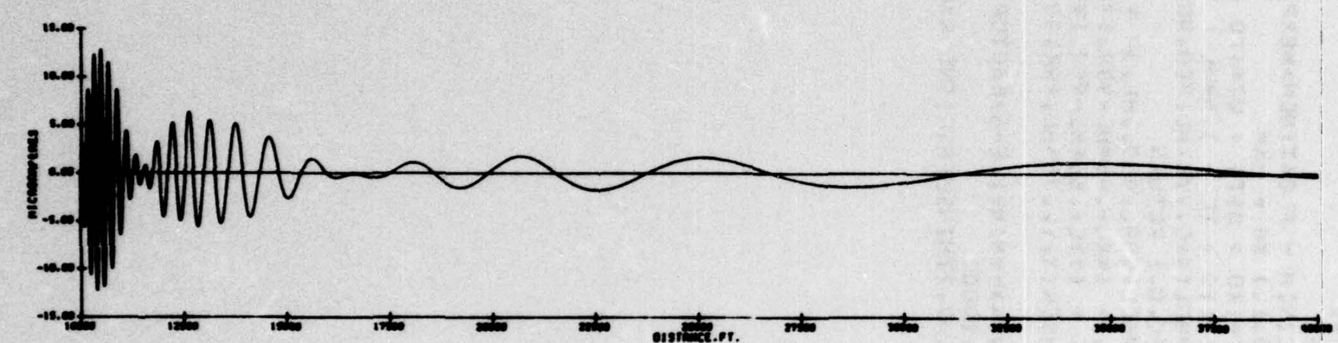
```
      SUBROUTINE SCLAX(AINCH,VAR,N,VMAX,VMIN,DELTA,ND,EXP)
      DIMENSION VAR(1)
C
      AXLEN = AINCH
      VMAX = VAR(1)
      VMIN = VAR(1)
      DO 40 I=2,N
      VMAX = AMAX1(VMAX,VAR(I))
   40 VMIN = AMIN1(VMIN,VAR(I))
      ND = 0
      NE = 0
      M = 2
      TOTAL = VMAX - VMIN
C                                  DETERMINE EXPONENT AND INCREMENT/INCH
      VM = AMAX1(ABS(VMAX),ABS(VMIN))
      IF(VMAX*VMIN) 6,5,7
    7 VAV = ABS(VMAX+VMIN)/2.
      DELTA = TOTAL/AXLEN
      IF(TOTAL.GT.0..AND.TOTAL/VM.LT..75) GO TO 4
      IF(VMAX.EQ.VM) VMIN=0.
      IF(VMIN.EQ.-VM) VMAX=0.
      GO TO 5
    6 AXLEN = AXLEN*VM/TOTAL
    5 DELTA = VM/AXLEN
      VAV = VM/2.
C                                  TEST FOR VAV BETWEEN .01 AND 1000.
    4 IF(VAV.LE.1.E-11) GO TO 21
      IF(VAV - .01) 3,10,1
   41 IF(VAV - 1.) 3,10,10
    1 IF(VAV - 1000.) 10,2,2
C                                  VAV GE 1000.
    2 IF(NE.EQ.0) VAV = VM
      VAV = VAV/1000.
      NE = NE - 3
      GO TO 1
C                                  VAV LT 1.
    3 VAV = VAV*1000.
      NE = NE + 3
      GO TO 41
C                                  DETERMINE DECIMAL PLACES IN DELTA
   10 IF(DELTA.LT.VM/1.E4) GO TO 21
      DELTA = DELTA*10.**NE
   11 IF(DELTA - 1.) 12,19,13
   12 DELTA = DELTA*10.
      ND = ND + 1
      GO TO 11
   13 IF(DELTA - 10.) 15,8,14
   14 DELTA = DELTA/10.
      ND = ND - 1
      GO TO 13
C                                  DELTA NOW BETWEEN 1 AND 10
   15 IF(DELTA - 5.) 16,17,17
   16 IF(DELTA - 2.) 19,18,18
   17 DELTA = 5./10.**(ND+NE)
      GO TO 20
```

```
   18 DELTA = 2./10.**(ND+NE)
      M = 5
      GO TO 20
    8 ND = ND - 1
   19 DELTA = 1./10.**(ND+NE)
C                                       RESET VMIN (FIRSTV) FOR AXIS
   20 AK = VMIN/DELTA + .01
      K = (IFIX(AK)/M)*M
      IF(VMIN.LT.0.) K=K-M
      VMIN = DELTA*FLOAT(K)
      NDIV = (VMAX - VMIN)/DELTA + .9
      IF(FLOAT(NDIV).GT.AINCH*2.) DELTA=DELTA*AMAX1(2.,FLOAT(M)/2.)
      IF(ND.LE.0) ND = -1
   21 EXP = NE
      WRITE(6,1002) VMAX,VMIN,DELTA,ND,NE
      RETURN
 1002 FORMAT(1HO,3E13.3,3I7//)
      END
```

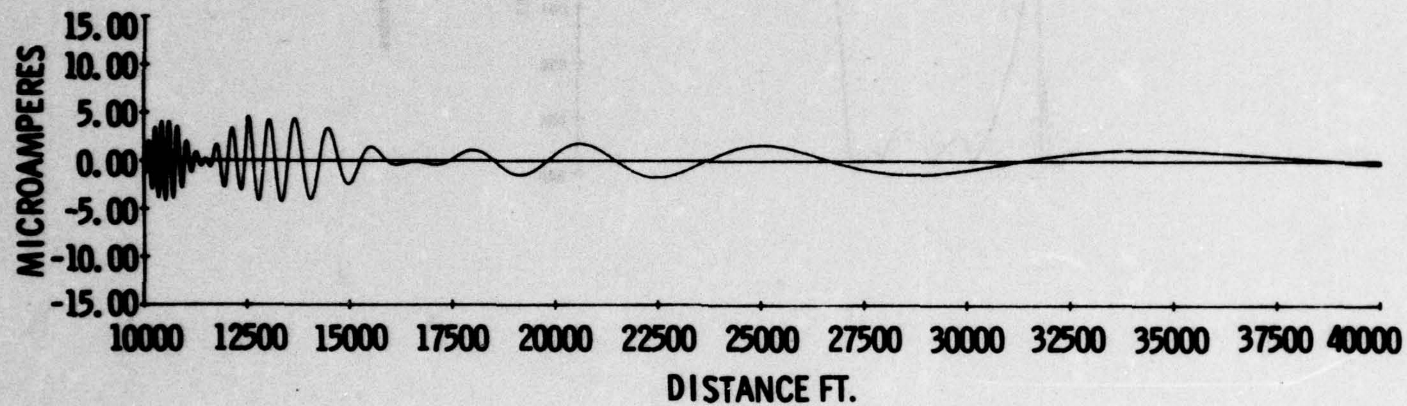
```
      SUBROUTINE AXIS3(XO,YO,VMAX,VMIN,DELV,AINCH,BCD,NCR,NDEC,PWR,VSC)
      FACTOR = 10.**PWR
      AMIN = VMIN*FACTOR
      AMAX = VMAX*FACTOR
      DELX = ABS(DELV)*FACTOR
      DIMENSION BCD(1)
      HT = .15
      W1=0.
      W2=0.
      W3 = 0.
      NEXP = 0
      NCH=IABS(NCR)
      IF(PWR.NE.0.) NEXP = 6
      CINCH=ABS(AINCH)
      IF((VMAX-VMIN)/AMAX1(VMAX,-VMIN).LT.1.E-6) GO TO 50
      IF((AMAX-AMIN)/(DELX+1.E-8).GT.3.*CINCH) DELX = (AMAX-AMIN)/CINCH
      IF(DELX.GT.AMAX-AMIN) DELX = AMAX - AMIN
      IF(NCR.LT.0) W3 = 1.
      NUM=(AMAX-AMIN)/DELX+1.9
      ANC=CINCH/FLOAT(NUM-1)
      IF(AINCH.LT.C.)GO TO 5
      W2=1.
      GO TO 10
    5 W1=1.
   10 CALL PLOT(XO,YO,3)
      VSC = DELX/FACTOR/ANC
      ANUM=AMIN-DELX
      X=0.
      Y=0.
      XM=0.
      OFF = .05
      DO 40 I=1,NUM
      ANUM=ANUM+DELX
      II=0
   25 IF(ABS(ANUM)/10.**II.LT.1.)GO TO 20
      II=II+1
      GO TO 25
   20 IF(ANUM.LT.C.)II=II+1
      IF(ABS(ANUM).LT.1.) II=II+1
      IMORE=NDEC+1
      II=II+IMORE
      IF(IFIX(W1)*I.EQ.1) HT = AMIN1(HT ,ANC/FLOAT(II+2))
      HL = AMAX1(.12,1.2*HT)
      CENTER = FLOAT(II)*HT/(1.+W1)
      XC = X - CENTER - W2*.15
      IF(XC.LT.XM) XM = XC
      IF(W2*W3.GT.C.) XC = .15
      IF(ABS(XC).GT.ABS(XM)) XM = XC
      YC = Y - W1*(HT + .15 - W3*(HT+.3)) - W2*OFF
      CALL PLOT(XO+X,YO+Y,2)
      CALL PLOT(XO+X+.1*W2,YO+Y+.1*W1,3)
      CALL PLOT(XO+X-.1*W2,YO+Y-.1*W1,2)
      CALL NUMBER(XO+XC,YO+YC,HT,ANUM,0.,NDEC)
      CALL PLCT(XO+X,YO+Y,3)
      X=X+ANC*W1
```

```
      Y=Y+ANC*W2
   40 CONTINUE
      BST = (CINCH - FLOAT(NCH+NEXP)*HL)/2.
      IF(W3.EQ.1.) XM = -XM
      XXC = W1*(XO + BST) + W2*(XO + XM - OFF + W3*(2.*OFF+HL))
      YYC = W1*(YO + YC - 1.5*HL + W3*(HT + 2.*HL)) + W2*(YO+BST)
      CALL SYMBOL(XXC,YYC,HL,BCD,90.*W2,NCH)
      IF(PWR.EQ.0.) RETURN
      CALL SYMBOL(999.,999.,HL,5H * 10,90.*W2,5)
      X = 999. + (XXC-.66*HL-999.)*W2
      Y = 999. + (YYC+.66*HL-999.)*W1
      CALL NUMBER(X,Y,.75*HL,PWR,90.*W2,-1)
      RETURN
   50 VSC = (VMAX-VMIN+1.E-6/FACTOR)/CINCH
      WRITE(6,1000)
 1000 FORMAT(1H0,27HINSUFFICIENT RANGE FOR AXIS )
      RETURN
      END
```

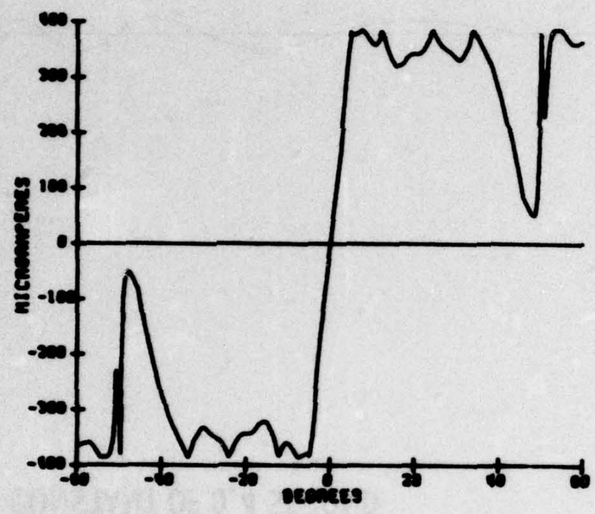
SIMULATED CERTIFICATION FLIGHT for
TEST CASE AIRPORT - GIVING
INSTANTANEOUS CDI - USING MEASURED
ALFORD ANTENNA



SIMULATED TEST FLIGHT SHOWING EFFECTS OF DYNAMIC SIMULATION - ASSUMED TIME CONSTANT OF 0.4 SECOND

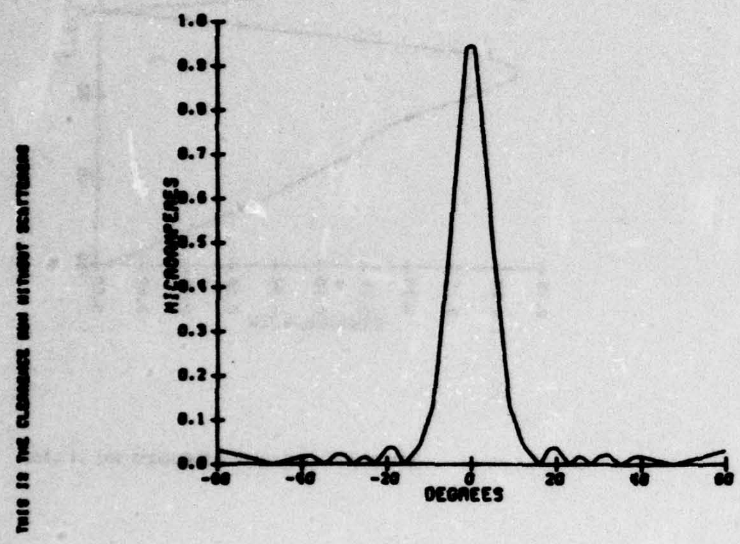


SIMULATED CLEARANCE RUN for MEASURED PATTERN
ALFORD 14 AND 6

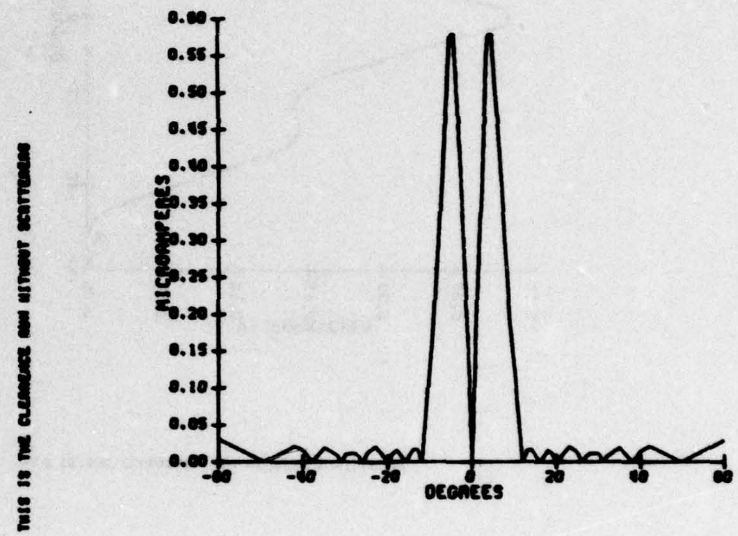


THIS IS THE CLEARANCE RUN WITHOUT SCATTERING

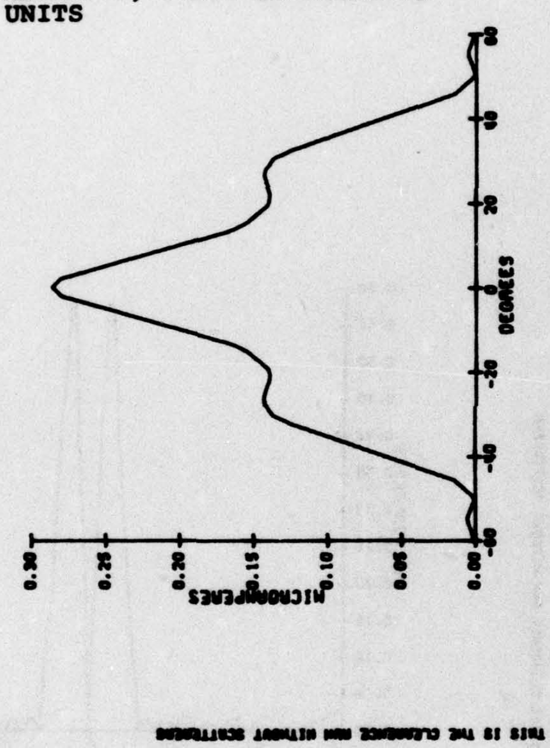
MEASURED ANTENNA PATTERN - CARRIER and SIDEBAND for ALFORD 14, SCALE in RELATIVE UNITS



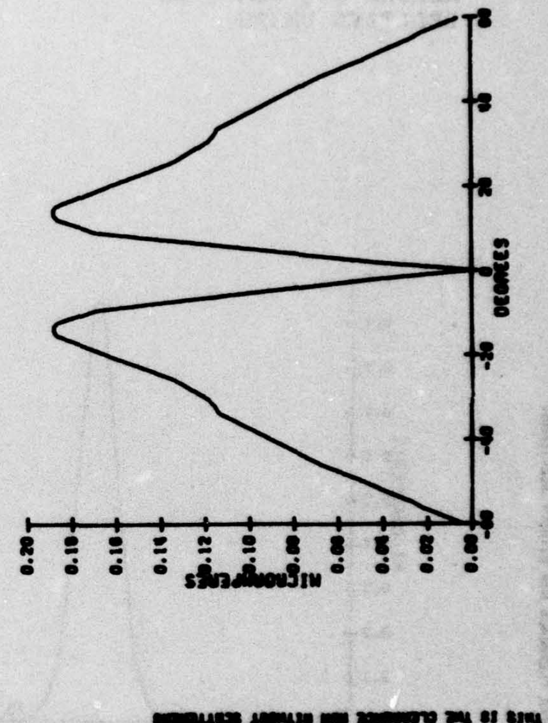
SIDEBAND ONLY for ALFORD 14



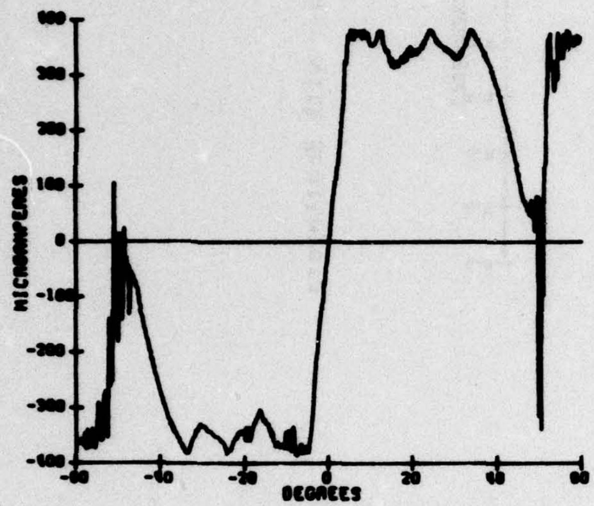
MEASURED ANTENNA PATTERN - CARRIER and SIDEBAND for ALFORD 6, SCALE in RELATIVE UNITS



SIDEBAND ONLY for ALFORD 6



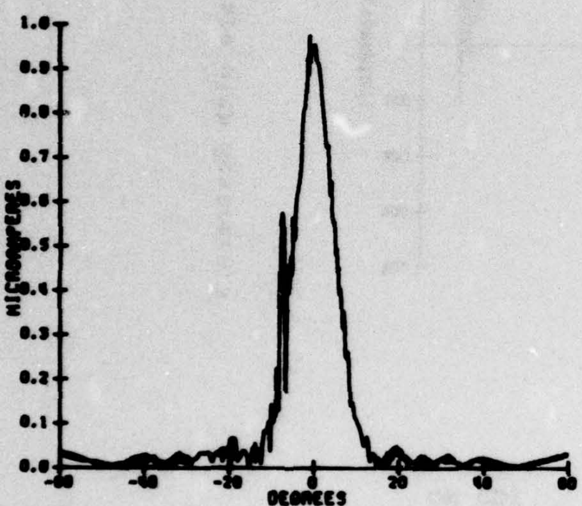
SIMULATED CLEARANCE RUN for TEST CASE AIRPORT SHOWING EFFECT of SCATTERERS ON CDI



This is Orbit Case with Scatterers

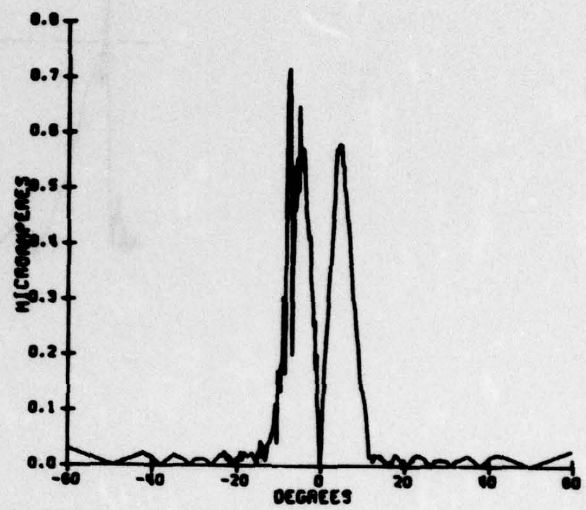
MEASURED ANTENNA PATTERN CARRIER and SIDEBAND for ALFORD 14 SHOWING SCATTERERS, SCALE IN RELATIVE UNITS

This is Orbit Case with Scatterers



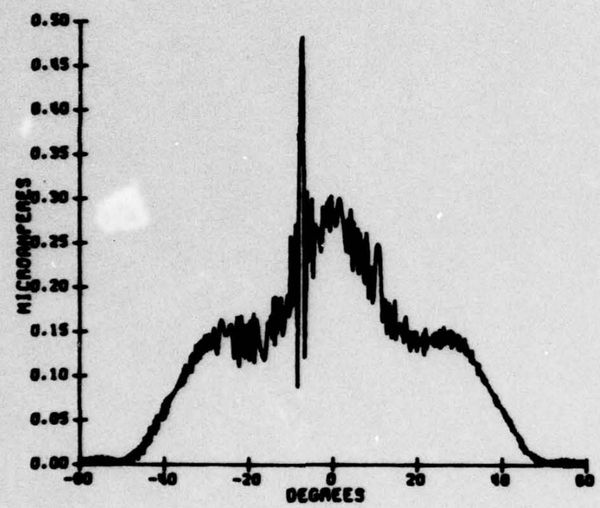
SIDEBAND ONLY - WITH SCATTERERS for ALFORD 14

This is Orbit Case with Scatterers



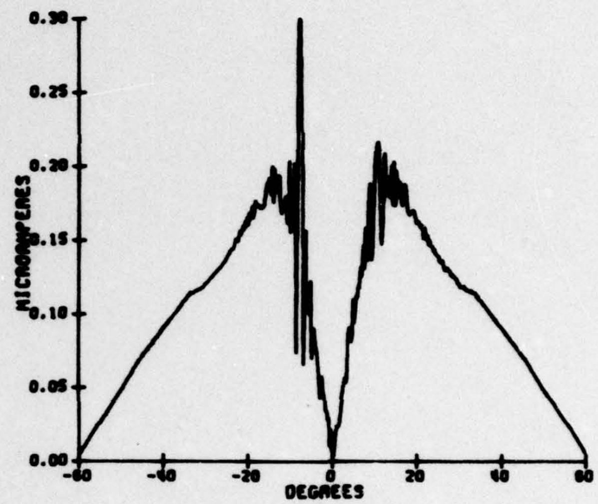
MEASURED ANTENNA PATTERN - CARRIER and SIDEBAND ONLY for ALFORD 6 SHOWING SCATTERERS, SCALE IN RELATIVE UNITS

This is Orbit Case with Scatterers



SIDEBAND ONLY SHOWING SCATTERERS for ALFORD 6

This is Orbit Case with Scatterers



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