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**DERIVATION OF NARROWBAND FREQUENCY-AGILE
RADAR SIGNATURES FROM WIDEBAND DATA
(ANALYSIS OF X-BAND DATA)**

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) This investigation demonstrated theoretically and experimentally that frequency-agile narrowband radar signatures can be derived from wideband data. The experimental work used X-Band satellite data from Lincoln Laboratory's Long Range Imaging Radar (Haystack). The computer programs required for deriving narrowband signatures from two dimensional radar images were delivered to AFAL with this report.			

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SECTION I

INTRODUCTION

A study recently carried out by Calspan evaluated the characteristics of a number of radar systems with the possibility that such a system might be used to observe satellites. Two important characteristics of the candidate systems studied for this application were that they were narrowband and frequency-agile. However, no data were available on satellites that could be used in simulations of these systems. Calspan proposed that the required narrowband data could be obtained by filtering wideband data collected by the Long Range Imaging Radar (LRIR) (also known as the Haystack radar) operated by Lincoln Laboratory. In this report, narrowband means bandwidth such that individual scatterers on the satellite cannot be resolved.

It was determined that the work that needed to be done could be separated into two parts: Phase I would be the development of processing software and a proof of the concept using the single frequency data available for comparison, and Phase II would be a rather detailed analysis of frequency agile signatures corresponding to specific candidate radar systems. This report covers the Phase I work only, and due to a change in requirements for this data, Phase II will probably not be performed. Section 2 of this report is a mathematical justification of the method, with some details given in Appendix A. Section 3 briefly describes the method used to derive the required signatures from the data available and discusses the computer software, with details supplied in Appendix B. Finally, the results and conclusions are given in Section 4, and may be summarized: the method is sound, both in theory and practice.

SECTION II

MATHEMATICAL JUSTIFICATION OF APPROACH

In the frequency domain a wideband radar pulse may be thought of as several adjacent narrowband pulses. Thus it is quite reasonable to expect that individual narrowband pulses could be obtained from wideband pulses by some form of data processing. The purpose of this section is to show how this can be done and to define the restrictions and limitations of the process, both in general and for the specific case of the LRIR.

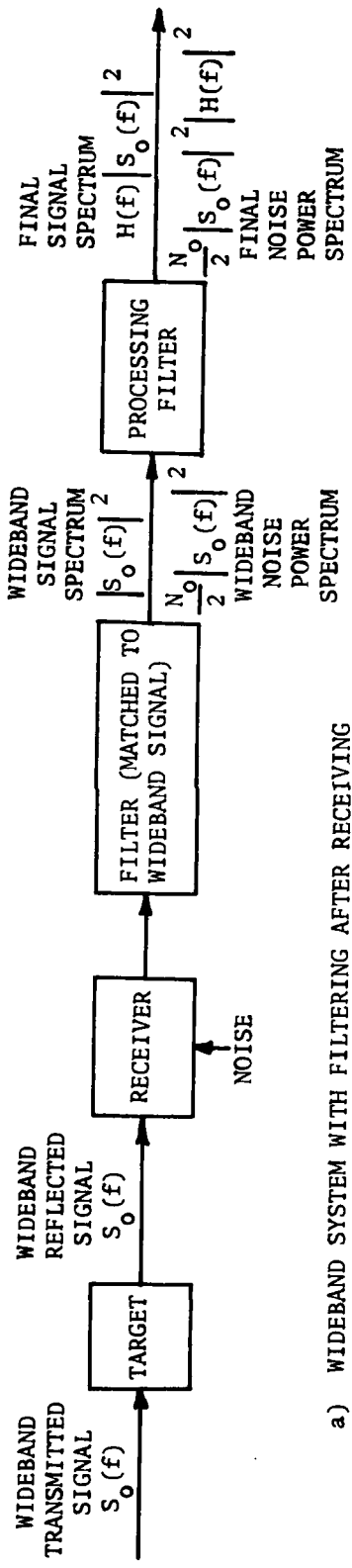
2.1 General Approach

Narrowband radar returns can be derived from wideband returns by a simple filtering operation. This can be shown quite easily by investigation of the received signal frequency spectrum. This analysis is carried out in detail in Appendix A and is summarized here.

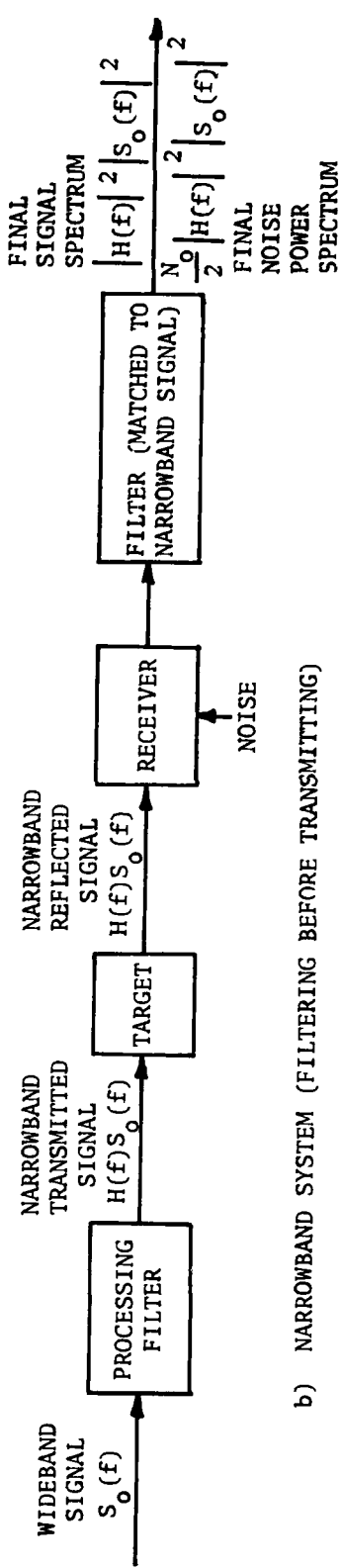
Consider a transmitted waveform with transmitted energy E_T and spectrum $\sqrt{E_T} S_0(f)$ reflected from a point target as in Figure 2.1.a. The received signal has a spectrum $\beta \sqrt{E_T} S_0(f)$ where β is an attenuation factor. (For simplicity, Doppler shift has been omitted from this discussion although it could be included with no loss of generality.) This signal together with additive white Gaussian noise with power spectral density $\frac{1}{2} N_0$ is mixed down to the radar's intermediate frequency and input to a filter matched to the Doppler shifted signal. The filter signal output spectrum is $\beta \sqrt{E_T} |S_0(f)|^2$ with an additive noise component having power spectrum $\frac{1}{2} N_0 |S_0(f)|^2$. Note that here the signal (which is deterministic) is represented by its spectrum while the noise (which is a stochastic process) is represented by its power spectrum. The output signal-to-noise ratio (SNR) is given by:

$$\text{SNR} = \frac{(\text{Peak Signal})^2}{\text{Noise Variance}} = \frac{2\beta^2 E_T}{N_0}$$

Now a second filter $H(f)$ is placed after the matched filter. The output from the second filter has a signal component spectrum $\beta \sqrt{E_T} |S_0(f)|^2 H(f)$ and noise power spectrum $\frac{1}{2} N_0 |S_0(f)|^2 |H(f)|^2$. The output signal components for



a) WIDEBAND SYSTEM WITH FILTERING AFTER RECEIVING



b) NARROWBAND SYSTEM (FILTERING BEFORE TRANSMITTING)

Figure 1. COMPARISON OF WIDEBAND AND NARROWBAND RADAR SYSTEMS

this system (Figure 1-a) are $\beta \sqrt{E_T} \hat{S}_0$ where

$$\begin{aligned} \hat{S}_0(f) &= S_0(f) \text{ for } |f-f_0| \leq B/2 \\ &\quad \text{and } |f+f_0| \leq B/2 \\ &= 0 \text{ otherwise} \end{aligned}$$

Next, consider the system shown in Figure 1-b. The wideband signal with spectrum $S_0(f)$ is first passed through the filter $H(f)$ and the narrowband signal $\sqrt{E_T} H(f) S_0(f)$ is transmitted. The received signal is $\beta \sqrt{E_T} H(f) S_0(f)$ which is input to a filter matched to the transmitted signal. The output has a signal component with a spectrum $E_T |H(f)|^2 |S_0(f)|^2$ and a noise component with power spectrum $\frac{1}{2} N_0 |H(f)|^2 |S_0(f)|^2$.

The noise power spectra for the two systems shown in Figure 1 are identical, but their signal component spectra are slightly different. The signal components will only agree if $H(f) = |H(f)|^2$ for all f . Hence if $H(f)$ is defined as:

$$\begin{aligned} H(f) &= 1 \text{ for } |f-f_0| \leq B/2 \\ &\quad \text{and } |f+f_0| \leq B/2 \\ &= 0 \text{ otherwise} \end{aligned}$$

Then the output of the wideband system with filtering after receiving is identical to the output of the system in which a narrowband signal was transmitted and received.

Notice that the output signal-to-noise ratio for either system is given by:

$$\text{SNR} = \frac{2\beta^2 E_T}{N_0} \left[\frac{\int_{-\infty}^{\infty} |\hat{S}_0(f)|^2 df}{\int_{-\infty}^{\infty} |S_0(f)|^2 df} \right]$$

where the term in brackets is the ratio of the narrowband transmitted energy to the wideband transmitted energy.

The conclusions are that:

1. Simulated narrowband data can be extracted from wideband field data by a filtering operation.
2. A narrowband transmitted waveform can be simulated whose frequency components within the simulated bandwidth are identical to those of the wideband signal within the same frequency limits and zero outside these limits.
3. There is a loss of signal-to-noise ratio in filtering wideband data to obtain narrowband data because the equivalent transmitted energy is less than the actual wideband transmitted energy.

2.2 Special Considerations for Haystack Radar

In the general discussion given above it is assumed that the wideband radar return passes through a filter exactly matched to a wideband pulse. The Haystack radar transmits a chirped pulse and mixes the received pulse with a replica of the transmitted pulse delayed in time to correspond to a return from a reference range and offset in frequency by the intermediate frequency. A return from the reference range will then give a signal at the center of the radar's intermediate frequency band. Returns from slightly different ranges will result in constant frequency signals with frequency proportional to range. However, these signals are also slightly displaced in time from the reference signal. The receiver filter is perfectly matched to the return from a scatterer at the reference range at a particular time, but at that time it is not perfectly matched to returns from scatterers at slightly different ranges. The purpose of this section is to demonstrate that this problem is negligibly small for satellites with dimensions of interest in this study.

Consider the way in which the chirp pulses are collapsed by Haystack.

Body Center at Range R_0

Scatterer i at range R_i is stationary and has RCS σ_i

Center Frequency = f_0

Swept Bandwidth = B

Pulse Duration = T

We use complex representation to simplify equations. The transmitted signal is represented as:

$$s(t) = e^{j2\pi[f_0 t + \frac{B}{2T} t^2]} \quad \text{for } -T/2 \leq t \leq T/2 \quad (1)$$

The return from the i^{th} scatterer is:

$$r_i(t) = \sqrt{\sigma_i} e^{j2\pi[f_0(t-\tau_i) + \frac{B}{2T}(t-\tau_i)^2]} \quad (2)$$

for $\tau_i - T/2 \leq t \leq \tau_i + T/2$

where $\tau_i = 2R_i/c$.

This signal is beat against a replica of $s(t)$ delayed by $\tau_0 = 2R_0/c$ and centered at a lower frequency ($f_0 - f_{\text{IF}}$).

$$\begin{aligned} y_i(t) &= r_i(t) e^{-j2\pi[(f_0 - f_{\text{IF}})(t - \tau_0) + \frac{B}{2T}(t - \tau_0)^2]} \quad (3) \\ &= \sqrt{\sigma_i} e^{-j2\pi f_{\text{IF}} \tau_0} e^{j2\pi[f_0(\tau_0 - \tau_i) + \frac{B}{2T}(\tau_i^2 - \tau_0^2)]} e^{j2\pi[f_{\text{IF}} - \frac{B}{T}(\tau_i - \tau_0)]t} \end{aligned}$$

for $-T/2 + \tau_i \leq t \leq T/2 + \tau_i$

Hence a scatterer at range i yields a CW pulse centered at τ_i at frequency $f_{IF} - \frac{B}{T} (\tau_i - \tau_0)$. Note that the duration of the chirp affects only the limits of the return; the phase and frequency of the return are fully determined by the chirp rate $(\frac{B}{T})$.

The return from several scatterers comprising a realistic target can be found by summing the $y_i(t)$ for each of the scatterers.

Figure 2 depicts the individual components, $y_i(t)$, (and their summation, $y(t)$) of the return from a scatterer located at τ_0 , the reference range, one located slightly closer to the radar at τ_- and one located slightly farther from the radar at τ_+ . The figure shows clearly the effect of the slight displacement of the individual scatterers from each other. Let us define a segment of $y(t)$ centered at t_0 with duration δ :

$$y'(t) = y(t) \quad \text{for } \tau_0 - \frac{T}{2} \leq t_0 + \tau_0 - \frac{\delta}{2} \leq t \leq t_0 + \tau_0 + \frac{\delta}{2} \leq \tau_0 + \frac{T}{2} \quad (4)$$

$$= 0 \quad \text{otherwise}$$

The contribution of the i^{th} scatterer ($i=+, 0, \text{ or } -$) in this signal is:

$$y_i'(t) = \sqrt{\sigma_i} e^{-j2\pi f_{IF} \tau_0} e^{j2\pi [f_0(\tau_0 - \tau_i) + \frac{B}{2T} (\tau_i^2 - \tau_0^2)]} e^{j2\pi [f_{IF} - \frac{B}{T} (\tau_i - \tau_0)] t} \quad (5)$$

$$\text{where } t_0 + \tau_0 - \frac{\delta}{2} \leq t \leq t_0 + \tau_0 + \frac{\delta}{2}$$

$$y'(t+t_0) = \sqrt{\sigma_i} e^{-j2\pi f_{IF} \tau_0} e^{j2\pi [f_0(\tau_0 - \tau_i) + \frac{B}{2T} (\tau_i^2 - \tau_0^2)]} e^{j2\pi [f_{IF} - \frac{B}{T} (\tau_i - \tau_0)] [t+t_0]} \quad (6)$$

$$= \sqrt{\sigma_i} e^{-j2\pi f_{IF} (\tau_0 - t_0)} e^{j2\pi [(f_0 + \frac{B}{T} t_0)(\tau_0 - \tau_i) + \frac{B}{2T} (\tau_i^2 - \tau_0^2)]} e^{j2\pi [f_{IF} - \frac{B}{T} (\tau_i - \tau_0)] t} \quad (7)$$

$$\text{where } \tau_0 - \frac{\delta}{2} \leq t \leq \tau_0 + \frac{\delta}{2}$$

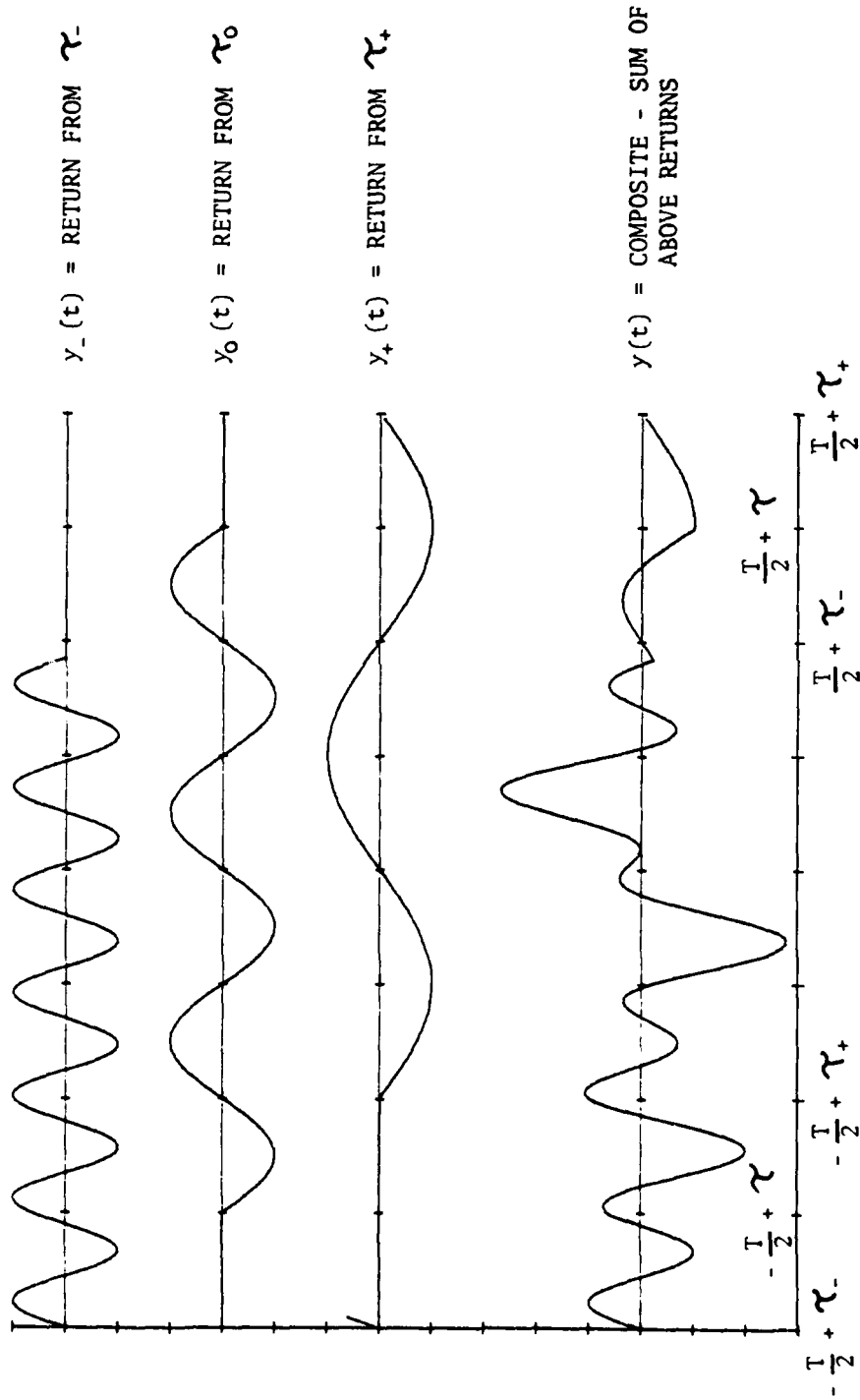


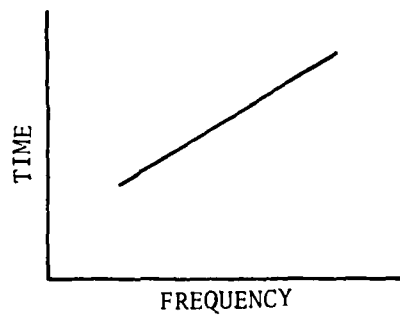
Figure 2 COMPONENTS AND COMPOSITE OF CHIRPED RETURN FROM 3-SCATTERER TARGET

Equation 7 has the same form as the completely general Equation 3. This shows that except for fringe or end effects, the signal from a multiple scatterer target is in all other respects completely general. Therefore, when the chirped radar pulse is very long in comparison to the range extent of the target ($\Delta\tau \ll \delta$), as it is for the LRIR looking at satellites of reasonable size, the filtering used with wideband radar returns is negligibly different from a true matched filter and, therefore, should not have a significant effect on the derivation of narrowband signals from the wideband data.

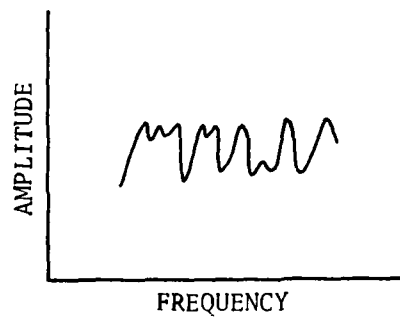
SECTION III DESCRIPTION OF METHOD

As the discussion in the previous section implies, filtering wideband radar returns to obtain narrowband returns is a relatively simple process. Most of the effort in this study was related to the form in which the data were available. In order to minimize the effort required to obtain the data, understand and compensate for radar dependent characteristics, remove translational motion of the satellite, and be certain of the validity of the data, the most practical form for transferring the wideband data from Lincoln Laboratory to Calspan was in the form of two dimensional images. Since these images are the result of reversible processing of the needed wideband data, much of the software developed in this study was aimed at reversing many of the processing steps involved in creating the images.

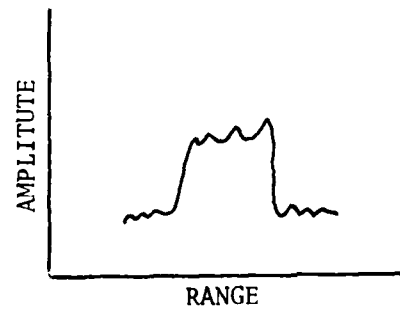
One way to describe the methods used for this processing is briefly to review this imaging process. Figure 3 shows the ramp waveform transmitted by LRIR. The received waveform is mixed with a delayed (to an appropriate reference range) replica of the transmitted waveform to generate the uncollapsed pulse. This pulse is digitized, Doppler corrected, weighted and Fourier transformed to obtain a high resolution pulse, where successive samples from the transform represent range samples near the reference range. Samples of many pulses at the same range relative to a reference point fixed on the target are weighted and Fourier transformed in the cross-range dimension to obtain Doppler or cross-range resolution of target scatterers. This final step is repeated for each sampled range, and the composite represents a two-dimensional image in the range-cross-range plane.



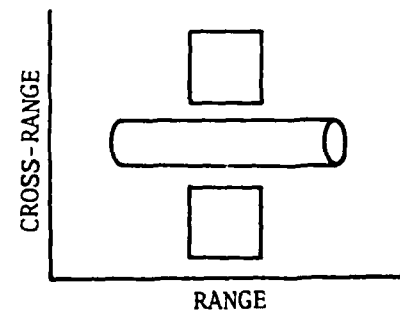
RAMP WAVEFORM



UNCOLLAPSED PULSE



HIGH RESOLUTION PULSE



RADAR IMAGE

Figure 3 REVIEW OF IMAGING PROCESS

The software implemented in this study reversed most of the steps in image processing. It is important to note that two rather involved steps did not have to be reversed as they would have been required even if the raw data had been directly available to Calspan. The first of these was the compensation discussed in Appendix A to remove the apparent range shift due to Doppler frequency. The second was the very accurate range tracking of the target that was required to ensure that the same frequency could be selected from successive radar pulses.

The software implemented is summarized by the block diagram in Figure 4. The plotting of the two-dimensional images was done to ensure that the data were being read properly from the magnetic tapes. The narrowband images were plotted to facilitate eyeball correlations among signatures. The majority of the software performed the reverse image processing steps described above and presented various outputs to permit checking of intermediate results. Simple statistics were calculated to permit comparisons among actual narrowband signatures and derived narrowband signatures. This software is described in detail in Appendix B.

SECTION IV RESULTS AND CONCLUSIONS

The primary purpose of this investigation was to demonstrate that narrowband signatures derived from wideband data are a good representation of actual narrowband signatures in practice as well as in theory. This section describes the results of performing the required comparisons.

The nature of the LRIR precluded, at reasonable cost, obtaining wideband and actual narrowband data simultaneously. The data available for this investigation are summarized in Table 1. Since the geometry differences from pass to pass would make the signatures quite different, only a qualitative pattern lobe correlation could be made between different passes; quantitative comparisons could be made on a statistical basis. Therefore, it was decided to concentrate on satellite 10352 since there were three actual narrowband signatures available to compare to each other and to the signature at the same frequency that could be derived from wideband data.

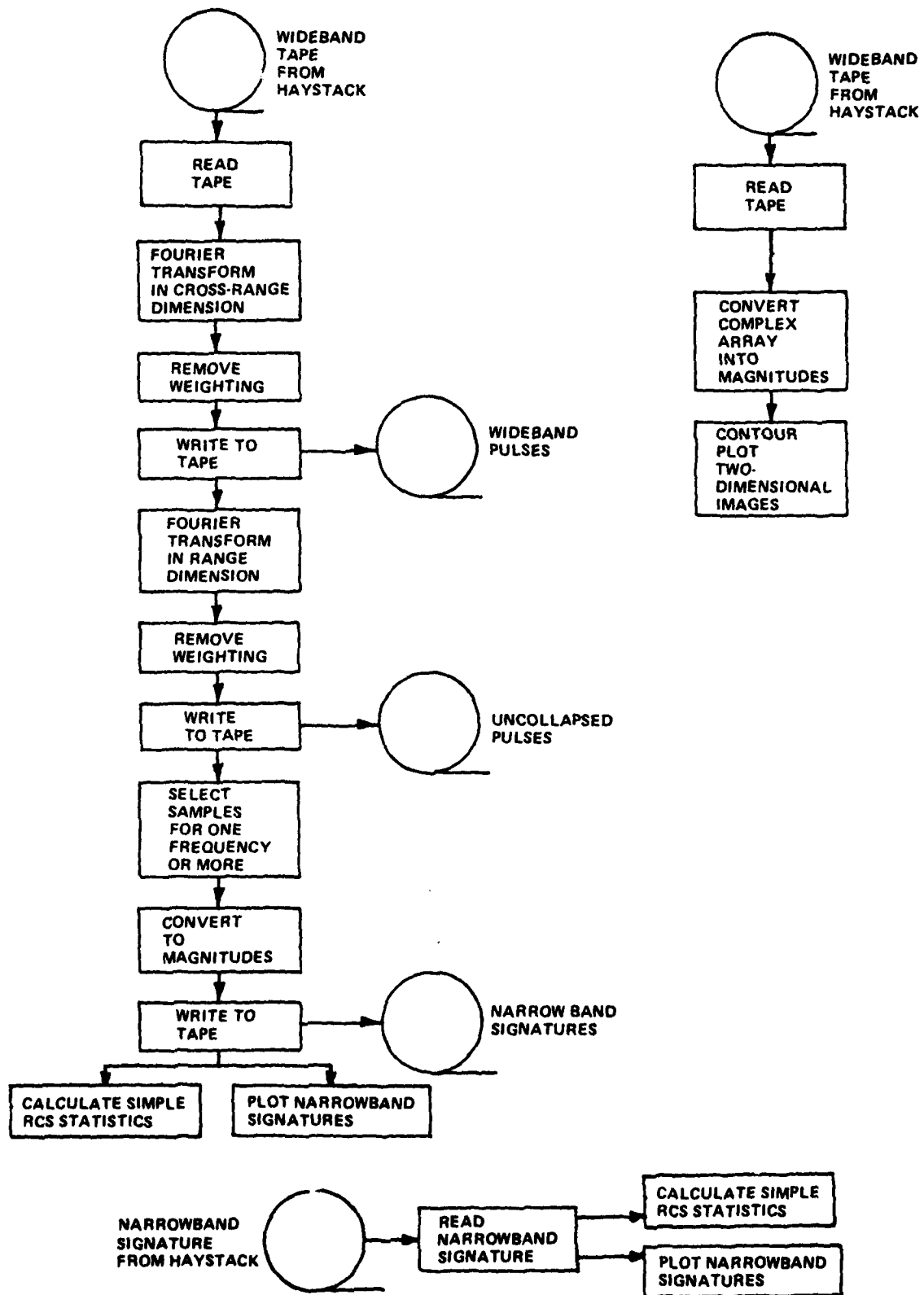


Figure 4 DATA REDUCTION SOFTWARE FUNCTIONAL DIAGRAM

TABLE 1
DATA RECEIVED FROM LINCOLN LABORATORY

NARROWBAND DATA			WIDEBAND DATA		
OBJECT	DATE	DURATION (SEC)	OBJECT	DATE	IMAGES
10129	11/9/78	460	10129	11/8/78	20
10973	9/20/78	465	10973	9/20/78	5
10141	11/9/78	700	10141	11/9/78	18
10352	11/8/78	520	10352	11/7/78	18
10352	11/8/78	730			
10352	11/9/78	560			
10917	9/19/78	770	10917	9/20/78	12
7490	11/9/78	605	7490	11/8/78	13
			10514	11/9/78	19
			11098	11/9/78	19
TOTAL 124 IMAGES					

The data from the three narrowband passes had been collected at either 100 or 200 pulses per second and a frequency of 10.0 GHz. Since this was much higher than the effective pulse rate (three to four pulses per second) used in the imaging process, groups of narrowband data were averaged to obtain a comparably low sample rate. This averaging also eliminated a non-random noise that, Lincoln Laboratory personnel agreed, was a figment of the radar operating in the narrowband mode rather than a characteristic of the satellite. These data were then plotted and statistics calculated to permit comparison to each other and to the signatures derived from the wideband data.

The wideband data from the pass of Object 10352 were processed as described in Section 3, selecting the same 10.0 GHz center frequency as used above. The signature segments derived from each image were concatenated to obtain a signature comparable to that from a narrowband pass. This signature was plotted and its statistics calculated.

The plots from the three actual narrowband passes and the narrowband data derived from the wideband pass were compared by "eyeball" correlation to see if they were generally similar. It was found that all the signatures had generally similar characteristics. Figures 5 and 6 show segments of two of these signatures. The similarities and differences are quite reasonable for two different passes of the same satellite as seen at a radar frequency of 10.0 GHz. One other characteristic that could be seen but not quantified was the match-up of the segments of the derived signature at the ends of the individual images. The 18 images gave 17 junctions of which three had a relatively long gap between the end of one image's data and the beginning of the next, eleven had short gaps and three had overlapping data. In the cases of short gaps or overlaps, the excellent continuity and retracing of the signature plot was an indication that the signature segments were independent of the individual images and that there were no significant effects at the ends of the segments of the signature. Although these two observations did not directly validate the derived signature, they did indirectly add credence in a double negative sense: the signature did not show a problem.

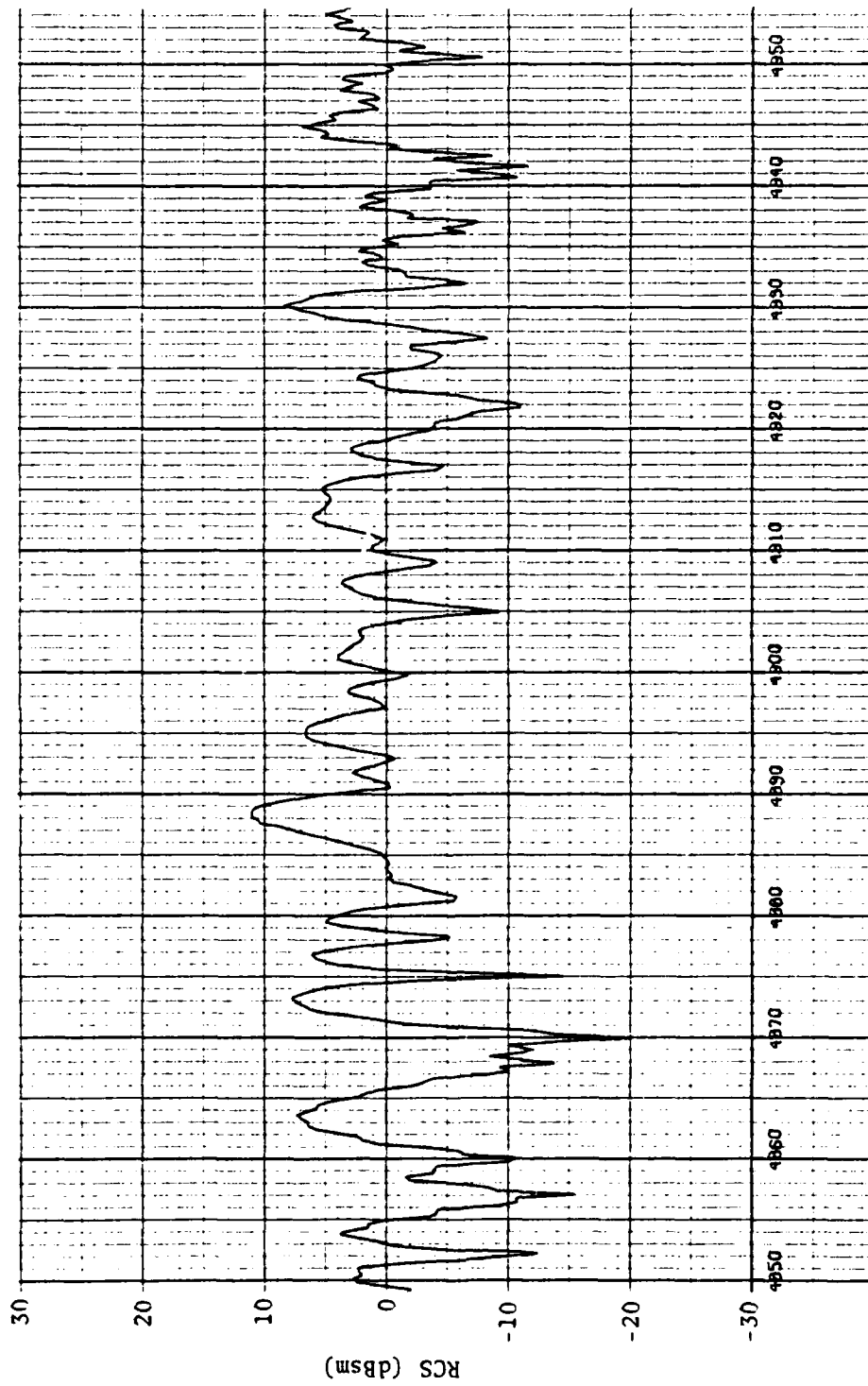


Figure 5 PORTION OF NARROWBAND SIGNATURE OF OBJECT 10352 AT 10.0 GHZ

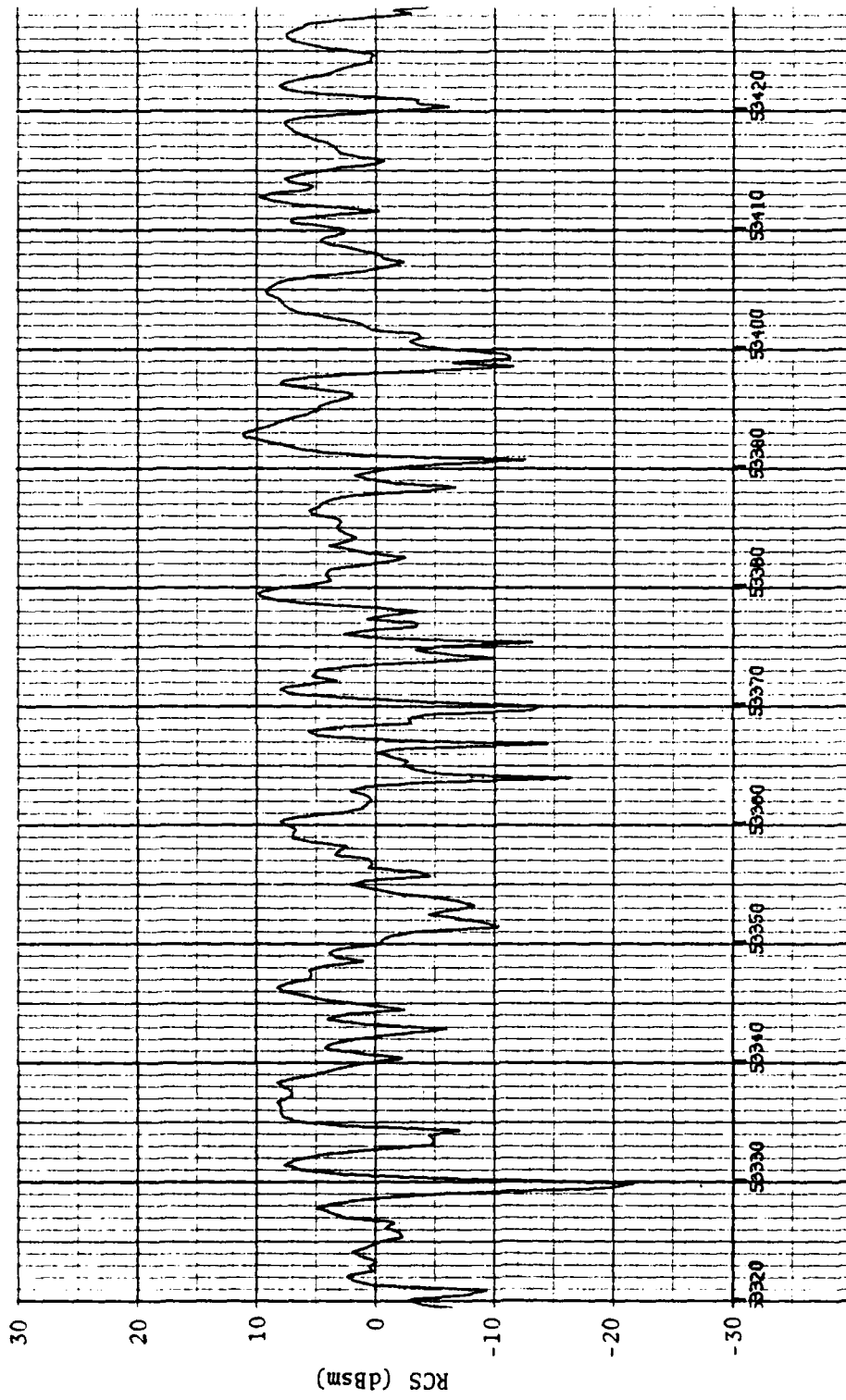


Figure 6 PORTION OF DERIVED NARROWBAND SIGNATURE OF OBJECT 10352 AT 10.0 GHz

Analysis of the signature statistics led to a more positive indication of the validity of the derived signature. Table 2 shows several statistics that compare the derived signature to the three actual signatures. Clearly, the derived signature fits well with the actual signatures, considering the variation among the actual signatures. The other statistic available for comparison was the distribution of RCS values over the signatures. The normalized distributions are shown in Figure 7, and the corresponding cumulative distributions are shown in Figure 8. Again, the derived signature fits well within the bounds established by comparison of the actual narrowband signatures.

TABLE 2
COMPARISON OF ACTUAL AND DERIVED RCS SIGNATURES

Pass	Mean RCS	Standard Deviation of RCS	Maximum RCS	Minimum RCS
Actual Narrowband 11/8/78	1.3	5.7	12	-25
Actual Narrowband 11/9/78	-1.5	5.9	11	-27
Actual Narrowband 11/8/78	0.9	5.6	12	-23
Derived from Wideband 11/7/78	1.4	5.4	13	-25

The major conclusion that can be drawn from this investigation is that, theoretically and practically, narrowband signatures derived from wideband data are a very good representation of actual narrowband signatures. The most important restriction is that the signal-to-noise ratio (SNR) of the derived signature is lower than the original wideband SNR by the ratio of the bandwidths, if the wideband signal spectrum is flat, as is typical. There is no restriction on the complexity or number of radar scatterers of the target.

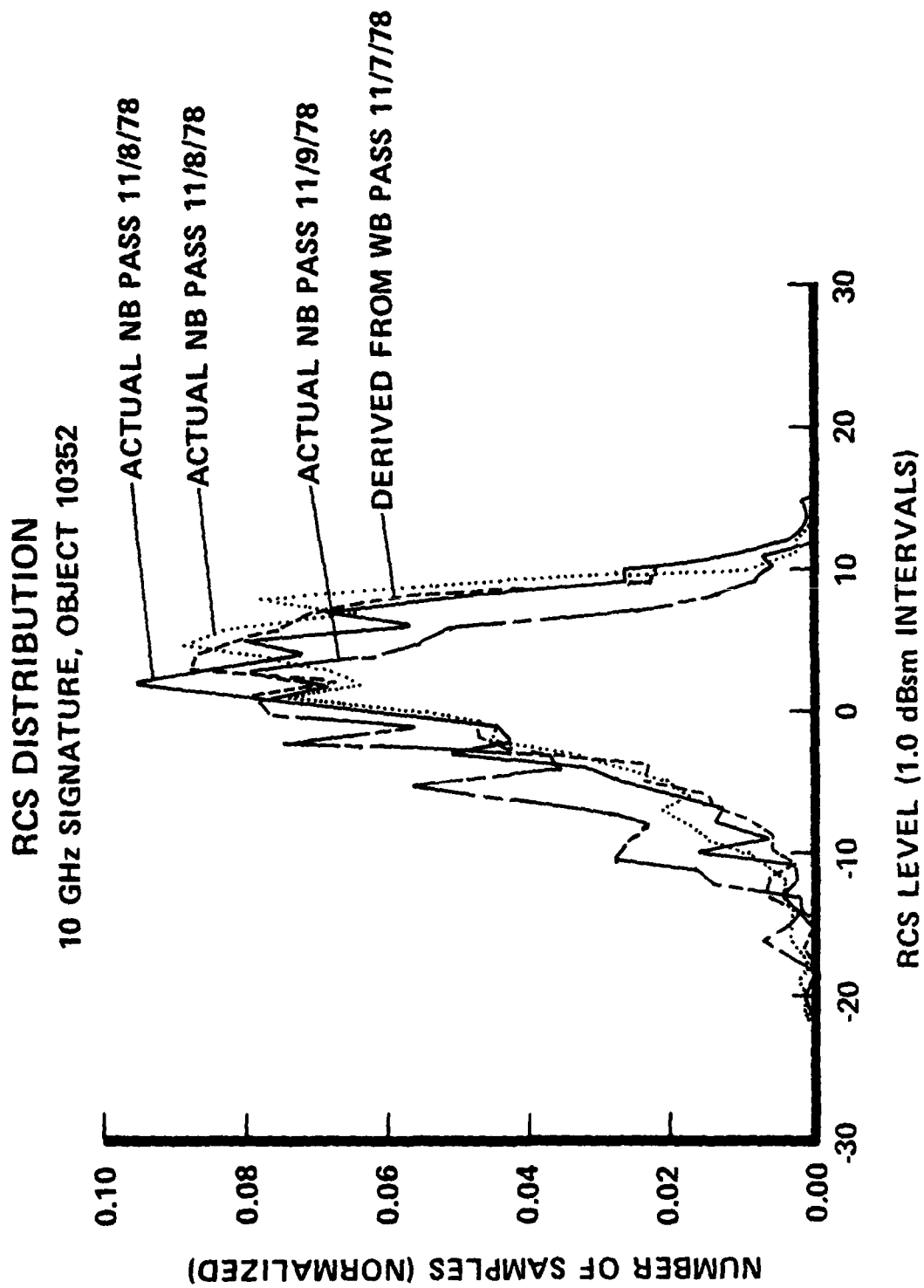


Figure 7 RCS DISTRIBUTION

**CUMULATIVE RCS DISTRIBUTION
10 GHz SIGNATURE, OBJECT 10352**

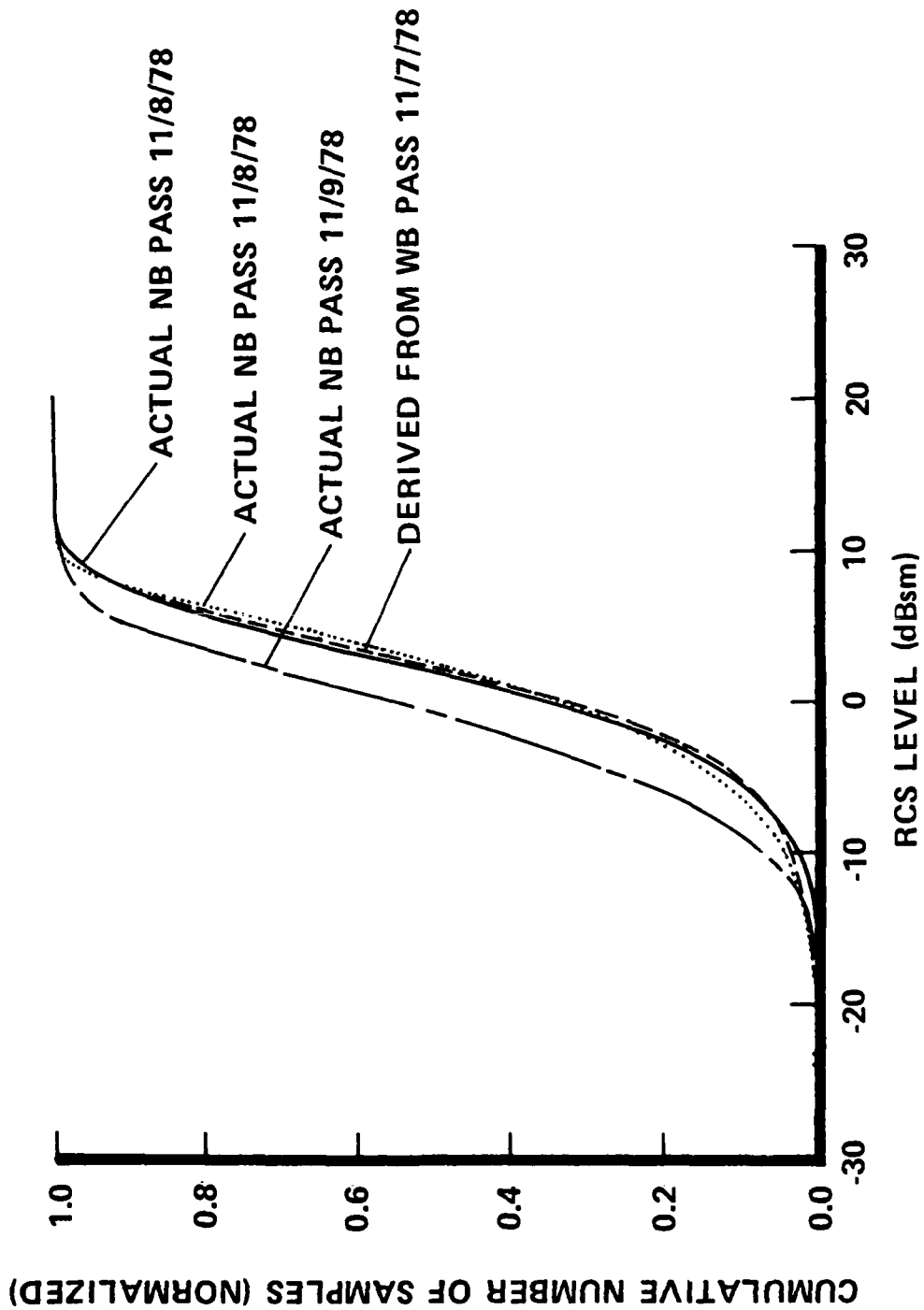


Figure 8 CUMULATIVE RCS DISTRIBUTION

The value of this capability to derive narrowband information from wideband data is multifold. 1) Narrowband data can be obtained without the necessity of modifying a wideband radar transmitter and receiver. 2) Narrowband data at multiple frequencies can be obtained simultaneously from the wideband data, permitting different radars and/or frequency-agile radars to be compared under identical geometric conditions and with real rather than simulated data. An example of a return at a second frequency is given in Figure 9; the sample corresponds to that shown in Figure 6. 3) Although not specifically discussed here, phase coherence is not lost in this filtering process, which means that coherent waveforms can be evaluated using data derived by this process.

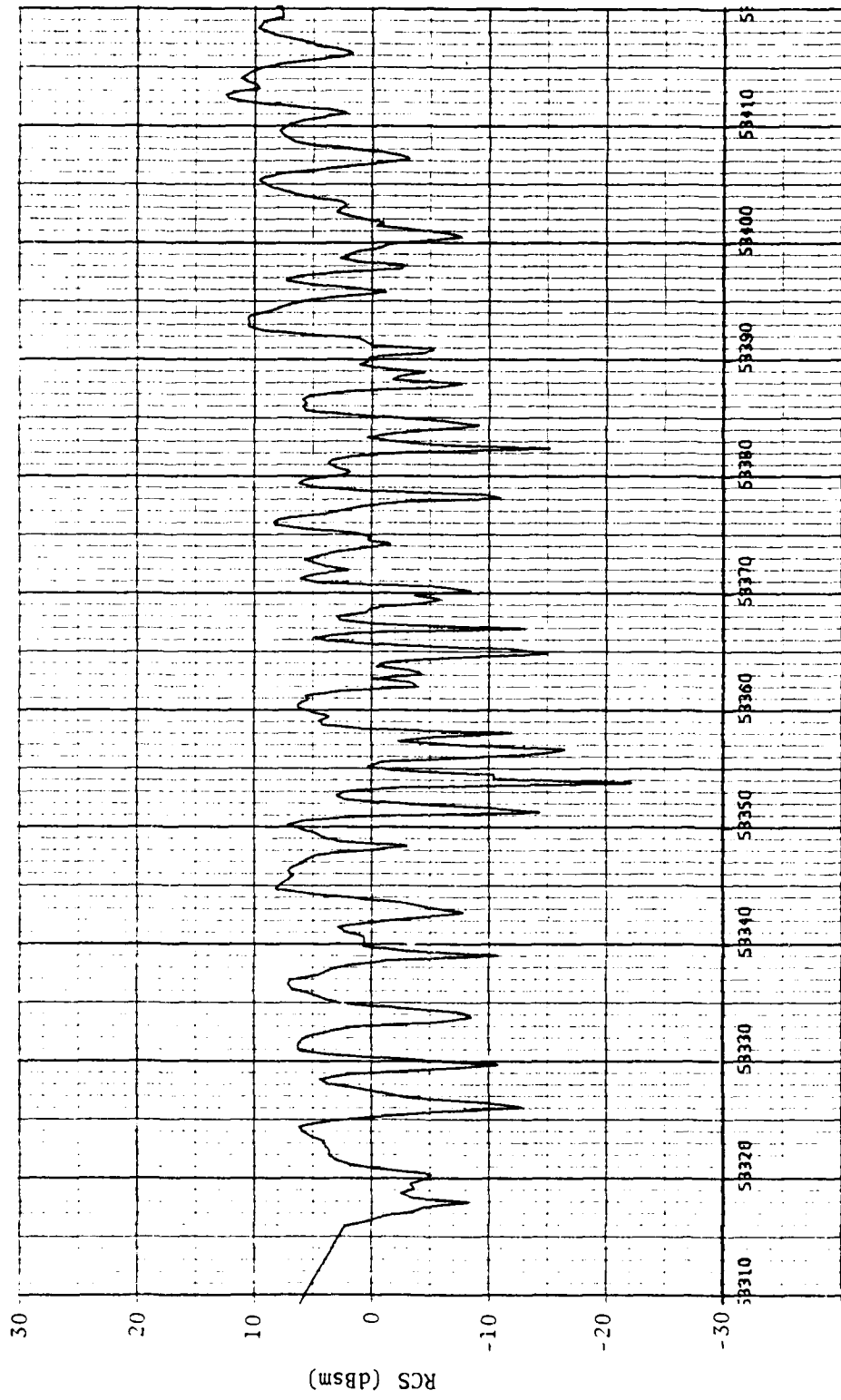


Figure 9 PORTION OF DERIVED NARROWBAND SIGNATURE OF OBJECT 10352 AT 10.032 GHz

APPENDIX A

DERIVATION OF NARROWBAND SIGNALS FROM WIDEBAND SIGNALS

This appendix shows that narrowband radar returns can be derived from wideband returns by a simple filtering operation. This is done by showing that the output from filtering a wideband return is identical to the output that would have been obtained if the radar had transmitted and received a narrowband signal.

A wideband signal $S(t)$ is transmitted; it has the form:

$$S(t) = \sqrt{2 E_T} g(t) \cos [2\pi f_0 t + \phi(t)]$$

where $\int_{-\infty}^{\infty} f^2(t) dt = 1$

E_T = transmitted signal energy

$g(t)$ = amplitude modulation function

$\phi(t)$ = phase modulation function

and f_0 = RF frequency

The signal is reflected from a point target and the return can be represented as:

$$r(t) = \beta \sqrt{2 E_T} g(t) \cos [2\pi(f_0 + f_D) t + \phi(t)] + n(t)$$

where β = channel attenuation

f_D = Doppler frequency shift

$n(t)$ = zero mean white Gaussian noise with spectral density $\frac{1}{2} N_0$

Here it is assumed that the target moves no more than a small fraction of a range resolution cell during the coherent duration of the waveform. If this

is not true, as with the Haystack radar looking at satellites, a simple correction is made to compensate for the known Doppler shift.

The frequency spectrum (amplitude only) of the signal portion of this return, $S(f)$, is shown in Figure A1 (positive frequency only) with the noise power spectral density, $P_{SDN}(f)$, shown below it. The combined signal plus noise return is supplied to a matched filter in the receiver which effectively multiplies the frequency spectrum of the signal $S_0(f)$ by $S_0^*(f)$ and the noise power spectrum density is multiplied by $S_0(f)$

where:

$$S_0(f+f_D) = \frac{1}{2} \int_{-\infty}^{\infty} g(t) \cos [2\pi(f_0+f_D)t + \phi(t)] e^{-j2\pi ft} dt$$

The spectrum at the output of the matched filter may be considered as the combination of signal and noise related terms:

$$|S_0(f)|^2 \text{ and } P_{SDNO}(f), \text{ respectively, and are shown in Figure A2.}$$

Now assume that this signal is next applied to an ideal filter with center frequency f_C and bandwidth B . The signal spectrum portion of the output of this filter is:

$$\begin{aligned} |\hat{S}_0(f)|^2 &= |S(f)|^2 \text{ for } |f+f_C| \leq B/2 \\ &\quad \text{and } |f-f_C| \leq B/2 \\ &= 0 \text{ otherwise} \end{aligned}$$

and the noise power spectrum portion is:

$$\begin{aligned} \hat{P}_{SDNO}(f) &= P_{SDNO}(f) = \frac{N_0}{2} |S(f)|^2 \text{ for } |f+f_0| \leq B/2 \\ &\quad \text{and } |f-f_0| \leq B/2 \\ &= 0 \text{ otherwise} \end{aligned}$$

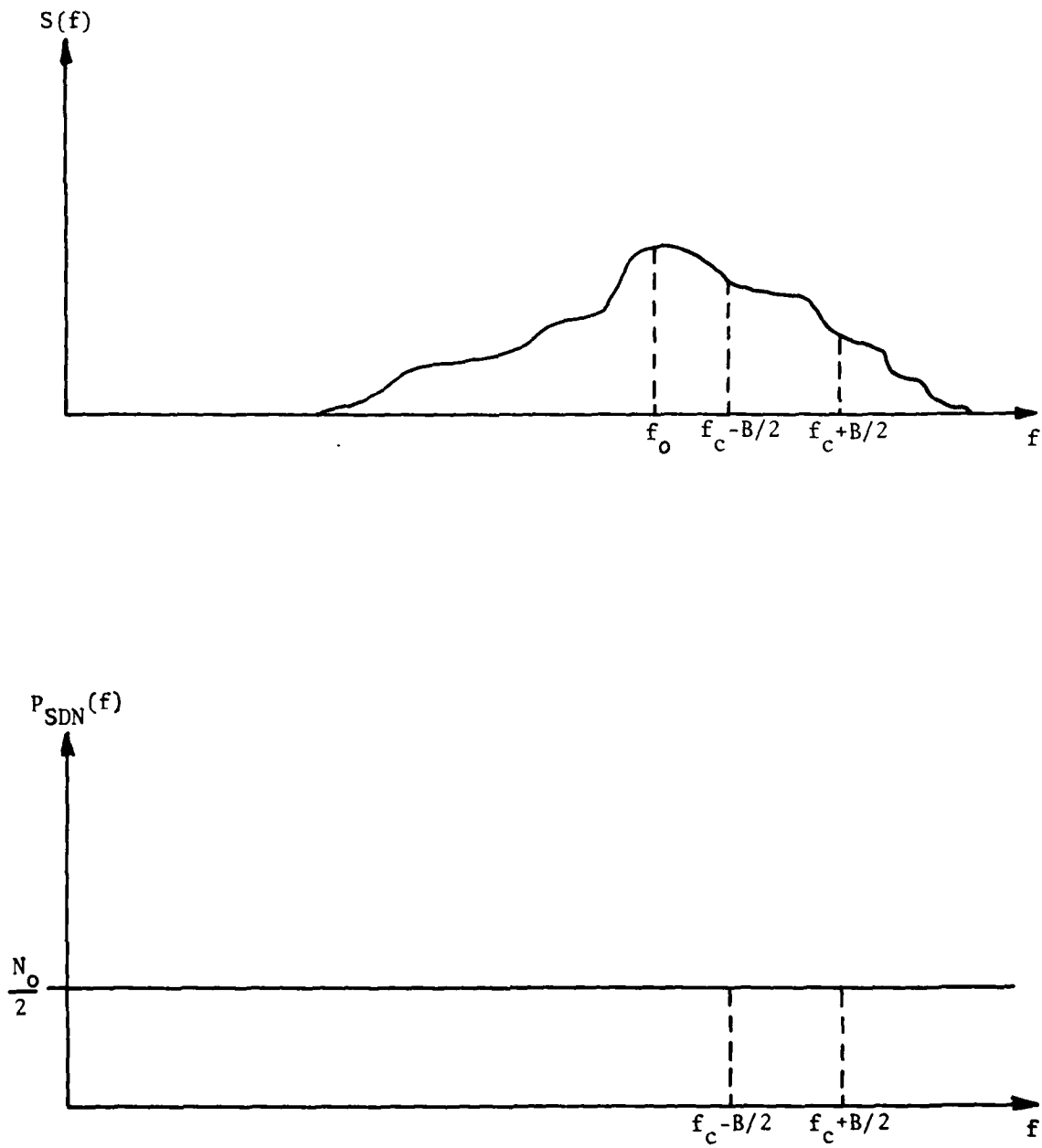


Figure A.1 PREFILTER SIGNAL SPECTRUM AND NOISE POWER SPECTRAL DENSITY

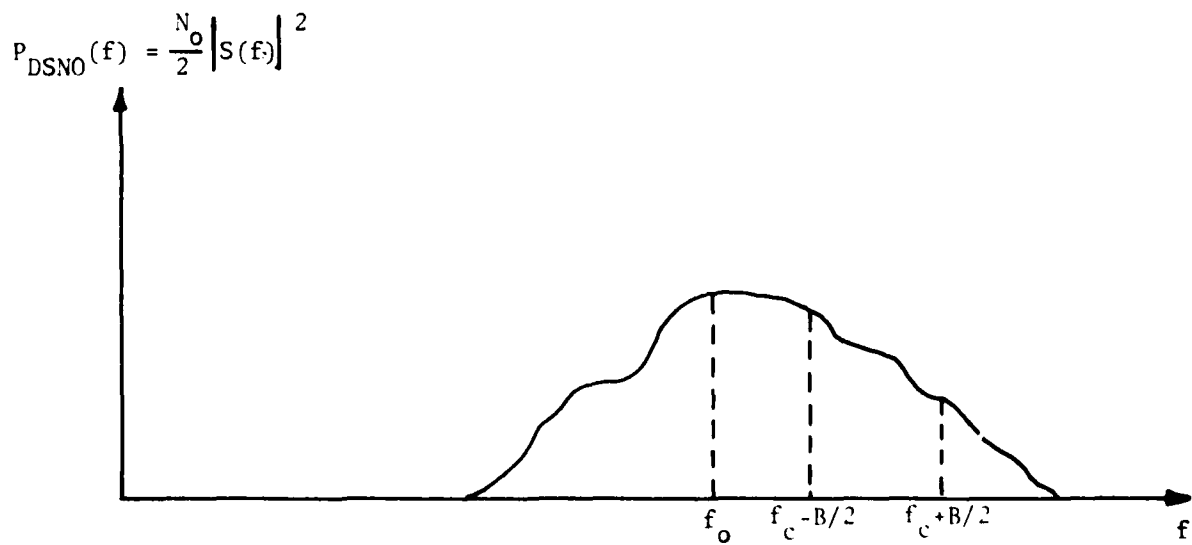
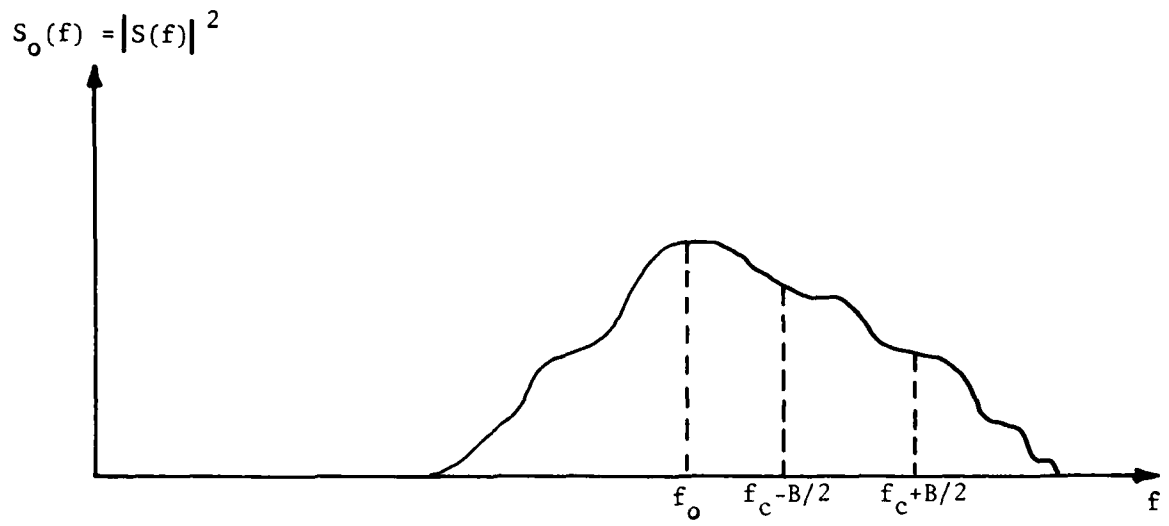


Figure A.2 POSTFILTER SIGNAL SPECTRUM AND NOISE POWER SPECTRUM

This return from the ideal filter is equivalent to the output of the matched filter if the input signal was originally

$$\hat{S}(t) = 2 \operatorname{Re} \left\{ \int_{f_0 - B/2}^{f_0 + B/2} S_0(f) e^{j2\pi ft} df \right\}$$

It is exactly the return that would have resulted if a narrowband signal (frequencies from $f_0 - B/2$ to $f_0 + B/2$) had been transmitted and received. In other words, filtering a wideband return after receiving will obtain the same result as transmitting and receiving a narrowband signal.

APPENDIX B
SOFTWARE DESCRIPTION AND USERS' GUIDE

I. Physical Characteristics

Tape #AXDSRC is a 9-track, non-labeled, 800 BPI tape with the following DCB information: RECFM=FB, LRECL=80, and BLKSIZE=8000. It is IBM compatible and contains 3 files.

II. Format

Each record on the tape is a card image of 80 characters and may be read in the same manner used to read a deck of cards.

III. Contents

The content of each file is as follows:

1. File 1

This file contains the software used to derive the narrowband data from the wideband coherent images. It includes a main driver, a block data routine, processing routines and output routines. The prologues (including inputs and outputs) are given in Table B1. Below is a brief description of each:

- A) MATH - reads inputs and controls program flow through the processing and output routines.
- B) BLOCK - a block data to initialize constants in common /LORINF/ for ladder plots.
- C) Processing routines:
 - INV1 - performs an inverse Fourier transform on complex image data in the cross-range direction to generate wideband pulse shapes.

INV2 - performs an inverse Fourier transform on the complex pulse shapes to generate frequency spectra.

KAISER - generates a set of Kaiser weights for the frequency spectra.

PRDIST - calculates the mean, standard deviation, minimum, maximum, frequencies of occurrence and cumulative distribution of a set of data.

D) Output Routines:

LORINI, LDRPLT, PLT - initializes for and generates the side-band ladder plots.

MAGPLT - generates a printer plot of the magnitudes of a 2-dimensional image.

OUT1 - generates a listing of data statistics calculated in subroutine PRDIST.

E) The following are routines referenced in this program but not included on this tape due to particular machine dependency:

FOURT - performs Cooley-Tukey Fast Fourier Transform

CORE - allows use of I/O statements to perform conversions on a variable list into core instead of to/from an I/O device

CTIME2, DATE, JBNAME - returns time-of-day, date and name of job into core

PLOT, SYMBOL, NUMBER, EFLOT - Calspan basic plot software

PLTTME - see File 3.

2. File 2

This file contains the software used to convert raw wideband radar data into 2-dimensional contour images. The software is composed of a main

driver/processing routine and a contour plot subroutine. The prologues describing each routine and its usage are given in Table B2. Below is a brief description of each:

- A) IMAG2 - reads input data from tape and cards, processes the data for plotting, calls contour subroutine and then writes identifying information on contour image.
- B) MCCNTR - the contour plot subroutine, employs Calspan's basic plot software (PLOT, AXIS, SYMBOL, NUMBER) to generate the 2-dimensional contour images.

3. File 3

This file contains the software used to process narrowband radar data and output results in the form of plots and statistical summaries. The software is composed of a main driver, processing routines and output routines. A brief description of each routine will be given below, while the prologues describing each program can be found in Table B3.

- A) NBAND - reads parameter cards, advances tape to initial position, controls flow through processing and output routines.
- B) Processing Routines:
 - SMOOTH - reads narrowband tape of RCS data in dBsm units, converts to square meters and calculates average RCS for the user selected number of data points.
 - CONVRT - converts an array of RCS data points from square meters to dBsm.
 - PRDIST - calculate the mean, standard deviation, minimum, maximum, and distribution of a set of data.
- C) Output Routines:
 - OUT1 - outputs to the printer the statistics calculated in PRDIST
 - PLTTIME - outputs narrowband plot of RCS vs time.

PLTASP - outputs narrowband plot of RCS vs aspect angle or
projected aspect angle.

Note: As pointed out in File 1 description, the programs on both
File 2 and File 3 call for Calspan's basic plot package composed of PLOT, AXIS,
SYMBOL, NUMBER,--which have not been included on this tape due to particular
machine dependency.

TABLE B1

PROLOGUES TO ROUTINES ON FILE 1

```

CC***** MAIN *****
CC*
CC*
CC*
CC* PURPOSE
CC* TO DERIVE NB DATA FROM WB DATA THROUGH INVERSE FOURIER TRANS-
CC* FORMS.
CC*
CC* METHOD
CC* AN INVERSE FOURIER TRANSFORM IS PERFORMED ON THE COMPLEX
CC* IMAGE IN THE CROSS-RANGE DIRECTION FOR EACH RANGE GATE
CC* REQUESTED. THIS GENERATES THE ORIGINAL WB PULSE SHAPES. AN
CC* INVERSE FFT IS THEN DONE ON EACH PULSE SHAPE TO GENERATE
CC* FREQUENCY SPECTRA. VARIOUS TAPE, LIST AND PLOTS ARE PRODUCED
CC* AT EACH STAGE OF THE PROCESSING. FINALLY, STATISTICS ARE DONE
CC* ON A SINGLE FREQUENCY (IFSTAT).
CC*
CC* PROGRAM INPUTS:
CC* TAPES - UNIT 1: WB COMPLEX IMAGE TAPE FROM LL
CC* CARDS - UP TO 3 NAMELISTS ARE READ:
CC*   &INPUT1 - REQUIRED
CC*   NGATE1 - FIRST RANGE GATE IN IMAGE TO BE PROCESSED
CC*   NGATES - NUMBER OF GATES TO BE PROCESSED (MUST BE
CC*             DIVISIBLE BY 4)
CC*   NIMAGS - NUMBER OF IMAGES TO PROCESS
CC*   SLL - SIDELobe LEVEL (DB) FOR WEIGHTING
CC*   MGPLTS - LOG. INDICATOR FOR MAGNITUDE PLOTS OF THE
CC*             IMAGE, WB PULSES & FREQ (FOR EACH IMAGE)
CC*   WBLDR - LOGICAL INDICATOR FOR WB LADDER PLOT
CC*   WBTAPE - LOG. INDICATOR FOR WB PULSE SHAPE TAPE.
CC*   WBLST - LOG. INDICATOR FOR DIAG. LIST OF 1 PULSE
CC*   IPLIST - PULSE NUMBER TO BE LISTED
CC*   NBPLT - LOG. INDICATOR FOR NB RCS VS. TIME PLOT
CC*   NBTAPE - LOG. INDICATOR FOR NB FREQUENCY TAPE
CC*   NBLST - LOG. INDICATOR FOR DIAG. LIST OF 1 FREQ.
CC*   IFLIST - FREQ NUMBER TO BE LISTED
CC*   IFPLUT - FREQ NUMBER TO BE PLOTTED ON RCS PLOT
CC*   IFSTAT - FREQ NUMBER FOR STATISTICS
CC*   RCSL - LOW BIN RCS VALUE FOR HISTOGRAM
CC*   RCSR - HIGH BIN RCS FOR HIST.
CC*   RCSINC - RCS INCREMENT FOR HIST.
CC*   CALIB - CALIBRATION FACTOR FOR FREQ DATA
CC*   LDRINF - READ ONLY IF WBLDR=T
CC*   XLEFT, XRIGHT, XLEN, YBOT, YTOP, YLEN, LABREP, RUNGSP
CC*   **FOR DESCRIPTION OF THESE SEE COMMON LDRINF BELOW**
CC*   &TIMEPLT - READ (BY SUBROUTINE PLTIME) ONLY IF NBPLT=T
CC*   RCSLNG - LENGTH (IN) OF RCS (Y) AXIS
CC*   RCSLCL - INCREMENT PER INCH (DB) FOR RCS
CC*   TMSLCL - INCREMENT PER INCH (SEC) FOR TIME (X) AXIS
CC*   TAPEID - TITLE TO BE PLACED ON RCS PLOT
CC*   RCSTTL - TITLE FOR RCS AXIS
CC*   RCSMIN - MIN. VALUE FOR RCS
CC*
CC* PROGRAM OUTPUTS:
CC* TAPES - UNIT 2: WB PULSE SHAPES (IF WBTAPE=T)
CC*         UNIT 3: DERIVED NB DATA FOR ALL FREQUENCIES (IF NBTAPE
CC*           =T)
CC* PLOTS - 2 POSSIBLE (NOT BOTH IN 1 RUN):
CC* 1) WB PULSE SHAPE LADDER PLOT (IF WBLDR=T)
CC* 2) NB RCS VS. TIME PLOT FOR FREQ # IFPLUT (IF NBPLT=T)
CC* LISTS - PRINTER PLOTS OF MAGNITUDE (IF MGPLTS=T) OF:
CC* WB IMAGES, WB PULSES AND NB FREQUENCIES
CC* DIAG. LIST OF PULSE # IPLIST (IF WBLST=T)
CC* DIAG. LIST OF FREQ # IFLIST (IF NBLST=T)
CC* STATISTICAL RESULTS FOR EACH IMAGE
CC*
CC* COMMON VARIABLES USED
CC* /LDRINF/ - VARIABLES USED FOR WB LADDER PLOT
CC*
CC* REMARKS
CC* - TO PRODUCE A WB LADDER PLOT, PLOTTER=CALCOMP,LUNG=V,
CC* PAPER=SG SHOULD BE SPECIFIED ON THE EXEC CARD
CC* - TO PRODUCE A NB RCS PLOT, PLOTTER=CALCOMP,LUNG=X,PAPER=SG
CC* SHOULD BE USED
CC* - AT THIS TIME, THE PROGRAM CAN DO EITHER THE LADDER PLOT OR
CC* THE RCS PLOT, NOT BOTH

```

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TABLE B1

PROLOGUES TO ROUTINES ON FILE 1 (CONT.)

```

CC*
CC* SUBROUTINE AND FUNCTION SUBPROGRAMS REQUIRED
CC* CTIML2,DATE,EPPLUF,JBNAME - CALSUBS
CC* KAISER
CC* INV1,INV2,LDRINI,LDRPLT,PNDIST,OUT1,PLTIME - STORED ON PRIVATE
CC* DISKLIB 'LCMD,DISKLIB'
CC*
CC* AUTHOR/PROGRAMMER
CC* C.M.SZCZESNY
CC* MAR 1979
CC*
CC* ***** BLOCK *****
CC*
CC* SUBROUTINE BLOCK
CC*
CC* PURPOSE
CC* TO INITIALIZE VARIABLES IN COMMON
CC*
CC* COMMON VARIABLES USED
CC* VARIABLES ARE INITIALIZED IN THE FOLLOWING COMMONS:
CC* LDRINF
CC*
CC* AUTHOR/PROGRAMMER
CC* C.M.SZCZESNY
CC* MAR 1979
CC*
CC* ***** INV1 *****
CC*
CC* SUBROUTINE INV1
CC*
CC* PURPOSE
CC* TO PERFORM AN INVERSE FOURIER TRANSFORM ON COMPLEX IMAGE
CC* DATA IN THE CROSS-RANGE DIRECTION, TO GENERATE WB PULSE
CC* SHAPES.
CC*
CC* CALLING SEQUENCE
CC* CALL INV1 (V,NF,NG,NTOL)
CC*
CC* DESCRIPTION OF PARAMETERS
CC* INPUTS:
CC* NF - NO. OF CROSS-RANGE CELLS IN THE IMAGE
CC* NG - NO. OF RANGE GATES IN THE IMAGE
CC* NTOL - ACTUAL NO. OF PULSES USED TO GENERATE THE IMAGE
CC* HYBRIDS:
CC* V - COMPLEX ARRAY CONTAINING THE 2-DIMENSIONAL IMAGE
CC*
CC* COMMON VARIABLES USED
CC* NONE
CC*
CC* SUBROUTINE AND FUNCTION SUBPROGRAMS REQUIRED
CC* FOURT - CALSUBS FOURIER TRANSFORM ROUTINE
CC*
CC* AUTHOR/PROGRAMMER
CC* M.BURNS
CC* MAR 1979
CC*
CC* ***** INV2 *****
CC*
CC* SUBROUTINE INV2
CC*
CC* PURPOSE
CC* TO PERFORM AN INVERSE FOURIER TRANSFORM ON COMPLEX IMAGE
CC* DATA IN THE RANGE DIRECTION TO GENERATE FREQUENCY SPECTRA
CC* FROM THE WB PULSE SHAPES.
CC*
CC* CALLING SEQUENCE
CC* CALL INV2 (V,NF,NG,NTOL,WT2,CALIB)
CC*
CC* DESCRIPTION OF PARAMETERS
CC* INPUTS:
CC* NF - NO. OF CROSS-RANGE CELLS IN THE IMAGE
CC* NG - NO. OF RANGE GATES IN THE IMAGE
CC* NTOL - ACTUAL NO. OF PULSES USED TO GENERATE THE IMAGE
CC* WT2 - ARRAY OF WEIGHTS FOR THE RANGE DIMENSION
CC* CALIB - CALIBRATION FACTOR FOR SPECTRAL DATA
CC* HYBRIDS:
CC* V - COMPLEX ARRAY CONTAINING THE 2-DIMENSIONAL IMAGE
CC*
CC* COMMON VARIABLES USED
CC* NONE
CC*
CC* SUBROUTINE AND FUNCTION SUBPROGRAMS REQUIRED
CC* FOURT - CALSUBS FOURIER TRANSFORM ROUTINE

```

TABLE B1

PROLOGUES TO ROUTINES ON FILE 1 (CONT.)

```

CC*
CC* AUTHOR/PROGRAMMER
CC* M.BURNS
CC* MAR 1979
CC*
CC*****
CC***** KAISER *****
CC*
CC* SUBROUTINE KAISER
CC*
CC* PURPOSE
CC* GENERATES A SET OF KAISER WEIGHTS.
CC*
CC* CALLING SEQUENCE
CC* CALL KAISER (N,SLL,BUF, IER)
CC*
CC* DESCRIPTION OF PARAMETERS
CC* INPUTS:
CC* N - NUMBER OF SAMPLES
CC* SLL - DESIRED LEVEL OF SIDELOBES BELOW MAINLOBE IN DB(NEG.)
CC* OUTPUTS:
CC* BUF - ARRAY FOR WEIGHTS
CC* IER - ERROR FLAG
CC* IF NON-ZERO, THEN INPUT SLL WAS BAD AND DEFAULT
CC* WEIGHTING IS CHOSEN.
CC*
CC* COMMON VARIABLES USED
CC* NONE
CC*
CC* SUBROUTINE AND FUNCTION SUBPROGRAMS REQUIRED
CC* NONE
CC*
CC* AUTHOR/PROGRAMMER
CC* M.BURNS
CC* MAR 1979
CC*
CC*****
CC***** PRODIST *****
CC*
CC* SUBROUTINE PRODIST
CC*
CC* PURPOSE
CC* EVALUATION OF DATA STATISTICS
CC* 1) MEAN VALUE
CC* 2) STANDARD DEVIATION
CC* 3) MAXIMUM
CC* 4) MINIMUM
CC* 5) HISTOGRAM(FREQUENCIES OF OCCURRENCE)
CC* 6) CUMULATIVE DISTRIBUTION
CC*
CC* CALLING SEQUENCE
CC* CALL PRODIST (X,NP,A,B,C,D,EX)
CC*
CC* DESCRIPTION OF PARAMETERS
CC* INPUTS:
CC* X IS THE NAME FOR THE DATA ARRAY
CC* NP IS THE NUMBER OF DATA POINTS
CC* A,B,C,.... DEFINE CELL SIZES AS
CC* A(B)C(D)E - ( THAT IS, A TO C IN INCREMENTS OF SIZE B,
CC* THEN TO E IN INCREMENTS OF SIZE D).
CC* FOR A(B)C, SET E=D=C OR SET E= 0.0.
CC*
CC* COMMON VARIABLES USED
CC* OUTPUTS:
CC* /LCPROB/ SCL DESC. OF PARAMETERS IN REMARKS
CC*
CC* REMARKS
CC* RESULTS ARE LEFT IN LABELED COMMON LCPROB, DEFINED BY
CC* COMMON/LCPROB/ NBUCK(101),DIST(101),CELL1(102),XMAX,XMIN,
CC* XBAR,DEV,K1,NX
CC* NBUCK(I) IS THE NO. OF OCCURRENCES(INTEGER) FOR THE ITH CELL.
CC* DIST(I) IS THE CUMULATIVE DISTRIBUTION(FLOATING POINT VALUE IN
CC* INTERVAL 0.0 TO 1.0) CORRESPONDING TO THE RIGHT HAND
CC* EDGE OF THE ITH CELL.
CC* CELL1(I),CELL1(I+1) DEFINE THE LEFT AND RIGHT HAND EDGES,
CC* RESPECTIVELY, OF THE ITH CELL. (CELL1(1) IS SET TO
CC* -10**75 CELL1(K1+1) IS SET TO 10**75 BY THE PROGRAM
CC* XMAX,XMIN ARE MAXIMUM AND MINIMUM X VALUES, RESPECTIVELY.
CC* XBAR IS THE COMPUTED AVERAGE VALUE FOR THE X S.
CC* DEV IS THE COMPUTED STANDARD DEVIATION FOR THE X S.
CC* K1 IS THE NUMBER OF INTERVALS.
CC* NX IS THE NUMBER OF DATA POINTS (=NP)

```

TABLE B1

PROLOGUES TO ROUTINES ON FILE 1 (CONT.)

```

CC*
CC* NOTE: A ROUTINE CALLED OUT1 (STORED ON 'LCMD.DISKLIB' AS
CC* AXOUT1) CAN BE USED TO LIST THE RESULTS GENERATED BY
CC* PRDIST.
CC*
CC* SUBROUTINE AND FUNCTION SUBPROGRAMS REQUIRED
CC* NONE
CC*
CC* AUTHOR/PROGRAMMER
CC* M.BURNS
CC*
CC* MAR 1979
CC*
CC*****

```

```

CC***** LDRINI *****
CC*
CC* SUBROUTINE LDRINI
CC*
CC* PURPOSE
CC* TO INITIALIZE FOR LADDER PLOTS BY DEFINING PAGE ORIGIN AND
CC* WRITING LADDER LABEL WITH TITLE AND X,Y AXIS DESCRIPTORS.
CC*
CC* CALLING SEQUENCE
CC* CALL LDRINI
CC*
CC* COMMON VARIABLES USED
CC* INPUTS:
CC* /LDRINF/ XTAG,XUNITS,XLEFT,XRIGHT,XLEN,
CC* YTAG,YUNITS,YBOT,YTOP,YLEN,TITLE,RUNGLB
CC*
CC* SUBROUTINE AND FUNCTION SUBPROGRAMS REQUIRED
CC* PLOT,SYMBOL,CORE - CALSUBS
CC*
CC* AUTHOR/PROGRAMMER
CC* C.M.SZCZESNY
CC* FEB 1979
CC*
CC*****

```

```

CC***** LDRPLT *****
CC*
CC* SUBROUTINE LDRPLT
CC*
CC* PURPOSE
CC* TO GENERATE A PLOT OF Y VS. X THAT WILL BE ONE RUNG IN A
CC* LADDER OF SUCH PLOTS.
CC*
CC* CALLING SEQUENCE
CC* CALL LDRPLT (X,Y,NPTS,RUNGID)
CC*
CC* DESCRIPTION OF PARAMETERS
CC* INPUTS:
CC* X - ARRAY OF X DATA VALUES
CC* Y - ARRAY OF Y DATA VALUES
CC* NPTS - NUMBER OF POINTS IN X,Y TO BE PLOTTED
CC* RUNGID - IDENTIFIER FOR THIS RUNG (SUCH AS TIME,RECORD #,ETC)
CC*
CC* COMMON VARIABLES USED
CC* INPUTS:
CC* /LDRINF/ XLEFT,XRIGHT,XLEN,YBOT,YTOP,YLEN,RUNGSP,LABELP
CC*
CC* SUBROUTINE AND FUNCTION SUBPROGRAMS REQUIRED
CC* PLOT,NUMBER - CALSUBS
CC* PLT - DRAWS Y VS. X
CC*
CC* REMARKS
CC* USAGE:
CC* USING SUBROUTINE LDRPLT REQUIRES LINKAGE OF 2 OTHER SUBROUTINE
CC* LDRINI AND PLT (STORED AS GNLDINI AND GNPLT ON LCMD.DISKLIB).
CC* LDRINI MUST BE CALLED ONCE BEFORE 1ST CALL TO LDRPLT.
CC* LDRPLT IS CALLED FOR EACH TRACE THAT IS TO BE A RUNG ON THE
CC* LADDER PLOT. THE CALLING PROGRAM MUST THEN EXECUTE A CALL TO
CC* EFPLDT (ON CALSUBS) AFTER ALL TRACES ARE PLOTTED.
CC*
CC* AUTHOR/PROGRAMMER
CC* C.M.SZCZESNY
CC* FEB 1979
CC*
CC*****

```

TABLE B1

PROLOGUES TO ROUTINES ON FILE 1 (CONT.)

```

CC***** PLT *****
CC*
CC*          SUBROUTINE PLT
CC*
CC*  PURPOSE
CC*    TO PLOT THE (X,Y) COORDINATES AND CLIP THOSE LINES THAT ARE
CC*    ABOVE AND BELOW THE PLOT BOUNDARIES.
CC*
CC*  CALLING SEQUENCE
CC*    CALL PLT (X,Y,NPTS,XMIN,XMAX,XSPAN,YMIN,YMAX,YSPAN)
CC*
CC*  DESCRIPTION OF PARAMETERS
CC*    INPUTS:
CC*      X      - ARRAY OF X DATA VALUES
CC*      Y      - ARRAY OF Y DATA VALUES
CC*      NPTS   - NUMBER OF POINTS IN X,Y TO BE PLOTTED
CC*      XMIN  - MINIMUM VALUE FOR X-AXIS
CC*      XMAX  - MAXIMUM VALUE FOR X-AXIS
CC*      XSPAN - LENGTH(INCHES) OF X-AXIS
CC*      YMIN  - MINIMUM VALUE FOR Y-AXIS
CC*      YMAX  - MAXIMUM VALUE FOR Y-AXIS
CC*      YSPAN - LENGTH(INCHES) OF Y-AXIS
CC*
CC*  COMMON VARIABLES USED
CC*    NONE
CC*
CC*  SUBROUTINE AND FUNCTION SUBPROGRAMS REQUIRED
CC*    PLOT - CALSUBS
CC*
CC*  AUTHOR/PROGRAMMER
CC*    C.M.SZCZESNY
CC*    FEH 1979
CC*
CC*****

```

```

CC***** MAGPLT *****
CC*
CC*          SUBROUTINE MAGPLT
CC*
CC*  PURPOSE
CC*    TO GENERATE A PRINTER PLOT OF THE MAGNITUDES OF A 2-DIMENSION
CC*    IMAGE
CC*
CC*  CALLING SEQUENCE
CC*    CALL MAGPLT (V,NROW,NCOL,VSCALE,VTH)
CC*
CC*  DESCRIPTION OF PARAMETERS
CC*    INPUTS:
CC*      V      - ARRAY CONTAINING THE IMAGE
CC*      NROW  - 1ST DIMEN. OF V (#ELEMENTS IN CROSS-RANGE DIRECTION)
CC*      NCOL  - 2ND DIMEN. OF V (#ELEMENTS IN RANGE DIRECTION)
CC*      VSCALE- SCALE FACTOR FOR V
CC*      VTH   - THRESHOLD TO BE USED ON V
CC*
CC*  COMMON VARIABLES USED
CC*    NONE
CC*
CC*  SUBROUTINE AND FUNCTION SUBPROGRAMS REQUIRED
CC*    NONE
CC*
CC*  AUTHOR/PROGRAMMER
CC*    M.BURNS
CC*    MAR 1979
CC*
CC*****

```

TABLE B1

PROLOGUES TO ROUTINES ON FILE 1 (CONT.)

```

CC***** OUT1 *****
CC*
CC* SUBROUTINE OUT1
CC*
CC* PURPOSE
CC* PRINT OUTPUT OF DATA STATISTICS FROM SUBROUTINE PRDIST
CC*
CC* CALLING SEQUENCE
CC* CALL OUT1
CC*
CC* COMMON VARIABLES USED
CC* INPUTS:
CC* /LCPRUB/
CC* NBUCK - NO. OF OCCURRENCES FOR EACH CELL
CC* DIST - CUMULATIVE DISTRIBUTIONS CORRESPONDING TO RIGHT
CC* HAND EDGE OF EACH CELL
CC* CELL1 - DEFINES THE EDGES OF THE CELLS FROM RIGHT TO LEFT
CC* XMAX - MAXIMUM VALUE
CC* XMIN - MINIMUM VALUE
CC* XBAR - COMPUTED AVERAGE
CC* DEV - COMPUTED STANDARD DEVIATION
CC* K1 - NO. OF INTERVALS
CC* NX - NO. OF DATA POINTS
CC*
CC* REMARKS
CC* SAMPLE PRINT OUT COULD LOOK LIKE THIS.
CC* MEAN= 11.42 SIGMA= 8.6236 MAX.= 30.00 MIN= 1.00 NO. PTS.=200
CC*
CC* CELL FREQ. CUM. CELL FREQ. CUM.
CC* ***** 0. 0. 0. 10.00 12.00 20 60.00
CC* 0. 1.00 0 0. 12.00 14.00 10 65.00
CC* 1.00 2.00 20 10.00 14.00 10 70.00
CC* 2.00 3.00 10 15.00 16.00 20 80.00
CC* 3.00 4.00 10 20.00 18.00 10 85.00
CC* 4.00 5.00 10 25.00 20.00 5 87.50
CC* 5.00 6.00 10 30.00 22.00 0 87.50
CC* 6.00 7.00 10 35.00 24.00 5 90.00
CC* 7.00 8.00 10 40.00 26.00 0 90.00
CC* 8.00 9.00 10 45.00 28.00 0 90.00
CC* 9.00 10.00 10 50.00 30.00 ***** 20 100.00
CC*
CC* A SKIP TO A NEW SHEET PLUS A HEADER LINE SHOULD BE SUPPLIED
CC* BY THE USER IN THE MAIN CALLING PROGRAM.
CC*
CC* SUBROUTINE AND FUNCTION SUBPROGRAMS REQUIRED
CC* NONE
CC*
CC* AUTHOR/PROGRAMMER
CC* BURNS/SZCZESNY
CC* MAR 1979
CC*
CC*****

```

TABLE B2

PROLOGUES TO ROUTINES ON FILE 2

```

CC*****
CC
CC          ** IMAG2 **
CC
CC          X-BAND CONTOUR PLOT PROGRAM
CC
CC PURPOSE
CC TO READ A TAPE OF WIDEBAND RADAR DATA, CONVERT
CC THESE DATA INTO MAGNITUDE VALUES AND PRODUCE TWO
CC DIMENSIONAL CONTOUR IMAGES OF THE CONVERTED DATA
CC
CC INPUTS
CC CARDS:
CC VARIABLES TO CONTROL READING, PRINTING, PLOTTING
CC METHOD:
CC 3 NAMELIST STATEMENTS AND 1 FORMATTED READ STATEMENT ARE
CC USED TO INPUT PARAMETERS AS SHOWN BELOW:
CC
CC NAMELIST /DOINDX/ - PARAMETERS TO CONTROL READING OF
CC THE INPUT TAPE
CC NREC1 - THE RECORD NUMBER (POSITION) OF THE INITIAL
CC RECORD TO BE READ FOR EACH IMAGE
CC NREC2 - THE RECORD NUMBER (POSITION) OF THE LAST
CC RECORD TO BE READ FOR EACH IMAGE
CC NIMAGS - THE TOTAL NUMBER OF IMAGES ON THE TAPE
CC NIMAGP - THE NUMBER OF THESE IMAGES TO BE PROCESSED
CC DURING THIS RUN
CC FORMATTED READ (1000) - PARAMETER TO CONTROL WHICH IMAGES
CC ARE PLOTTED. USED IN CONJUNCTION
CC WITH THE NAMELIST DOINDX
CC IMAGNO - AN ARRAY OF IMAGE NUMBERS, IN ASCENDING ORDER,
CC OF THOSE IMAGES TO BE PLOTTED FOR A GIVEN TAPE.
CC SEE COMMENTS BELOW IN THE SOURCE FOR MORE INFO
CC
CC NAMELIST /IFLAGS/ - PRINT AND PLOT FLAGS
CC IPRINT - ASSUMES A VALUE OF 0, 1 OR 2
CC IF 0 - NO OUTPUT TO PRINTER OF MAGNITUDE OR PHASE VALUES
CC IF 1 - MAGNITUDE VALUES ARE OUTPUTTED TO PRINTER
CC IF 2 - MAGNITUDE AND PHASE VALUES ARE OUTPUTTED
CC IPLOT - ASSUMES A VALUE OF 0 OR 1
CC IF 0 - NO CONTOUR PLOTTING OF MAGNITUDE VALUES IS DONE
CC IF 1 - CONTOUR PLOT THE MAGNITUDE VALUES
CC ISCALE - ASSUMES A VALUE OF 0 OR 1
CC IF 0 - USER SUPPLIED INPUTS FOR SIZE OF X AND Y AXIS
CC (SIZEX, SIZEY) AND NUMBER OF UNITS OF X AND Y PER
CC INCH FOR EACH AXIS (XUNITS, YUNITS) ARE PASSED TO
CC THE PLOT SUBROUTINE UNCHANGED.
CC IF 1 - USER SUPPLIED INPUTS FOR SIZEX, XUNITS, YUNITS
CC ARE IGNORED AND THE PROGRAM CALCULATES VALUES
CC FOR THE 3 VARIABLES BASED ON THE RATIO OF CROSS
CC RANGE CELLS TO DOWN RANGE CELLS. SEE SOURCE
CC COMMENTS FOR MORE INFORMATION
CC
CC NAMELIST /IMPLOTT/ - PARAMETERS TO CONTROL THE CONTOUR PLOT
CC PROCEDURE.
CC NLEV - NUMBER OF CONTOUR LEVELS DESIRED
CC CTHV - CONTOUR THRESHOLD VALUE (SMALLEST VALUE CONTOURED)
CC CINC - INCREMENT BETWEEN CONTOUR LINES
CC SIZEX - SIZE OF X AXIS IN INCHES
CC SIZEY - SIZE OF Y AXIS IN INCHES
CC XUNITS - NUMBER OF UNITS OF X PER INCH (E.G. 1.5M/IN)
CC YUNITS - NUMBER OF UNITS OF Y PER INCH
CC XMIN - INITIAL VALUE FOR X AXIS
CC YMIN - INITIAL VALUE FOR Y AXIS
CC YORIGIN - POSITION OF X ORIGIN IN INCHES
CC XORIGIN - POSITION OF Y ORIGIN IN INCHES
CC LABELX - ARRAY OF CHARACTERS FOR X LABEL
CC LABELY - ARRAY OF CHARACTERS FOR Y LABEL
CC LBLsiz - NUMBER OF CHARACTERS IN X OR Y LABEL (SAME SIZE)
CC
CC TAPE:
CC RAW WIDEBAND PULSE DATA TO BE CONVERTED TO
CC MAGNITUDE VALUES FOR PLOTTING

```

TABLE B2

PROLOGUES TO ROUTINES ON FILE 2 (CONT.)

```

CC*
CC*   OUTPUTS
CC*   SYSPRINT - HEADER RECORD FOR EACH IMAGE. ALSO PHASE
CC*             AND MAGNITUDE VALUES IF PRINT FLAG IS "ON"
CC*
CC*   PLOTTER - MAGNITUDE VALUES ASSOCIATED WITH EACH IMAGE
CC*             ARE CONTOUR PLOTTED ALONG WITH APPROPRIATE
CC*             HEADER INFO USING THE VERSATEC PLOTTER
CC*
CC*   SUBROUTINES AND FUNCTION SUBPROGRAMS REQUIRED
CC*
CC*   INTERNAL (IBM SUPPLIED) FORTRAN FUNCTIONS
CC*   AIMAG - EXTRACTS IMAGINARY PORTION OF COMPLEX VAR
CC*   REAL  - EXTRACTS REAL PORTION OF COMPLEX VARIABLE
CC*   ATAN2 - TANGENT FUNCTION ,RETURNS A 4 QUADRANT RESULT
CC*   CABS  - ABSOLUTE VALUE OF COMPLEX VARIABLE
CC*   INT   - INTERGER PORTION OF FLOATING POINT VARIABLE
CC*   ALOG10 - LOG FUNCTION
CC*
CC*   EXTERNAL SUBROUTINE:
CC*   MCCNTR
CC*             PURPOSE: PRODUCE CONTOUR PLOT OF DATA
CC*                       IN A 2-DIMENSIONAL ARRAY
CC*             REQUIRES: PLOT,AXIS,SYMBOL,NUMBER
CC*             ARGUMENTS (2-DIMENSIONAL ARRAY,PLOT
CC*                       PARAMETERS)-SEE DESCRIPTION OF SUB
CC*                       MCCNTR FOR MORE DETAILS
CC*
CC*   AUTHOR/PROGRAMMER
CC*   CALSPAN
CC*   FEB 1979
CC*   P.M.MCMAHON
CC*
CC* ***** MCCNTR *****
CC*
CC*             SUBROUTINE MCCNTR
CC*
CC*   PURPOSE
CC*   TO GENERATE PLOTTED CONTOUR IMAGES OF A 2-DIMENSIONAL ARRAY
CC*   OF DATA POINTS
CC*
CC*   CALLING SEQUENCE
CC*   CALL MCCNTR(A,N1,NX,NY,C,NC,XMIN,DX,ALX,YMIN,DY,ALY,X1,Y1,
CC*             XLAB,YLAB,NL,IPXY)
CC*
CC*   DESCRIPTION OF PARAMETERS
CC*   INPUTS:
CC*   A      - 2 DIMENSIONAL ARRAY OF POINTS TO BE PLOTTED
CC*   N1     - NUMBER OF ROWS IN THE ARRAY IN THE CALLING PROGRAM
CC*   NX     - NUMBER OF X VALUES
CC*   NY     - NUMBER OF Y VALUES
CC*   C      - 1 DIMENSIONAL ARAY OF CONTOUR LEVELS TO BE PLOTTED
CC*   NC     - NUMBER OF CONTOUR LEVELS TO BE PLOTTED
CC*   XMIN   - X VALUE OF FIRST POINT IN THE ARRAY ( USED AS
CC*             THE INITIAL VALUE OF THE X-AXIS)
CC*   DX     - NUMBER OF UNITS OF X/INCH IN THE PLOT (USED AS THE
CC*             INTERVAL FOR THE X AXIS)
CC*   ALX    - LENGTH OF X AXIS IN INCHES
CC*   YMIN   - Y VALUE OF FIRST POINT IN ARRAY A (USED AS THE
CC*             INITIAL VALUE OF THE Y-AXIS)
CC*   DY     - NUMBER OF UNITS OF X/INCH IN THE PLOT (USED AS THE
CC*             INTERVAL FOR THE Y-AXIS)
CC*   ALY    - LENGTH OF Y-AXIS IN INCHES
CC*   X1     - COORDINATE IN INCHES OF THE X ORIGIN (ORIGIN RESET
CC*             FROM 0.0 TO X1,Y1)
CC*   Y1     - COORDINATE IN INCHES OF THE Y ORIGIN
CC*   XLAB   - ARRAY OF CHARACTERS TO BE USED AS THE X LABEL
CC*   YLAB   - ARRAY OF CHARACTERS TO BE USED AS THE Y LABEL
CC*   NL     - NUMBER OF CHARACTERS IN EITHER LABEL (NOTE: LENGTH
CC*             OF XLAB = LENGTH OF YLAB)
CC*   IPXY  - PLOT FLAG, ALWAYS SET AT 2 FOR THIS TYPE OF DATA
CC*             IPXY = 1- PLOT IS SYMETRIC ABOUT X-AXIS,CORRESPONDING
CC*             POINTS PLOTTED IN UPPER QUADRANTS
CC*             IPXY = 2- PLOT ONLY THOSE LEVELS FROM THE GIVEN
CC*             POINTS--PLOT THE DATA AS GIVEN
CC*
CC*   REMARKS
CC*   THE REQUESTED CONTOUR LEVELS ARE INTERPOLATED FROM THE DATA
CC*   POINTS AND THEN WRITTEN TO A DATA SET AND SORTED BEFORE
CC*   BEING PLOTTED ON THE VERSATEC
CC*
CC*   AUTHOR/PROGRAMMER
CC*   E.BECKER
CC*   FEB 1979
CC*   P.M.MCMAHON
CC* *****

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TABLE B3

PROLOGUES TO ROUTINES ON FILE 3

```

CC***** NBAND *****
CC
CC      AXD NARROW BAND PLOT PROGRAM
CC
CC      PURPOSE
CC      TO READ SELECTED RECORDS OF A TAPE OF NARROW BAND RADAR DATA
CC      WHERE EACH RECORD IS COMPOSED OF RADAR CROSS SECTION, TIME,
CC      ASPECT ANGLE AND PROJECTED ASPECT ANGLE AND THEN PERFORM THE
CC      FOLLOWING OPERATIONS:
CC      1) SMOOTH THE DATA ACCORDING TO USER SUPPLIED PARAMETERS
CC      2) CALCULATE DESCRIPTIVE STATISTICS ON THE RCS DATA
CC      3) PLOT RCS VS TIME OR RCS VS ASPECT ANGLE OR RCS VS
CC      PROJECTED ASPECT ANGLE
CC
CC      DESCRIPTION OF PARAMETERS
CC      INPUTS
CC      CARDS:
CC      VARIABLES TO CONTROL SMOOTHING, PLOTTING, STATISTICS, TAPE READING
CC      METHOD-
CC      4 NAMELIST READ STATEMENTS ARE USED TO INPUT PARAMETERS
CC      AS SHOWN BELOW:
CC
CC      NAMELIST /READTP/ - PARAMETERS TO CONTROL READING OF THE
CC      INPUT TAPE
CC      NREC1 - THE RECORD NUMBER OF THE INITIAL RECORD TO BE READ
CC      FROM THE TAPE
CC      NREC2 - THE RECORD NUMBER OF THE LAST RECORD TO BE READ
CC      FROM THE TAPE
CC
CC      NAMELIST /IFLAGS/ - CONVERSION, STATISTICS, PLOT AND TYPE
CC      OF RCS UNITS FLAGS
CC      ICNVRT - ASSUMES A VALUE OF 0 OR 1
CC      IF 0 - NO CONVERSION OF RCS DATA BETWEEN SM AND DBSM
CC      IF 1 - CALL SUBROUTINE TO CONVERT RCS ARRAY FROM
CC      RCS/SM TO RCS/DBSM
CC      ISTATS - ASSUMES A VALUE OF 0 OR 1
CC      IF 0 - DO NOT CALCULATE DESCRIPTIVE STATISTICS ON THE
CC      RCS DATA ARRAY
CC      IF 1 - CALL SUBROUTINE TO CALCULATE DESCRIPTIVE STATS
CC      IPLOT - ASSUMES A VALUE OF 0, 1, 2 OR 3
CC      IF 0 - NO PLOTTING OF ANY DATA IS PERFORMED
CC      IF 1 - PRODUCE A PLOT OF TIME(X) VS RCS(Y) VALUES
CC      IF 2 - PRODUCE A PLOT OF ASPECT ANGLE(X) VS RCS VALUES
CC      IF 3 - PRODUCE A PLOT OF PROJECTED ASPECT ANGLE(X) VS
CC      RCS(Y) VALUES
CC      TYPRCS - ASSUMES A VALUE OF 0 OR 1
CC      IF 0 - RCS IN SM UNITS, THEREFORE NO AUTOMATIC SYMMETRICAL
CC      SCALING OF RCS(Y) AXIS ABOUT 0
CC      IF 1 - RCS IN DBSM UNITS, THEREFORE AUTOMATICALLY SCALE
CC      SYMMETRICALLY ABOUT 0 RCS
CC
CC      NAMELIST /IPULSE/ - PARAMETERS TO CONTROL SMOOTHING AND
CC      DATA OUTPUT
CC      NPULSES - THE NUMBER OF PULSES TO BE AVERAGED TO PRODUCE
CC      ONE RCS DATA POINT FOR PLOTTING OR STATISTICS
CC      NTHOUT - CONTROLS HOW MANY SMOOTHED DATA POINTS ARE
CC      OUTPUTED TO PRINTER FOR CHECKING PURPOSES
CC
CC      NAMELIST /STATS/ - PARAMETERS TO CONTROL THE FREQUENCY
CC      DISTRIBUTION THAT IS OUTPUTED BY
CC      THE STATISTICS ROUTINE
CC
CC      TAPE:
CC      NARROW BAND RADAR RECORDS COMPOSED OF RADAR CROSS SECTION,
CC      TIME OF OBSERVATION AND TWO ASPECT ANGLES
CC      OUTPUTS:
CC      SYSPRINT - HEADER RECORD FOR THE FILE, A RECORD OF DATA FROM
CC      THE TAPE AT A USER SPECIFIED INTERVAL, AND
CC      DESCRIPTIVE STATISTICS INC. FREQUENCY DISTRIBUTION IF
CC      THE ISTATS FLAG IS "ON"
CC      PLOTTER - A LINE PLOT OF RCS(DBSM OR SM) VS TIME, ASPECT ANGLE OR
CC      PROJECTED ASPECT ANGLE IF IPLOT = 1, 2 OR 3, RESPECTIVELY
CC      USING CALSPANS CALCOMP PLOTTER

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TABLE B3

PROLOGUES TO ROUTINES ON FILE 3 (CONT.)

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CC* SUBROUTINE AND FUNCTION SUBPROGRAMS REQUIRED
CC* SMOOTH - PERFORMS SMOOTHING OPERATION ON THE RCS DATA
CC* CONVRT - CONVERTS AN ARRAY OF RCS/SM DATA TO RCS/DBSM DATA
CC* PRDIST - CALCULATE MEAN, STANDARD DEVIATION, MIN, MAX AND
CC* FREQUENCY DISTRIBUTION OF AN ARRAY OF RCS DATA
CC* OUT1 - OUTPUTS RESULTS CALCULATED IN PRDIST
CC* PLTIME - DRAWS A PLOT OF RCS VS TIME ON THE CALCUMP
CC* PLTASP - DRAWS PLOT OF RCS VS ASPECT ANGLE OR RCS VS PROJECTED
CC* ASPECT ANGLE ON CALCUMP
CC*
CC* AUTHOR/PROGRAMMER
CC* P.M.McMAHON
CC* APR 1979
CC* CALSPAN CORPORATION
CC* *****
CC*
CC* ***** SMOOTH *****
CC*
CC* SUBROUTINE SMOOTH
CC*
CC* PURPOSE
CC* TO READ NPLSES RECORDS OF DATA FROM THE NARROW BAND TAPE, CALCULATE
CC* THE MEAN OF THE RCS DATA POINTS AND SELECT THE MEDIAN TIME, ASPECT
CC* ANGLE AND PROJECTED ASPECT VALUES
CC*
CC* CALLING SEQUENCE
CC* CALL SMOOTH(NPLSES,RCSVAL,TMEVAL,ASPECT1,ASPECT2,EOP)
CC*
CC* DESCRIPTION OF PARAMETERS
CC* INPUTS
CC* ARGUMENT LIST:
CC* NPLSES - USER DEFINED VALUE FOR THE NUMBER OF RECORDS TO BE
CC* READ AND AVERAGED
CC* TAPE:
CC* NARROW BAND RADAR TAPE WITH RECORDS COMPOSED OF A RCS VALUE,
CC* TIME VALUE AND 2 ASPECT ANGLES
CC* OUTPUTS
CC* ARGUMENT LIST:
CC* RCSVAL - MEAN OF THE RCS VALUES(AFTER CONVERTING UNITS FROM DBSM
CC* TO SM) FOR NPLSES RECORDS
CC* TMEVAL - MEDIAN TIME VALUE OF THE NPLSES RECORDS
CC* ASPECT1 - MEDIAN ASPECT ANGLE OF THE NPLSES RECORDS
CC* ASPECT2 - MEDIAN PROJECTED ASPECT ANGLE OF THE NPLSES RECORDS
CC* EOP - END OF FILE FLAG, SET TO 1 IF EOF IS REACHED WHILE
CC* READING THE TAPE WITHIN SMOOTH
CC*
CC* REMARKS
CC* THE MAIN PROGRAM ADVANCES THE TAPE TO THE STARTING RECORD AND
CC* TESTS FOR THE END-OF-FILE CONDITION. IF EOP=1, THE OTHER VALUES
CC* BEING RETURNED ARE IGNORED
CC*
CC* SUBROUTINE AND FUNCTION SUBPROGRAMS REQUIRED
CC* NONE
CC*
CC* AUTHOR/PROGRAMMER
CC* P.M.McMAHON
CC* APR 1979
CC* CALSPAN CORPORATION
CC* *****
CC* ***** CONVRT *****
CC*
CC* SUBROUTINE CONVRT
CC*
CC* PURPOSE
CC* CONVERTS AN ARRAY OF RCS(SM) DATA TO RCS(DBSM)
CC*
CC* CALLING SEQUENCE
CC* CALL CONVRT(N,RCSQDB)
CC*
CC* DESCRIPTION OF PARAMETERS
CC* INPUTS
CC* N - NUMBER OF DATA POINTS IN THE RCS ARRAY(MAX=10000)
CC* RCSQDB - THE RCS ARRAY IN ORIGINAL(SQ. M) UNITS
CC* OUTPUTS
CC* RCSQDB - THE RCS ARRAY IN CONVERTED(DBSM) UNITS FOR PLOTTING
CC*
CC* REMARKS
CC* THE ORIGINAL UNITS ON THE TAPE IS DBSM HOWEVER, THE SMOOTH SUB
CC* CONVERTS TO SM BEFORE AVERAGING. THIS ROUTINE CONVERTS BACK TO
CC* DBSM FOR PLOTTING OR STATISTICS

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TABLE B3

PROLOGUES TO ROUTINES ON FILE 3 (CONT.)

```

CC* SUBROUTINE AND FUNCTION SUBPROGRAMS REQUIRED
CC* IBM SUPPLIED LOG FUNCTION ALOG10
CC*
CC* AUTHOR/PROGRAMMER
CC* P.M.MCMAHON
CC* APR 1979
CC* CALSPAN CORPORATION
CC* *****
C* SUBROUTINE PRDIST
C*
C* PURPOSE
C* EVALUATION OF DATA STATISTICS
C* 1) MEAN VALUE
C* 2) STANDARD DEVIATION
C* 3) MAXIMUM
C* 4) MINIMUM
C* 5) HISTOGRAM(FREQUENCIES OF OCCURRENCE)
C* 6) CUMULATIVE DISTRIBUTION
C*
C* USAGE
C* CALL PRDIST(X, NP, A, B, C, D, E)
C*
C* WHERE
C* X IS THE NAME FOR THE DATA ARRAY
C* NP IS THE NUMBER OF DATA POINTS
C* A, B, C, D, E - DEFINE CELL SIZES AS
C* A(B)C(D)E - ( THAT IS, A TO C IN INCREMENTS OF SIZE B,
C* THEN TO E IN INCREMENTS OF SIZE D).
C* FOR A(B)C, SET E=D=C OR SET E= 0.0.
C*
C* REMARKS
C* RESULTS ARE LEFT IN LABELED COMMON LCPROB, DEFINED BY
C* COMMON/LCPROB/ NBUCK(101),DIST(101),CELL1(102),XMAX,XMIN,
C* XBAR,DEV,K1,NX
C*
C* NBUCK(I) IS THE NO. OF OCCURRENCES(INTEGER) FOR THE ITH CELL.
C* DIST(I) IS THE CUMULATIVE DISTRIBUTION(FLOATING POINT VALUE IN
C* INTERVAL 0.0 TO 1.0) CORRESPONDING TO THE RIGHT HAND
C* EDGE OF THE ITH CELL.
C* CELL1(I),CELL1(I+1) DEFINE THE LEFT AND RIGHT HAND EDGES,
C* RESPECTIVELY, OF THE ITH CELL. (CELL1(1) IS SET TO
C* -10**75 CELL1(K1+1) IS SET TO 10**75 BY THE PROGRAM
C* XMAX,XMIN ARE MAXIMUM AND MINIMUM X VALUES, RESPECTIVELY.
C* XBAR IS THE COMPUTED AVERAGE VALUE FOR THE X S.
C* DEV IS THE COMPUTED STANDARD DEVIATION FOR THE X S.
C* K1 IS THE NUMBER OF INTERVALS.
C* NX IS THE NUMBER OF DATA POINTS (= NP)
C*
C* SUBROUTINE AVAILABLE
C*
C* THIS ROUTINE IS AN OPTIONAL OUTPUT ROUTINE COMPATIBLE WITH
C* THE PRECEDING PRDIST ROUTINE.
C* CALLING SEQUENCE - CALL OUT1
C* A SKIP TO A NEW SHEET PLUS A HEADER LINE SHOULD BE SUPPLIED BY
C* THE USER IN THE MAIN PROGRAM.
C* *****
C* SUBROUTINE OUT1
C* PURPOSE
C* PRINT OUTPUT OF DATA STATISTICS FROM SUBROUTINE PRDIST
C*
C* USAGE
C* CALL OUT1
C*
C* REMARKS
C* SAMPLE PRINT OUT COULD LOOK LIKE THIS.
C* MEAN= 11.42 SIGMA= 8.6236 MAX.= 30.00 MIN= 1.00 NO. PTS.=200
C* CELL FREQ. CUM. CELL FREQ. CUM.
C* **** - 0. 0 0. 10.00 - 12.00 20 60.00
C* 0. - 1.00 0 0. 12.00 - 14.00 10 65.00
C* 1.00 - 2.00 20 10.00 14.00 - 16.00 10 70.00
C* 2.00 - 3.00 10 15.00 16.00 - 18.00 20 80.00
C* 3.00 - 4.00 10 20.00 18.00 - 20.00 10 85.00
C* 4.00 - 5.00 10 25.00 20.00 - 22.00 5 87.50
C* 5.00 - 6.00 10 30.00 22.00 - 24.00 0 87.50
C* 6.00 - 7.00 10 35.00 24.00 - 26.00 5 90.00
C* 7.00 - 8.00 10 40.00 26.00 - 28.00 0 90.00
C* 8.00 - 9.00 10 45.00 28.00 - 30.00 0 90.00
C* 9.00 - 10.00 10 50.00 30.00 - ***** 20 100.00
C*
C* A SKIP TO A NEW SHEET PLUS A HEADER LINE SHOULD BE SUPPLIED
C* BY THE USER IN THE MAIN CALLING PROGRAM.
C* *****

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TABLE B3

PROLOGUES TO ROUTINES ON FILE 3 (CONT.)

```

CC***** PLTTIME *****
CC
CC          SUBROUTINE PLTTIME
CC
CC  PURPOSE
CC  DRAW A LINE PLOT OF RADAR CROSS SECTION(OBSM OR SM) VS TIME FOR
CC  REAL OR DERIVED(FROM WIDEBAND) NARROW BAND RADAR DATA.
CC
CC  CALLING SEQUENCE
CC  CALL PLTTIME(TIME,RCSDTA,NDPTS,NREC1,NREC2,NPULSE,NOBJ,FLG)
CC
CC  DESCRIPTION OF PARAMETERS
CC  INPUTS
CC  ARGUMENT LIST:
CC  TIME - ARRAY OF TIME DATA POINTS TO BE PLOTTED
CC  RCSDTA - ARRAY OF RCS DATA POINTS TO BE PLOTTED
CC  NDPTS - ARRAY OF RCS DATA POINTS IN TIME OR RCSDTA
CC  NREC1 - POSITION OF FIRST RECORD READ FROM TAPE - TO PROVIDE
CC  IDENTIFICATION INFORMATION ON THE PLOTTED OUTPUT
CC  NREC2 - POSITION OF LAST RECORD READ FROM TAPE - TO PROVIDE
CC  IDENTIFICATION INFORMATION AS ABOVE
CC  NPULSES - SMOOTHING INTERVAL SELECTED BY USER - FOR PLOT
CC  IDENTIFICATION
CC  NOBJ - OBJECT NUMBER - FOR PLOT IDENTIFICATION
CC  FLG - A FLAG THAT CONTROLS AUTOMATIC SYMMETRICAL SCALING OF
CC  RCS DATA (Y AXIS) ABOUT 01.E. IF FLG=1, SCALING IS
CC  AUTOMATIC. IF NOT 1, USER MUST SUPPLY BEGINNING AND
CC  ENDING POINTS OF THE Y AXIS
CC
CC  OUTPUTS:
CC  LINE PLOT OF RADAR CROSS SECTION VERSUS TIME WITH APPROPRIATE
CC  IDENTIFICATION INFORMATION ON CALSPAN CALCCOMP PLOTTER
CC
CC  SUBROUTINE AND FUNCTION SUBPROGRAMS REQUIRED
CC  CALSPAN PLOT SUBROUTINES
CC  PLOT - BASIC PLOT SUB USED BY HIGHER LEVEL PLOT ROUTINES
CC  AXIS - DRAWS X OR Y AXIS WITH TIC MARKS AND LABELS
CC  SYMBOL - DRAWS ALPHA CHARACTERS OF SPECIFIC SIZE AND LOCATION
CC  NUMBER - DRAWS NUMERIC INFORMATION OF SPECIFIED SIZE AT
CC  A SPECIFIED LOCATION
CC  LINE - DRAWS A STRAIGHT LINE BETWEEN POINTS DEFINED BY
CC  SUCCESSIVE ELEMENTS OF X AND Y ARRAYS
CC  IBM SUPPLIED FORTRAN FUNCTIONS
CC  INT - RETURNS INTEGER PORTION OF FLOATING PLOTT NUMBER
CC-----
CC  AMAXI - RETURNS MAXIMUM VALUE OF ARG OF FLOATING PT NUMBERS
CC  AMINI - RETURNS MINIMUM VALUE OF ARG OF FLOATING PT NUMBERS
CC-----
CC  AUTHOR/PROGRAMMER
CC  P.M.MCMANON
CC  APR 1979
CC
CC*****

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TABLE B3

PROLOGUES TO ROUTINES ON FILE 3 (CONT.)

```

CC***** PLTASP *****
CC
CC          SUBROUTINE PLTASP
CC
CC          PURPOSE
CC          DRAW A LINE PLOT OF RADAR CROSS SECTION(DBSM OR SM) VS ASPECT
CC          ANGLE OR PROJECTED ASPECT ANGLE FOR SELECTED PORTIONS OF NARROW
CC          BAND RADAR TAPE
CC
CC          CALLING SEQUENCE
CC          CALL PLTASP(ANGLE,RCSDTA,NOPTS,NREC1,NREC2,NPULSE,NOBJ,FLG)
CC
CC          REMARKS
CC          IN ORDER FOR THIS PLOT SUBROUTINE TO WORK PROPERLY THE DATA THAT
CC          IS PASSED TO IT MUST BE IN ASCENDING OR DESCENDING ORDER--
CC          THEREFORE UTMOST CARE MUST BE USED IN SPECIFYING NREC1 AND NREC2
CC          TO INSURE THAT THE ANGLE CHOSEN IS INCREASING OR DECREASING
CC          IN ONE DIRECTION ONLY
CC
CC          DESCRIPTION OF PARAMETERS
CC          INPUTS
CC          ARGUMENT LIST:
CC          ANGLE - ARRAY OF ASPECT ANGLE OR PROJECTED ASPECT ANGLE DATA
CC          POINTS TO BE PLOTTED
CC          RCSDTA - ARRAY OF RCS DATA POINTS TO BE PLOTTED
CC          NOPTS - ARRAY OF RCS DATA POINTS IN TIME OR RCSDTA
CC          NREC1 - POSITION OF FIRST RECORD READ FROM TAPE - TO PROVIDE
CC          IDENTIFICATION INFORMATION ON THE PLOTTED OUTPUT
CC          NREC2 - POSITION OF LAST RECORD READ FROM TAPE - TO PROVIDE
CC          IDENTIFICATION INFORMATION AS ABOVE
CC          NPULSES - SMOOTHING INTERVAL SELECTED BY USER - FOR PLOT
CC          IDENTIFICATION
CC          NOBJ - OBJECT NUMBER - FOR PLOT IDENTIFICATION
CC          FLG - A FLAG THAT CONTROLS AUTOMATIC SYMMETRICAL SCALING OF
CC          RCS DATA (Y AXIS) ABOUT 01.0. IF FLG=1, SCALING IS
CC          AUTOMATIC. IF NOT 1, USER MUST SUPPLY BEGINNING AND
CC          ENDING POINTS OF THE Y AXIS
CC
CC          OUTPUTS:
CC          LINE PLOT OF RADAR CROSS SECTION VS ASPECT ANGLE OR PROJECTED
CC          ASPECT ANGLE WITH APPROPRIATE IDENTIFYING INFORMATION ON
CC          CALSPAN CALCOMP PLOTTER
CC
CC          SUBROUTINE AND FUNCTION SUBPROGRAMS REQUIRED
CC          CALSPAN PLOT SUBROUTINES
CC          PLOT - BASIC PLOT SUB USED BY HIGHER LEVEL PLOT ROUTINES
CC          AXIS - DRAWS X OR Y AXIS WITH TIC MARKS AND LABELS
CC          SYMBOL - DRAWS ALPHA CHARACTERS OF SPECIFIC SIZE AND LOCATION
CC          NUMBER - DRAWS NUMERIC INFORMATION OF SPECIFIED SIZE AT
CC          A SPECIFIED LOCATION
CC          LINE - DRAWS A STRAIGHT LINE BETWEEN POINTS DEFINED BY
CC          SUCCESSIVE ELEMENTS OF X AND Y ARRAYS
CC
CC          IBM SUPPLIED FORTRAN FUNCTIONS
CC          INT - RETURNS INTEGER PORTION OF FLOATING POINT NUMBER
CC          AMAX1 - RETURNS MAXIMUM VALUE OF ARG OF FLOATING PT NUMBERS
CC          AMIN1 - RETURNS MINIMUM VALUE OF ARG OF FLOATING PT NUMBERS
CC
CC          AUTHOR/PROGRAMMER
CC          P.M.MCMAHON
CC          APR 1979
CC
CC*****
CC

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FROM COMPTON TO BDU