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A PROCEDURE FOR AUTOMATIC COMPUTER DETECTION AND CATALOGING OF --ETC(U)

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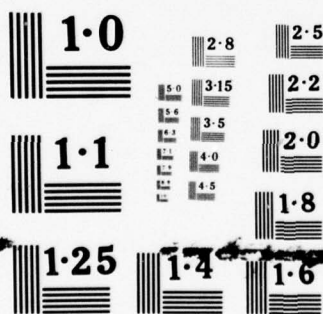
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TECHNICAL NOTE

A PROCEDURE FOR AUTOMATIC COMPUTER
DETECTION AND CATALOGING OF STRONG SIGNALS (U)

by

R. A. Mueller

Submitted to

Commander and Technical Director
Naval Undersea Research and Development Center
San Diego Division
San Diego, California 92132

Attn: Mr. Louis Strauss
Code 603

3 February 1970

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DETECTION AND CATALOGING OF STRONG SIGNALS. (10)

(10) by
R. A. Mueller

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Approved:

A. G. Menke
A. G. Menke
Project Director

Submitted:

R. A. Mueller
R. A. Mueller
Senior Scientist

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INTRODUCTION

(U) This report describes a computer cataloging technique that is capable of detecting strong signals. It was developed for use in analyzing the unprocessed but digitized signal data obtained in the joint US/UK VERULAM/ANDREW sea trials. Using the technique of energy averaging, the time of the peak arrival of one way signals and bottom reflections are detected and recorded.

(U) The methods developed in this report supplement previous cataloging procedures¹ which obtained the precursor transmit time directly from the analog tapes. Rather than duplicating previous work, pertinent data is inputted into the computer program. From the information developed by these methods a master catalog of sonar ping cycles can be obtained.

¹ TRACOR Document No. SD/68-004-U, "Summary Report - A Critique of Analysis Routines for VERULAM Test," 14 March 1968.

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GENERAL DESCRIPTION OF TECHNIQUE

(C) The data obtained during the joint US/UK VERULAM sonar tests were recorded on reels of 12 channel analog tape. In reducing this data individual channels are digitized so that digital techniques can be employed to further process the data. One of the tasks of highest priority is the processing of the two way received signals (echoes). Because of the inherent spreading and reflection losses of the transmitted pulse, the two way signal has a negative signal-to-noise ratio prior to signal processing. To minimize the computer time required to process the signal data, the echo arrival time is estimated by determining the travel time of other signals. To accomplish this a computer program called PEAK TIME was written to permit searching the VERULAM and ANDREW tapes for the time of arrival of certain high signal-to-noise ratio signals. Knowing the time of arrival of those signals would permit prediction of the time of arrival of low signal-to-noise echoes. This would then minimize the duration of signal correlation analysis necessary to find low signal-to-noise ratio signals.

(U) The computer program was configured to search for the time of arrival of the following signals:

VERULAM Tape

1. Main Pulse Fathometer Echo Return
 2. Main Pulse Slant-Bottom Reverberation
 3. Either: Precursor Direct-Path Outbound/ANDREW
Transponded Direct-Path Return
- Or: Precursor Bottom-Bounce Outbound/ANDREW
Transponded Direct-Path Return

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ANDREW Tape

1. Precursor One-Way Direct Path Signal (Optional)
2. Precursor One-Way Bottom-Bounce Signal
3. Main Pulse One-Way Direct-Path Signal (Optional)
4. Main Pulse One-Way Bottom-Bounce Signal

COMPUTER PROCESSING METHOD

(C) The original VERULAM and ANDREW data tapes were analog recordings of the unrectified signal received at each ship. These tapes have been sampled at a frequency of 6,250 Hertz (.00016 sec. interval) to produce digital tapes of the same unrectified signals. The PEAK TIME program first adds the absolute magnitude of a consecutive group of samples to produce an output proportional to the average amplitude of the unrectified signal over the duration of the sample group. A running average is obtained by repeatedly adding a new sample from the leading edge of the group simultaneous with subtracting the oldest sample from the trailing edge of the group. In searching between specified limits in this manner the maximum average value is found along with the time that that maximum occurred.

(U) To search the entire received signal data for each ping cycle is considered to be unnecessarily time consuming. Instead, a calculation is made to determine the approximate time each signal of interest is due to arrive and then to confine the search to a window centered about that time. The equations which are used to determine the window locations for the various signals are found in Appendix A. A derivation is given for the less obvious ones. These equations are used to locate initially the search windows in a series of ping cycles. For subsequent pings the windows are centered about the actual peak arrival times for the previous ping. If the peak is found to lie outside of a specified percentage width of the basic window, as measured



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from the center of the window, the peak is rejected and the time previously found is used. Figure 1 illustrates the averaging interval and the search window width and labels many values with the name used in the program.

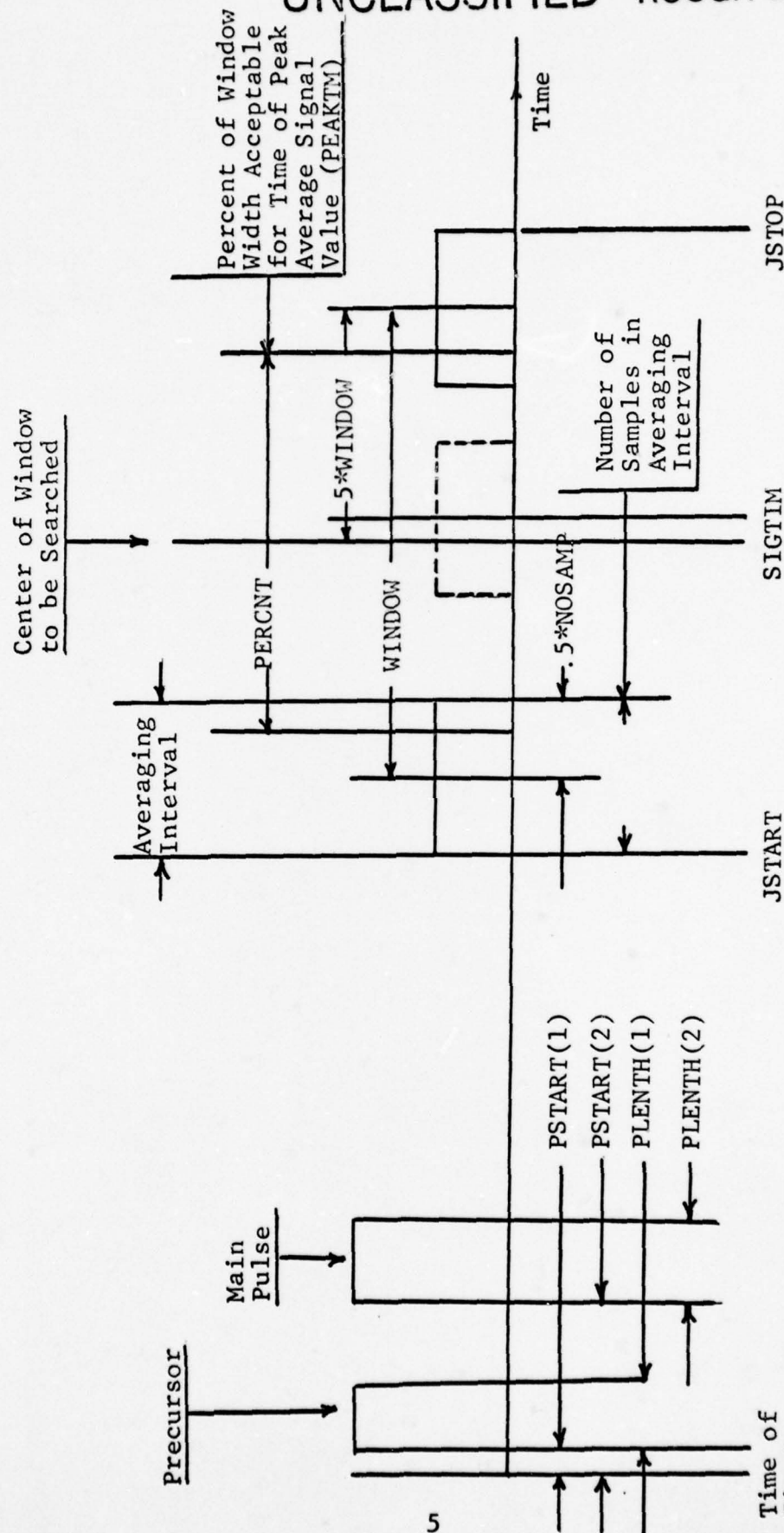
(U) After determining the time of each peak, the program calculates the range which corresponds to that time. In the case of the fathometer return, the range is the water depth. The slant-bottom range is the distance from the VERULAM to the bottom along the assumed straight-line bottom-bounce path to the ANDREW. In all other cases the range calculated is the horizontal range from the VERULAM to the ANDREW. Average range-rate over the most recent two pings is also calculated for the VERULAM to ANDREW cases.

(U) A print-out of the main program and the PEAKSK subroutine is given in Appendix B. A complete list of the required program inputs by Input Card Number and format is shown in Appendix C. A reproduction of the output print-out for a typical run is given in Appendix D along with an explanation of the meaning of the various names used.

RESULTS

(U) The program was test run using VERULAM digital tape number FT-155 and ANDREW digital tape number FT-162. These tapes cover the LFM pulses from ping numbers 25 to 53 for Run Number 684.

(C) Figure 2 shows the results obtained from the analysis. The time found for the peak signal for each ping is shown for the fathometer, the slant-bottom, and the bottom-bounce transponder/direct-path returns. The 90 percent window width limits within which the signal was required to lie are shown in each case. It may be seen that the fathometer return lies well within these limits in every case. (The fathometer window was 1.5 sec



JMAX - Center Sample Number of Averaging Interval having maximum value within search window. JMAX occurs at time PEAKTM.

Figure 1 AVERAGING INTERVAL AND SEARCH WINDOW WIDTH

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TIME
SEC.

VERULAM DIGITAL TAPE NO. FT-155

36.0

35.0

34.0

PRECURSOR BOTTOM-BOUNCE/TRANSPONDER DIRECT-PATH RETURN

.9
Window
Width
Limits

15.0

14.0

SLANT-BOTTOM RETURN

.9
Window
Width
Limits

7.0

6.0

FATHOMETER RETURN

.9
Window
Width
Limits

Figure 2 TRACKING OF FATHOMETER, SLANT-BOTTOM, AND ANDREW
TRANSPONDER RETURNS RECEIVED BY VERULAM

27

31

35

39

6

43

47

51

PING NO.

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permitting a deviation of .675 sec). It is interesting to note, however, that the fathometer return shifted by as much as 7% between successive returns in some cases.

(C) The slant-bottom return is also seen to lie well within its prescribed limits of .9 sec. However, this is not so for the transponded return from the ANDREW. Here the peak was found in most cases to lie up against one or the other edges of the window, indicating that there was, in fact, no peak within the window. A subsequent examination of the ANDREW analog tape indicates that the transponder delay time varied in an erratic manner and this explains the inability of the program to find a signal peak in the region it was presumed to exist.

(C) Figure 3 shows the results obtained from an analysis of the ANDREW tape over the same pings as covered by the VERULAM tape FT-155. The precursor bottom-bounce signal was required to lie within very narrow limits ($\pm .135$ sec) since it had a pulse duration of only 0.1 sec. It is seen that the program has tracked the signal well even with this narrow band. The main-pulse bottom-bounce signal, being of 1.0 sec duration was given broader limits ($\pm .9$ sec). The program appears to track this signal also.

CONCLUSIONS

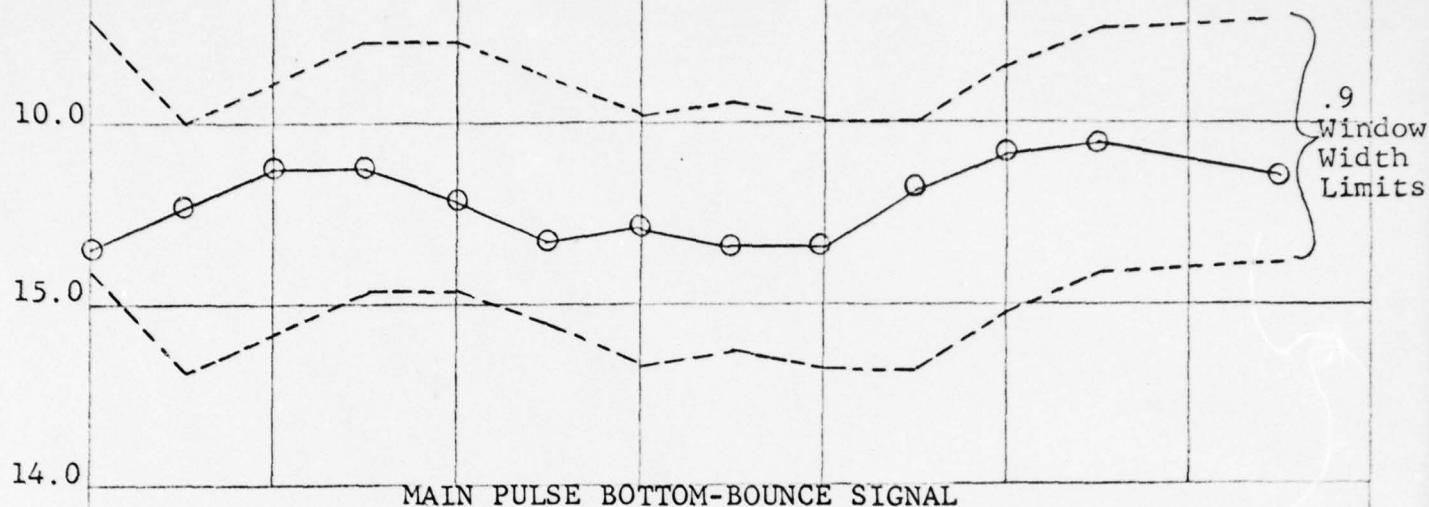
(C) The computer program appears capable of tracking all VERULAM and ANDREW signals well except those transponded by the ANDREW. This failure appears to be caused by an erratic time delay in the ANDREW transponder. Only by inputting the actual delay in the ANDREW transponder. Only by inputting the actual delay time for each ping could this condition be rectified. This would require examining the ANDREW tape to determine the actual delay time for each ping and inputting this value (ADELAY) for each ping search. The program would have to be modified to the extent of shifting ADELAY as an input from card number 2 to card numbers 5 and beyond as necessitated by the number of pings being searched.

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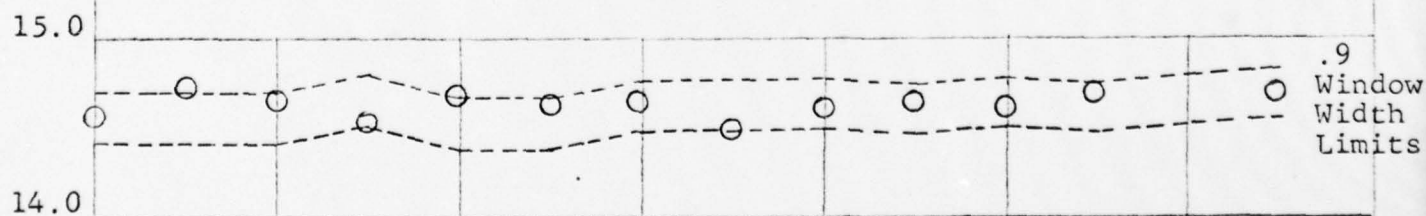
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TIME
SEC.

ANDREW DIGITAL TAPE NO. FT-162



MAIN PULSE BOTTOM-BOUNCE SIGNAL



PRECURSOR BOTTOM-BOUNCE SIGNAL

Figure 3 TRACKING OF PRECURSOR AND MAIN PULSE BOTTOM-BOUNCE SIGNALS RECEIVED BY ANDREW

27

31

35

39

8

43

47

51

PING NO.

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APPENDIX A

TIME AT WHICH SEARCH WINDOWS SHOULD BE
CENTERED WHEN LOOKING FOR SIGNAL PEAKS (U)

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APPENDIX A

TIME AT WHICH SEARCH WINDOWS SHOULD BE
CENTERED WHEN LOOKING FOR SIGNAL PEAKS (U)

A-1 (U) DEFINITION OF SYMBOLS

- R = VERULAM to ANDREW horizontal range in feet
(Fig. A-1)
- S = Straight-line slant-bottom distance in feet along
bottom-bounce path from VERULAM to ANDREW
(Fig. A-1)
- h = Ocean depth in feet (Fig. A-1)
- τ_b = Time from reference to beginning of transmission
(Fig. A-2)
- τ_c = Time from reference to center of transmission
(Fig. A-2)
- τ_e = Time from reference to end of transmission
(Fig. A-2)
- t_A = ANDREW transponder delay time (Fig. A-2)
- t_B = ANDREW transponder pulse duration (Fig. A-2)
- C = Speed of sound in seawater in ft/sec

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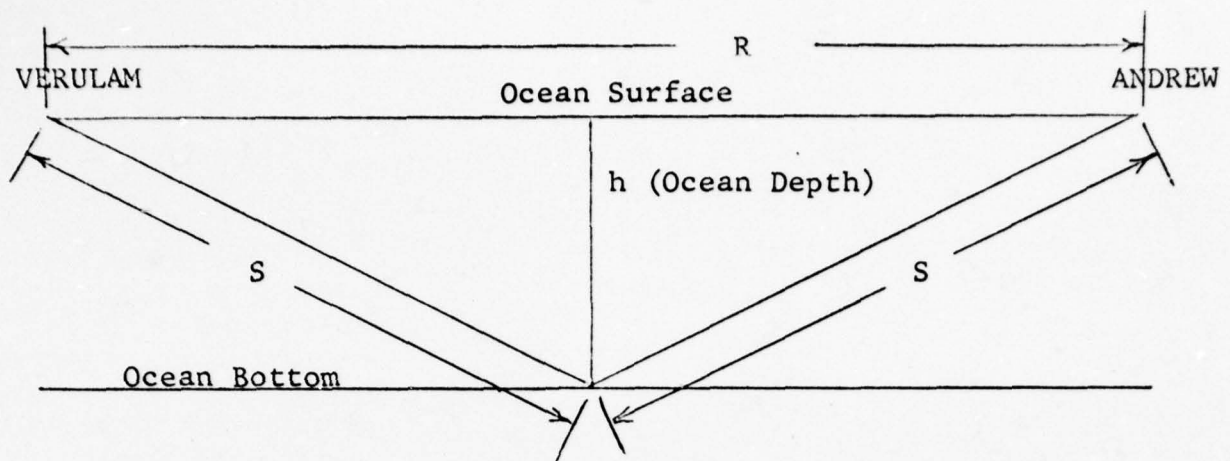


Figure A-1 DISTANCE DIMENSIONS

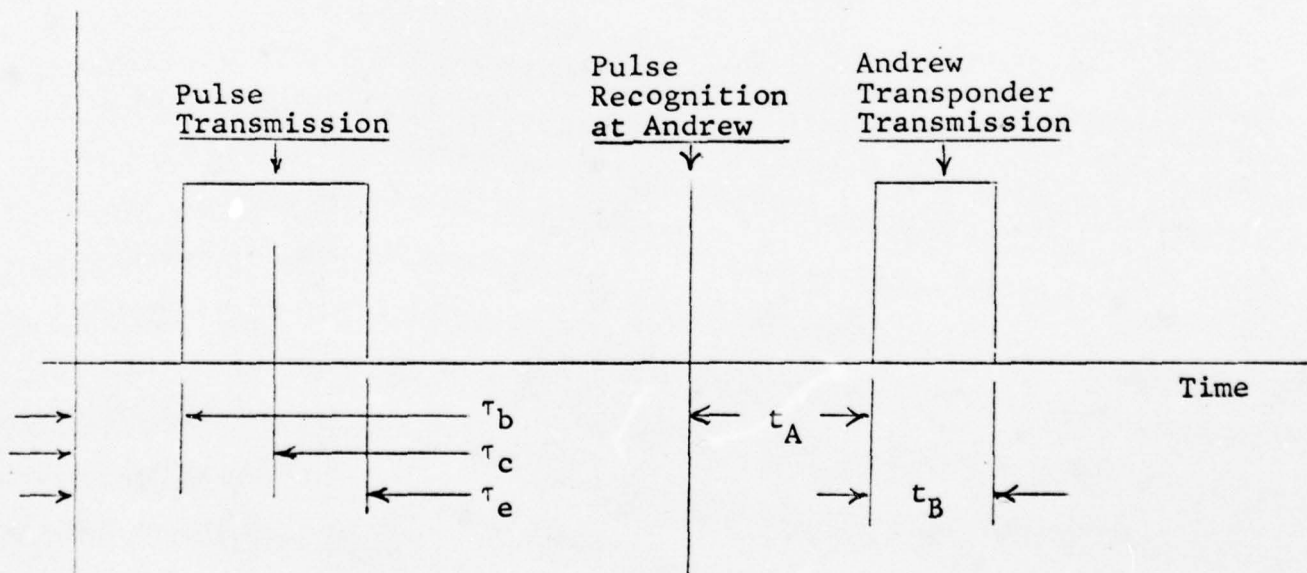


Figure A-2 TIME DIMENSIONS



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A-2 (U) PRECURSOR ONE-WAY BOTTOM-BOUNCE TIME

$$S = \left[\frac{R^2}{4} + h^2 \right]^{\frac{1}{2}}$$

$$\text{One-way travel time} = \frac{2S}{C} = \frac{[R^2 + 4h^2]^{\frac{1}{2}}}{C}$$

This is the time for the minimum distance path. Multipaths will cause the received signal to reach a maximum at the end of the transmitted signal. Hence:

$$T_{\text{PC1WBB}} = \frac{[R^2 + 4h^2]^{\frac{1}{2}}}{C} + \tau_e$$

If the travel time is known, the range can be determined by solving the above equation for R:

$$R = \left[C^2 (T_{\text{PC1WBB}} - \tau_e)^2 - 4h^2 \right]^{\frac{1}{2}}$$

A-3 (U) SLANT-BOTTOM REVERBERATION TIME

Due to the vertical width of the beam, the bottom will be ensonified at different ranges. Therefore, the reverberation return from a small time increment of the pulse will be spread out in time. Since the pulse itself has a finite time duration, the return at any one time is the sum of the returns from different parts of the pulse from different ranges. This constitutes a slice through the "reverberation ridge" in Figure A-3 at the time in question. Such a slice is shown in Figure A-4. The total return at the time of the slice will be the integral under the curve. However, the beginning and



termination of the pulse may truncate the curve so that the integration should be performed between limits. The location of the limits will slide from left to right at the listening time advances. Shown are the integration limits for the receive times t_1 , t_2 , and t_3 marked on Figure A-3.

(U) Obviously, the maximum will be achieved when the limits straddle the curve as they do with t_3 . Time t_3 , then, is when the bottom reverberation will reach its maximum. This time is equal to the round-trip travel time for the center of the beam plus half the pulse length. Thus:

$$T_{SB} = \frac{[R^2 + 4h^2]^{\frac{1}{2}}}{C} + \tau_c$$

A-4 (U) BOTTOM-BOUNCE ONE-WAY TRAVEL TIME

Same as Section A-2 above:

$$T_{BBLW} = \frac{[R^2 + 4h^2]^{\frac{1}{2}}}{C} + \tau_e$$

$$R = \left[C^2 (T_{BBLW} - \tau_e)^2 - 4h^2 \right]^{\frac{1}{2}}$$

A-5 (U) PRECURSOR ONE-WAY DIRECT PATH TIME

$$T_{PC1WDP} = \frac{R}{C} + \tau_e$$

$$R = C [T_{PC1WDP} - \tau_e]$$

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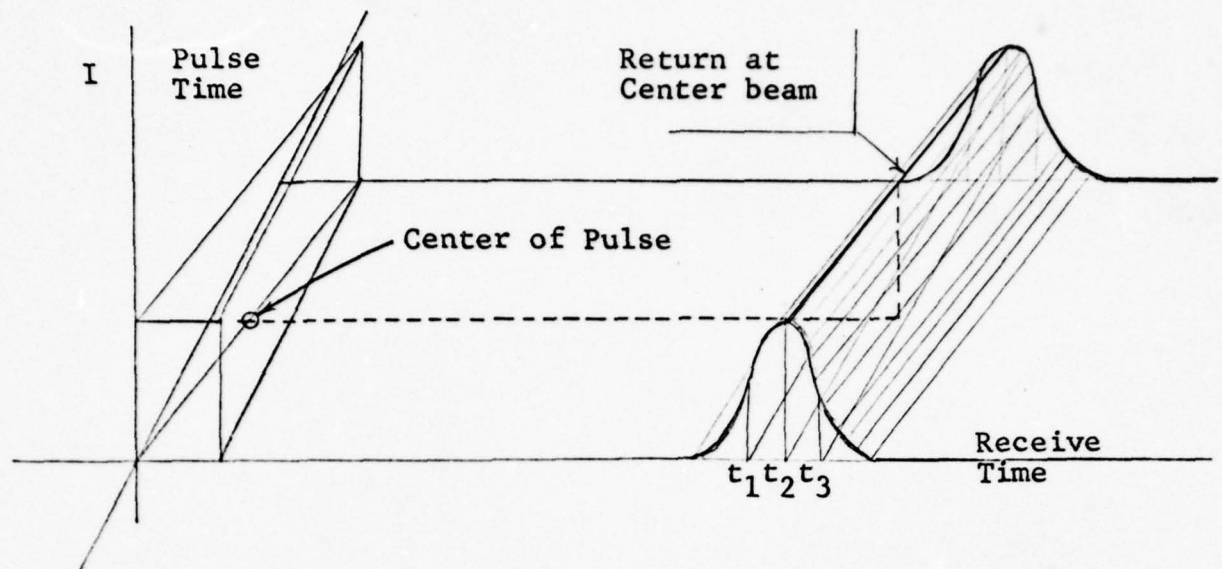


Figure A-3 SLANT-BOTTOM REVERBERATION CHARACTERISTICS

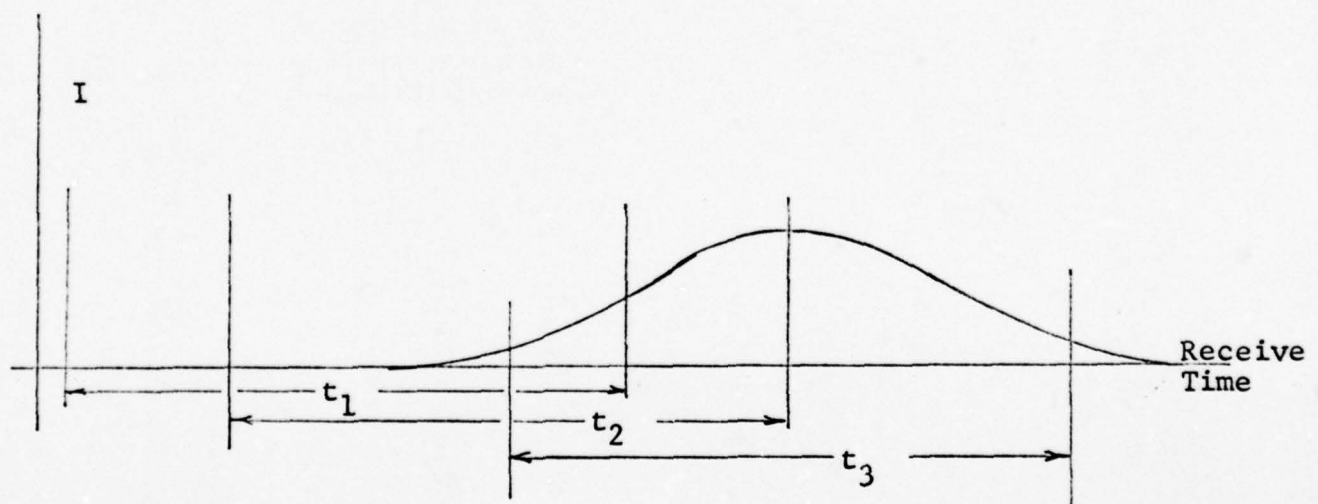


Figure A-4 SLANT-BOTTOM REVERBERATION VERSUS TIME

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A-6 (U) DIRECT-PATH ONE-WAY TRAVEL TIME

Same as Section A-5 above:

$$T_{DPlW} = \frac{R}{C} + \tau_e$$

$$R = C [T_{DPlW} - \tau_e]$$

A-7 (U) FATHOMETER ECHO PEAK TIME

Analysis is similar to that of Section A-3. The return from the bottom resulting from a small time increment of pulse will look as shown in Figure A-5, assuming a narrow beam is aimed directly at the bottom.

The slice through the bottom echo return "ridge" will, in general, look as shown in Figure A-6. If the receive time is relatively early, integration limits might be as shown as t_1 or t_2 . The maximum, obviously, will be at time t_3 . This time is equal to the minimum round trip travel time (for the vertical ray) plus the time from the reference to the end of the pulse:

$$T_F = \frac{2h}{C} + \tau_e$$

A-8 (U) TRANSPONDER TIME

The Transponder Time is the time measured from the reference for the pulse to be transmitted, travel by direct path from the VERULAM to the ANDREW, be transponded by the ANDREW with a time delay t_A , and the transponded pulse be returned to the VERULAM. The direct-path signal outbound will actuate the transponder since it will arrive before the bottom-bounce signal. However, the transponded signal can return by

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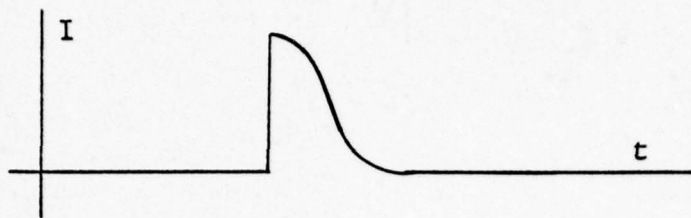


Figure A-5 BOTTOM ECHO FROM SHORT DURATION PULSE

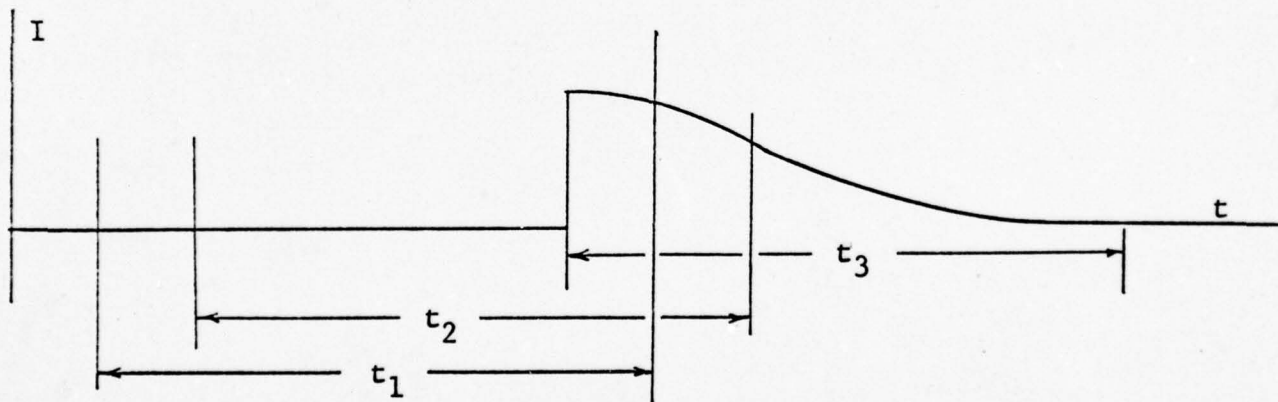


Figure A-6 BOTTOM ECHO RETURN VERSUS TIME



both direct-path and bottom-bounce and, thus, there will be two transponder times. In both cases the transponder is assumed to be triggered by the leading edge of the transmitted pulse.

(a) Direct Path Out/Direct Path Return

$$T_{XP} = \frac{2R}{C} + \tau_b - t_A - t_B$$

$$R = \frac{C}{2} [T_{XP} - \tau_b - t_A - t_B]$$

(b) Direct Path Out/Bottom-Bounce Return

$$T_{XP} = \frac{R}{C} + \tau_b + t_A + \frac{[R^2 + 4h^2]^{\frac{1}{2}}}{C} + t_B$$

$$R = \frac{C^2 [T_{XP} - \tau_b - t_A - t_B]^2 - 4h^2}{2C [T_{XP} - \tau_b - t_A - t_B]}$$

(c) Transponder Bottom-Bounce Out/Direct Path Return

$$T_{XP} = \frac{[R^2 + 4h^2]^{\frac{1}{2}}}{C} + \tau_e + t_A + \frac{R}{C} + t_B$$

This differs from (b) only in that τ_e here replaces τ_b there. In (b) it was assumed that the transponder was triggered by the beginning of the incoming pulse. Here (from Section A-4) it is assumed that the transponder is triggered by

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the end of the transmitted pulse. If the transponder is triggered a time τ_x after the arrival of the wavefront the equation becomes:

$$T_{XP} = \frac{[R^2 + 4h^2]^{\frac{1}{2}}}{C} + \frac{R}{C} + \tau_x + t_A + t_B$$

Solving for range:

$$R = \frac{C^2 [T_{XP} - \tau_x - t_A - t_B]^2 - 4h^2}{2C [T_{XP} - \tau_x - t_A - t_B]}$$

(d) Transponder Bottom-Bounce Out/Bottom Bounce Return

$$T_{XP} = \frac{2[R^2 + 4h^2]^{\frac{1}{2}}}{C} + \tau_x + t_A + t_B$$

$$R = \left[\frac{C^2}{4} (T_{XP} - \tau_x - t_A - t_B)^2 - 4h^2 \right]^{\frac{1}{2}}$$

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APPENDIX B

COMPUTER PROGRAM PEAK TIME
AND SUBROUTINE PEAKS (U)

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C HALFTH IS HALF SEARCH WINDOW WIDTH IN SECONDS
C PERCENT IS MIDDLE PERCENT OF SEARCH WINDOW PEAK MUST LIE WITHIN 10 BE ACCEPTED
C SAMPNT IS INTERVAL BETWEEN SAMPLES MEASURED IN SECONDS
C NOSAMP IS NUMBER OF SAMPLES OVER WHICH AMPLITUDE OF SAMPLES IS AVERAGED
C PULSNT IS INTERVAL IN SECONDS BETWEEN PULSES
C ANDOFF IS LENGTH OF TIME IN SECONDS FROM PRECURSOR TO ANDREW TAPE ON
C SD1BR2 = 1 IS SURFACE DUCT, = 2 IS BOTTOM BOUNCE OPERATION
C IN IS NUMBER OF PULSES SINCE LAST CALCULATION
C NLAST = 0 SAYS NOT LAST PULSE, = 1 SAYS LAST PULSE
    DIMENSION FRANGE(2),SRANGE(2),RANGE1(2),RANG2(2),WINDOW(3),
    CARANM1(2),ARANM2(2),PLENTH(2),PSTART(2)
    COMMON HALFTH,PERCENT,SAMPNT,NOSAMP,NSHIP,JSAMP
    INTEGER SD1BR2,PINGN
    READ 500,NORUN,NVIAPE,NATAPE,NOFIL
    500 FORMAT(8I10)
    READ 501,VSPEED,VDEPTH,VDEPRS,DEPTHL,RANGEL,ASPECT,ADEPTH,ADELAY,
    CADURAT,PLENTH(1),PLENTH(2),PSTART(1),PSTART(2),SAMPNT,
    CPULSNT,ANDOFF,XLEVEL,BWIDTH,PERCENT,SOUNSP,WINDOW(1),WINDOW(2),
    CWINDOW(3)
    501 FORMAT(8F10.4)
    PRINT 520,NORUN,NOFIL,NVIAPE,NATAPE,VSPEED,ASPECT,VDEPTH,
    CADEPTH,VDEPRS,ADELAY,DEPTHL,ADURAT,RANGEL,XLEVEL,SOUNSP,BWIDTH
    520 FORMAT(1H1,1X,10HRUN NUMBER,110.27X,15HNUMBER OF FILES,110//
    C34H VERALUM DIGITAL TAPE NUMBER FT,14,
    C15X,33H ANDREW DIGITAL TAPE NUMBER FT,14//
    C15X,13HVERALUM SPEED,F10.2,6H KNOTS,23X,
    C13HANDREW ASPECT,F10.2,4H DEG//8X,20HVERALUM SOURCE DEPTH,F10.2,
    C3H FT,27X,12HANDREW DEPTH,F10.2,3H FT//4X,24HVERALUM DEPRESSION AN
    CGLE,F10.2,4H DEG,16X,22HTRANSPONDER DELAY TIME,F10.2,4H SEC//
    C9X,19HINITIAL OCEAN DEPTH,F10.2,3H FT,13X,
    C26HTRANSPONDER PULSE DURATION,F10.2,4H SEC//16X,
    C12HTARGET RANGE,F10.2,3H FT,22X,17HTRANSPONDER LEVEL,F10.2,3H DB//
    C17X,11H SOUND SPEED,F10.2,7H FT/SEC,26X,9H BANDWIDTH,F10.2,3H HZ//
    PRINT 502,PLENTH(1),PLENTH(2),PULSNT,ANDOFF,SAMPNT,WINDOW(1),
    CWINDOW(2),WINDOW(3),PERCENT

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502 FORMAT(1H0,5X,22HPRECURSOR PULSE LENGTH,F10.2,4H SEC,
C21X,1/HMAIN PULSE LENGTH,F10.2,4H SEC//14X,14HPULSE INTERVAL,
CF10.2,4H SEC,23X,15HANDREW OFF TIME,F10.2,4H SEC//
C11X,1/H SAMPLING INTERVAL,F10.6,4H SEC,29X,9HWINDOW(1),F10.2,
C4H SEC//19X,9HWINDOW(2),F10.2,4H SEC,29X,9HWINDOW(3),F10.2,
C4H SEC//49X,31HPERCENT WINDOW WIDTH ACCEPTABLE,F10.2//)
SRANGE(1)=SQRT(((.5*RANGEL)**2)+(DEPTH1*DEPTH1))
@WDPP1=(RANGEL/SOUNSP)+PLENTH(1)+PSTART(1)-ANDOFF
@WDPM1=(RANGEL/SOUNSP)+PLENTH(2)+PSTART(2)-ANDOFF
@WBBP1=((SRANGE(1)*2.0)/SOUNSP)+PLENTH(1)+PSTART(1)-ANDOFF
@WBBM1=((SRANGE(1)*2.0)/SOUNSP)+PLENTH(2)+PSTART(2)-ANDOFF
FATH1M=(2.*DEPTH1/SOUNSP)+PLENTH(2)+PSTART(2)
SLANT1M=((SRANGE(1)*2.0)/SOUNSP)+.5*PLENTH(2)+PSTART(2)
XDPDP1=(2.*RANGEL/SOUNSP)+PSTART(1)+ADELAY+ADURAT
XDPBP1=(RANGEL/SOUNSP)+@WBBP1+ANDOFF+PSTART(1)+ADELAY+ADURAT
RANGEL(1)=RANGEL
RANG23(1)=RANGEL
ARANM1(1)=RANGEL
ARANM2(1)=RANGEL
XP1TIM=0.
RRATE1=0.
ANDPPI=0.
ANDPM1=0.
RRAT1M=0.
110 READ 500,PINGN0,NVFILE,NAFILE,SD1BB2,IN,NLAST
PRINT 530,PINGN0,NVFILE,NAFILE
PRINT 531
NSHIP=1
JSAMP=0
NOSAMP=PLENTH(2)/SAMPNT
HALFTM=.5*WINDOW(1)
PRINT 532
532 FORMAT(1H0,6HFATHOM)
CALL PEAKSK (FATH1M,FATIME,NVFILE)
FRANGE(1)=.5*SOUNSP*(FATIME-PSTART(2)-PLENTH(2))
HALFTM=.5*WINDOW(2)
PRINT 533
533 FORMAT(1H0,6HSL BOT)
CALL PEAKSK (SLANT1M,SLTIME,NVFILE)
PHI=57.29578*(ASIN(FATIME/SLTIME))
NOSAMP=ADURAT/SAMPNT
GO TO (11,12),SD1BB2
11 PRINT 534
534 FORMAT(1H0,6HX DDP)
CALL PEAKSK (XDPDP1,XP1TIM,NVFILE)

```

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```
RANGE1(2)=RANGE1(1)
RANGE1(1)=(.5*SOUNSP)*(XP1TIM-PSTART(1)-ADELAY-ADURAT)
RRATE1=(RANGE1(1)-RANGE1(2))/(PULSNT*FLOAT(IN))
GO TO 14
12 PRINT 535
535 FORMAT(1H0,6HX BRDP)
CALL PEAKSK (XDPRBT,XP2TIM,NVFILE)
RANG23(2)=RANG23(1)
TIMTW0=XP2TIM-PSTART(1)-ADELAY-ADURAT
RANG23(1)=(((SOUNSP*TIMTW0)**2)-(4.0*FRANGE(1)*FRANGE(1)))/
C(2.0*SOUNSP*TIMTW0)
RRAT23=(RANG23(1)-RANG23(2))/(PULSNT*FLOAT(IN))
14 NSHIP=2
JSAMP=0
NOSAMP=PLENTH(1)/SAMPNT
HALFTM=.5*WINDOW(3)
GO TO (16,17),SD10B2
16 PRINT 536
536 FORMAT(1H0,6H0W PDP)
CALL PEAKSK (0WDPPT,ANDPPT,NAFILE)
ANDPPT=ANDPPT+ANDOFF
17 PRINT 537
537 FORMAT(1H0,6H0W PBB)
CALL PEAKSK (0WRRPT,ANBBPT,NAFILE)
ANBBPT=ANBBPT+ANDOFF
NOSAMP=PLENTH(2)/SAMPNT
GO TO (18,19),SD10B2
18 PRINT 538
538 FORMAT(1H0,6H0W MDP)
CALL PEAKSK (0WDPMT,ANDPMT,NAFILE)
ANDPMT=ANDPMT+ANDOFF
ARANM1(2)=ARANM1(1)
ARANM1(1)=SOUNSP*(ANDPMT-PSTART(2)-PLENTH(2))
RRATE1=(ARANM1(1)-ARANM1(2))/(PULSNT*FLOAT(IN))
19 HALFTM=.5*WINDOW(1)
PRINT 539
539 FORMAT(1H0,6H0W MBB)
CALL PEAKSK (0WBBMT,ANBBMT,NAFILE)
ANBBMT=ANBBMT+ANDOFF
ARANM2(2)=ARANM2(1)
```

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```

ARANM2(1)=SQRT(((SQUNSP*(ANBBMT-PSTART(2)-PLENTH(2)))**2)-
C(4.*(FRANGE(1)**2)))
RRATM2=(ARANM2(1)-ARANM2(2))/(PULSNT*FLOAT(IN))
PRINT 540
PRINT 570,PSTART(1),PSTART(2),FATIME,FRANGE(1),SLTIME,PHI,
CXP1TIM,RANGE1(1),RRATE1
PRINT 541
PRINT 571,XP2TIM,RANG23(1),RRAT23,ANDPPT,ANBBPT,ANDPMT,
CARANM1(1),RRATM1,ANBBMT,ARANM2(1),RRATM2
530 FORMAT(1H1,/,12H PING NO. = ,I3,10X,19HVERALUM FILE NO. = ,I3,
C10X,18HANDREW FILE NO. = ,I3/)
531 FORMAT(1H0,10X,6HNO SAMP,5X,6HSAMPTM,4X,6HJSTART,6X,6HSTARIM,5X,
C5HJSTOP,6X,6HSTOPIM,9X,6HSIGTIM,10X,4HJMAX,9X,6HPEAKTM,/)
540 FORMAT(1H0,/,7X,9HPSTART(1),2X,9HPSTART(2),4X,6HFATIME,5X,
C6HFRANGE,5X,6HSLTIME,6X,3HPHI,6X,6HXP1TIM,5X,6HRANGE1,5X,6HRRATE1)
541 FORMAT(1H0,/,6HXP2TIM,5X,6HRANG23,5X,6HRRAT23,4X,6HANDPPT,4X,
C6HANBBPT,4X,6HANDPMT,5X,6HARANM1,5X,6HRRATM1,4X,6HANBBMT,5X,
C6HARANM2,5X,6HRRATM2)
560 FORMAT(1H0,4F20.6)
570 FORMAT(1H0,F12.2,F11.2,F12.2,F13.2,F10.2,F10.2,F11.2,F12.2,
CF10.2,/)
571 FORMAT(1H0,F6.2,F12.2,F10.2,F10.2,F10.2,F10.2,F12.2,F10.2,
CF10.2,F11.2,F11.2,/)
FATHTM=FATIME
SLANTM=SLTIME
XDPDPT=XP1TIM
XDPBBT=XP2TIM
@WDPPT=ANDPPT-ANDOFF
@WBBPT=ANBBPT-ANDOFF
@WDPMT=ANDPMT-ANDOFF
@WBBMT=ANBBMT-ANDOFF
IF(NLAST)
120 CONTINUE
END
110,110,120

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```

SUBROUTINE PEAKSK (SIGTIM,PEAKTM,N)
  DIMENSION ISIG(6300)
  COMMON HALFTM,PERCNT,SAMPNT,NOSAMP,NSHIP,JSAMP
  IF(SIGTIM) 80,81,81
61 JSTART=((SIGTIM-HALFTM)/SAMPNT)-(.5*(FLOAT(NOSAMP)))
  IF(JSTART) 82,82,83
62 JSTART=1
63 JSTOP=((SIGTIM+HALFTM)/SAMPNT)+(.5*(FLOAT(NOSAMP)))
  STARTM=SAMPNT*(FLOAT(JSTART))
  STOPM=SAMPNT*(FLOAT(JSTOP))
  SAMPMT=SAMPNT*(FLOAT(NOSAMP))
  ITOTAL=0
  IF(JSTOP-JSAMP) 80,80,86
66 IF(JSTART.LT.JSAMP) JSTART=JSAMP
  JEND=JSTOP-JSAMP
  GO TO(5,6,50,60),NSHIP
  5 CALL POST(N)
  CALL CLRPT
  NSHIP=3
60 K=0
61 CALL RGETPT(SIGVAL,NDFILE)
  JSAMP=JSAMP+1
  K=K+1
  IF(NDFILE) 30,30,80
60 IF(K-JEND) 31,9,9
  6 CALL POSTM3(N)
  CALL CLRM3
  NSHIP=4
60 K=0
66 CALL RGETM3(SIGVAL,NDFILE)
  JSAMP=JSAMP+1
  K=K+1
  IF(NDFILE) 35,35,80
65 IF(K-JEND) 36,9,9
  9 DO 2 NS=1,NOSAMP
  GO TO(41,42,41,42),NSHIP
41 CALL RGETPT(SIGVAL,NDFILE)
  GO TO 43
42 CALL RGETM3(SIGVAL,NDFILE)
43 JSAMP=JSAMP+1
  IF(NDFILE) 10,10,80
10 ISIG(NS)=ABS(SIGVAL)
  ITOTAL=ITOTAL+ISIG(NS)
  2 CONTINUE
  IPKTM=ITOTAL
  JMAX=JSAMP-(NOSAMP/2)
  PEAKTM=(FLOAT(JMAX))*SAMPNT
15 DO 4 NS=1,NOSAMP

```

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```

ITOTAL=ITOTAL-ISIG(NS)
GO TO (45,46,45,46),NSHIP
45 CALL KGETPT(SIGVAL,NDFILE)
GO TO 47
46 CALL KGETM3(SIGVAL,NDFILE)
47 JSAMP=JSAMP+1
IF(NDFILE) 20,20,80
20 ISIG(NS)=ABS(SIGVAL)
ITOTAL=ITOTAL+ISIG(NS)
IF(ITOTAL-IPKTOT) 26,26,25
25 IPKTOT=ITOTAL
JMAX=JSAMP-(NOSAMP/2)
26 IF(JSAMP-JSTOP) 4,75,75
4 CONTINUE
GO TO 15
75 PEAKTM=(FLOAT(JMAX))*SAMPNT
PRINT 105,NOSAMP,SAMPNT,JSTART,STARTM,JSTOP,STOPTM,SIGTIM,JMAX,
CPEAKTM
IF((ABS(SIGTIM-PEAKTM))-(PERCNT*HALFTM)) 80,80,70
76 PEAKTM=SIGTIM
PRINT 104,PEAKTM
80 CONTINUE
104 FORMAT(1H0,100X,F12.4,/)
105 FORMAT(1H+,9H SIGNAL...,I6,F12.4,I10,F12.4,I10,F12.4,F15.4,I15,
CF14.4)
RETURN
END

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APPENDIX C
PROGRAM INPUTS (U)

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APPENDIX C

PROGRAM INPUTS (U)

C-1 (U) INPUT CARD NO. 1 (FORMAT 8I10)

NORUN = VERULAM/ANDREW Run Number. Columns 1-10.
NVTAPE = VERULAM Digital Tape Number. Columns 11-20.
NATAPE = ANDREW Digital Tape Number. Columns 21-30.
NOFILE = Number of Files Being Searched in This
Computer Run. Columns 31-40.

C-2 (U) INPUT CARD NO. 2 (FORMAT 8F10.4)

VSPEED = VERULAM Speed in Knots. Columns 1-10.
VDEPTH = Depth of VERULAM Transducer in Feet. Columns
11-20.
VDEPRS = VERULAM Transducer Center-Beam Depression
Angle in Degrees. Columns 21-30
DEPTHL = Logged Value of Ocean Depth in Feet. Columns
31-40..
RANGEL = Logged Value of VERULAM-ANDREW Range in Feet.
Columns 41-50.
APSECT = ANDREW Aspect Angle in Degrees as Viewed
From VERULAM. Columns 51-60.
ADEPTH = ANDREW Depth in Feet. Columns 61-70.
ADELAY = ANDREW Transponder Delay Time in Seconds.
Columns 71-80.

C-3 (U) INPUT CARD NO. 3 (FORMAT 8F10.4)

ADURAT = Duration in Seconds of ANDREW Transponded
Pulse. Columns 1-10.



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PLENTH(1) = VERULAM Precursor Pulse Length in Seconds.
Columns 11-20.

PLENTH(2) = VERULAM Main Pulse Length in Seconds.
Columns 21-30.

PSTART(1) = VERULAM Precursor Start Time in Seconds
Measured From the Time of the First
Sample in the File. Columns 31-40.

PSTART(2) = VERULAM Main Pulse Start Time in Seconds
Measured From the Time of the First Sample
in the File. Columns 41-50.

SAMPNT = Interval in Seconds Between Successive
Digital Samples. Columns 51-60.

PULSNT = Interval Between Successive VERULAM Pulse
Transmissions in Seconds. Columns 61-70.

ANDOFF = The Length of Time in Seconds Between the
First Sample in VERULAM File and the First
Sample in the ANDREW File. Columns 71-80.

C-4 (U) INPUT CARD NO. 4 (FORMAT 8F10.4)

XLEVEL = VERULAM Transmit Center-Beam Source Level.
Columns 1-10.

BWIDTH = Receive Bandwidth in Hertz. Columns 11-20.

PERCNT = Percent of Search Window Width Located in
Center of Window Within Which Peak Value
Must Lie to be Accepted as Peak Time.

SOUNSP = Speed of Sound in Seawater Measured in
Feet per Second. Columns 31-50.

WINDOW(1) = Search Window Width in Seconds Used in
Searching for VERULAM Fathometer Return
and ANDREW Bottom-Bounce Main Pulse Signal.
Columns 41-50.



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WINDOW(2) = Search Window Width in Seconds Used in Searching the VERULAM Tape for the Following Returns:

1. Slant Bottom Reverberation
2. Direct Path Outbound/ANDREW Transponded Direct-Path Return
3. Bottom-Bounce Outbound ANDREW Transponded Direct-Path Return

Columns 51-60

WINDOW(3) = Search Window Width in Seconds Used in Searching the ANDREW Tape for the Following Signals:

1. Precursor Direct-Path Signal
2. Precursor Bottom-Bounce Signal
3. Main Pulse Direct-Path Signal

Columns 61-70.

C-5 (U) INPUT CARD NO. 5 AND BEYOND (FORMAT 8I10)

(A card for every VERULAM/ANDREW file to be searched)

PINGNO = VERULAM Ping Number Being Investigated.
Columns 1-10.

NVFILE = File Number on VERULAM Tape Being Used
Which Corresponds to PINGNO. Columns 11-20.

NAFILE = File Number on ANDREW Tape Being Used Which
Corresponds to PINGNO. Columns 21-30.

SD1BB2 = 1 for Surface-Duct Operation. (Beam
depression angle at or near zero degrees.)
= 2 for Bottom-Bounce Operation. (Beam
depressed well away from horizontal.)
Column 40.

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- IN = Number of Transmitted Pulses Since Last
 File Searched. Columns 41-50.
- NLAST = On the Input Card for the last VERULAM/
 ANDREW file to be searched an integer ≥ 1
 should be placed in Column 60 to cause
 the run to terminate.

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APPENDIX D
PROGRAM OUTPUTS (U)

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APPENDIX D

PROGRAM OUTPUTS (U)

(U) The program initially prints out the following basic information on the run:

RUN NUMBER - The VERULAM/ANDREW Run Number

NUMBER OF FILES - The number of pings being analyzed
in this computer run

VERULAM DIGITAL TAPE NUMBER

ANDREW DIGITAL TAPE NUMBER

VERULAM SPEED IN KNOTS

ANDREW ASPECT with respect to the VERULAM in degrees

VERULAM SOURCE DEPTH in feet

ANDREW DEPTH in feet

VERULAM DEPRESSION ANGLE in degrees

TRANSPONDER DELAY TIME in seconds

INITIAL OCEAN DEPTH in feet

TRANSPONDER PULSE DURATION in seconds

TARGET RANGE - VERULAM to ANDREW range in feet

TRANSPONDER LEVEL in dB

SOUND SPEED - Assumed speed of sound in seawater
in feet/sec

BANDWIDTH in Hertz

PRECURSOR PULSE LENGTH in seconds

MAIN PULSE LENGTH in seconds

PULSE INTERVAL in seconds

ANDREW OFFTIME - Time in seconds after VERULAM reference
time before ANDREW recorder was turned on



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SAMPLING INTERVAL - Time in seconds between consecutive samples.

WINDOW(1) - Time interval in seconds over which the following signal searches will be made:

VERULAM Tape: Main Pulse Fathometer Echo

ANDREW Tape : Main Pulse Bottom-Bounce Signal

WINDOW(2) - Time interval in seconds over which the following signal searches will be made:

VERULAM Tape: Main Pulse Slant-Bottom Reverberation

Precursor Direct-Path Transponder -
Actuated Direct Path Return

Precursor Bottom-Bounce Transponder -
Actuated Direct Path Return

WINDOW(3) - Time interval in seconds over which the following signal searches will be made:

ANDREW Tape: Precursor Direct-Path Signal

Precursor Bottom-Bounce Signal

Main Pulse Direct-Path Signal

PERCNT - The percent of the full window width within which the peak average signal value must lie to be acceptable. See Figure 1. If peak lies within this limit, it is used as center of window for corresponding search on next ping. If not, previously established window center is used.

(U) Following the listing of the basic information identifying the run the program prints out solution values found for each ping transmission within the run. These are identified by the PING NO. as well as VERULAM FILE NO. and ANDREW FILE NO. associated with the ping. Immediately beneath these headings nine calculated values are printed under the following names:

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- NOSAMP = The number of samples (at .00016 sec intervals) over which a running absolute amplitude average of the unrectified signal is maintained.
- SAMPTM = The time duration in seconds represented by NOSAMP.
- JSTART = The sample number for the first sample in the first NOSAMP averaging interval for a window search.
- STARTM = The time in seconds at JSTART. Time is measured from the reference which is established by PSTART(1), the time of commencement of the precursor transmission.
- JSTOP = The sample number for the last sample in the last NOSAMP averaging interval for a window search.
- STOPTM = The time in seconds at JSTOP.
- SIGTIM = The time about which the window search was carried out.
- JMAX = The sample number for the middle sample of the NOSAMP interval which had the highest average amplitude value over the particular window search.
- PEAKTM = The time at JMAX. If this time deviates from SIGTIM by more than the inputted percentage value (PERCNT) of the half-window width, the calculated value of PEAKTM is rejected. It is replaced by SIGTIM. When this occurs it is shown by the repeat print-out of the SIGTIM below and slightly to the right of the PEAKTM print-out.

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(U) Window searches may be conducted for any of eight different signal returns. These are identified at the left under the following names:

- FATHOM - The fathometer or vertical echo return from the bottom to the VERULAM from the main pulse
- SL BOT - The reverberation return from the bottom to the VERULAM from the center-beam of the main pulse
- X DPDP - The precursor direct-path outbound-transponder direct-path return-signal to the VERULAM
- X BBDP - The precursor bottom-bounce outbound-transponder direct-path returned signal to the VERULAM
- OW PDP - The one-way VERULAM to ANDREW precursor direct-path signal
- OW PBB - The one-way VERULAM to ANDREW precursor bottom-bounce signal
- OW MDP - The one-way VERULAM to ANDREW main-pulse direct-path signal
- OW MBB - The one-way VERULAM to ANDREW main pulse bottom-bounce signal

(U) The results of the search are set forth in the last part of the print-out for each file. The names here indicate:

- PSTART(1) - The time of commencement of the precursor pulse, measured in seconds from the first sample on the VERULAM file. Since the start of the precursor is usually the reference time from which all other times are measured, PSTART(1) is usually zero.

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- PSTART(2) - The time in seconds from the first sample on the VERULAM file at which the main pulse commences
- FATIME - The time in seconds at which the fathometer return signal peak was found to occur
- FRANGE - The ocean depth in feet corresponding to FATIME at the sound speed used
- SLTIME - The time in seconds at which the slant-bottom reverberation peak was found to occur
- PHI - The straight line depression angle resulting from FATIME and SLTIME
- XP1TIM - The time in seconds at which the precursor direct-path/direct path transponder signal peak was found to occur
- RANGE1 - The horizontal range corresponding to XP1TIM
- RRATE1 - The range-rate in ft/sec resulting from the last two calculated values of RANGE1.
(First calculation uses RANGE1 and RANGE1.)
- XP2TIM - The time in seconds at which the precursor direct-path/bottom-bounce transponder signal was found to occur
- RANG23 - The horizontal range in feet corresponding to XP2TIM
- RRAT23 - The range-rate in ft/sec resulting from the last two calculated values of RANG23.
(First calculation uses RANGE1 and RANG23.)
- ANDPPT - Time of arrival in seconds at which the direct-path precursor signal peak was found to arrive at the ANDREW

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- ANBBPT - Time of arrival in seconds at which the bottom-bounce precursor signal peak was found to arrive at the ANDREW
- ANDPMT - Time of arrival in seconds at which the direct-path main pulse peak was found to arrive at the ANDREW
- ARANM1 - The horizontal range in feet corresponding to ANDPMT
- RRATM1 - The range-rate in ft/sec resulting from the last two calculated values of ARANM1. (First calculation uses RANGEL and ARANM1.)
- ANBBMT - Time of arrival in seconds at which the bottom-bounce main pulse was found to arrive at the ANDREW
- ARANM2 - The horizontal range in feet corresponding to ANBBMT
- RRATM2 - The range-rate in ft/sec resulting from the last two calculated values of ARANM2. (First calculation uses RANGEL and ARANM2.)

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VERALUM DIGITAL TAPE NUMBER	684	NUMBER OF FILES	1
VERALUM DIGITAL TAPE NUMBER	FT 152	ANDREW DIGITAL TAPE NUMBER	FT 162
VERALUM SPEED	3.00 KNOTS	ANDREW ASPECT	90.00 DEG
VERALUM SOURCE DEPTH	20.00 FT	ANDREW DEPTH	50.00 FT
VERALUM DEPRESSION ANGLE	20.00 DEG	TRANSPONDER DELAY TIME	5.60 SEC
INITIAL OCEAN DEPTH	12790.00 FT	TRANSPONDER PULSE DURATION	1.00 SEC
TARGET RANGE	66880.00 FT	TRANSPONDER LEVEL	130.00 DB
SOUND SPEED	4950.00 FT/SEC	BANDWIDTH	1000.00 HZ
PRECURSOR PULSE LENGTH	.10 SEC	MAIN PULSE LENGTH	1.00 SEC
PULSE INTERVAL	65.00 SEC	ANDREW OFF TIME	14.00 SEC
SAMPLING INTERVAL	.000160 SEC	WINDOW(1)	1.50 SEC
WINDOW(2)	2.00 SEC	WINDOW(3)	.30 SEC
		PERCENT WINDOW WIDTH ACCEPTABLE	.90

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ERALUM FILE NO. = 1 ANDREW FILE NO. = 12

JSTART	STARTM	JSTOP	STOPTM	SIGTMM	JMAX	PEAKTM
33360	5.3376	48984	7.8374	6.5877	43450	6.9520
86784	13.8854	105533	10.8853	15.3855	91112	14.5779
207353	33.1765	226102	30.1763	34.6765	222916	35.6666
						34.6765
2284	.3654	4783	.7653	.5654	3510	.5616
4783	.6355	19596	3.1354	1.8855	8237	1.3179

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FAITME	FRANGE	SLTIME	PHI	XP1TMM	RATE1
6.95	13691.67	14.56	28.48	.00	66880.00
					.00

ANDPPT	ANBBPT	ANDPMT	ARANM1	RRATM1	ANBBM1	ARANM2	RRATM2
.00	14.56	.00	66880.00	.00	15.32	63106.81	-58.05

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