Naval Research Laboratory

Washington, DC 20375-5000

NRL/FR/5160—92-9383

The Range-Dependent Active System Performance Prediction Model (RASP)

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Acoustics Division

July 21, 1992

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY (Leave blank)

2. REPORT DATE
July 21, 1992

3. REPORT TYPE AND DATES COVERED

4. TITLE AND SUBTITLE
The Range-Dependent Active System Performance Prediction Model (RASP)

5. FUNDING NUMBERS

6. AUTHOR(S)
L. Bruce Palmer and David Meloy Fromm

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Naval Research Laboratory
Washington, DC 20375-5000

8. PERFORMING ORGANIZATION REPORT NUMBER
NRL/FR/5160—92-9383

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Office of Naval Technology
Arlington, VA 22217-5000

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited.

12b. DISTRIBUTION CODE

13. ABSTRACT (Maximum 200 words)

In 1984, the Naval Research Laboratory (NRL) published a report that described a sequence of computer programs to predict long-range, low-frequency monostatic or bistatic reverberation for either the ocean surface or bottom. Since that time, numerous improvements and extensions have been made to the original sequence of programs that have incorporated advances in the theory and understanding of underwater acoustics, numerical modeling, and computer software. Examples of enhancements include the addition of predicted target returns, improved spatial interpolations of sound speed, and the application of a wave-theoretic treatment of caustics. The present collective versions of the programs is now referred to as the Range-dependent Active System Performance, or RASP model. This report presents the theoretical foundations of the RASP model as well as the numerical implementation of this theory. Further, a detailed description of model software and instructions for model execution are provided along with the results of a sample execution.

14. SUBJECT TERMS
Active surveillance; Bistatic geometry; Ocean boundary scattering
Reverberation; Ray acoustics; Reverberation vs time
Monostatic geometry; Propagation; Transmission loss

15. NUMBER OF PAGES
124

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
UNCLASSIFIED	UNCLASSIFIED	UNCLASSIFIED	UL

NSN 7540-01-280-5500

Standard Form 298 (Rev 2-89)
Prescribed by ANSI Std Z39-18
298-102

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1. INTRODUCTION

One of the limitations on the performance of a long-range active sonar system is the level of acoustic reverberation present at the receiver. When a low-frequency acoustic signal is transmitted in the deep ocean, it tends to propagate over nearly cyclic refractive paths to long ranges while portions of the signal energy interact with the ocean surface and bottom boundaries. These boundary interactions give rise to backscattered reverberant returns that may exceed ambient noise and mask target echoes at a receiver.

The Naval Research Laboratory (NRL) has developed a comprehensive computer model to predict the boundary reverberation that would be received in real ocean environments. This model, which encompasses realistic multipath propagation and scattering processes, is called the Range-dependent Active System Performance (RASP) prediction model. This report describes the RASP model, its operation, and its application to analysis of low frequency active sonar concepts.

1.1 Background

In 1984, NRL published a report [1] that described a sequence of computer programs to predict long-range, low-frequency monostatic or bistatic reverberation from either the ocean surface or bottom. That model, no longer in existence, was known as the NRLREV model. The RASP model is an improved and extended version of the NRLREV model, although it retains the basic formulations and features of the original NRLREV model. Both models include:

- A variety of source and receiver geometries,
  - monostatic (collocation of source and receiver) in range-dependent environments
  - quasi-monostatic (source and receiver separated only in depth) in range-dependent environments
  - bistatic (range-separated source and receiver) in range-independent environments
- All major multipath contributors to reverberation,
- Angle and frequency dependencies of
  - backscattering strengths
  - bottom loss

Manuscript approved February 21, 1992.

- Source and receiver beam patterns,
- Finite pulse lengths, and
- Implementation in a modular structure that facilitates upgrades and extensions.

Additionally, the RASP model provides for:

- the prediction of target echo returns as a function of range for up to three target depths,
- improved depth and range interpolation of the sound-speed field,
- the application of a wave-theoretic caustic treatment at smooth caustics,
- commonly used models of angle dependent boundary backscattering strengths (Chapman-Harris formula [2], and the Urick-Mackenzie [3, 4] approach) and bottom loss (Fleet Numeric Weather Central (FNWC) bottom types [5, 6]),
- bottom backscattering strength and bottom loss functions that vary with range, and
- system processing parameters such as bandwidth and analysis time.

The version of RASP reported here does not include some of the features and programs that are presently in use at NRL. These include the prediction of volume reverberation, the treatment of the time spreading of multipath returns from a target (particularly important for a short-pulse propagation in a surface duct), the automatic selection and/or supplementation of ray paths, some plotting programs, and the ability to model bistatic geometries in a range- and azimuth-dependent environment. These additional capabilities will be reported in the future.

Much of the material of Ref. 1 has been either revised, summarized, or duplicated in this report. This is a result of the RASP model being an evolution of the original NRLREV model and an attempt to allow the reader to exercise the RASP model based solely on the information contained in this report.

1.2 Purpose

The purpose of this report is to document the RASP model and the procedures for executing the model. The model presently resides on a VAX Model 6310 computer system and uses the DISSPLA plotting package. The next section presents the theoretical formulations implemented in the RASP model. The third section presents a model overview as well as information on CPU time and required storage space. In the fourth section, each of the individual program modules are described in detail. Finally, the last section describes the MENU pre-processor and gives an example of a RASP execution. Three appendices are included in this report. Appendix A discusses a naming convention for the RASP data files and summarizes the contents of each file. Appendix B provides a detailed listing of the input variables for each program module. Appendix C describes the RASP distribution tape.

2. THEORETICAL FORMULATIONS

2.1 Boundary Reverberation

The following treatment of boundary reverberation was reported in Ref. 1 and is summarized here.

Assume that a point source S radiates a time-dependent acoustic signal in a three-dimensional ocean with the acoustic energy propagating away from S along the ray paths. As a ray encounters an ocean boundary it continues to propagate in the direction of specular reflection, minus a small amount of radiation dispersed according to some scattering law. The scattering can be viewed as arising from excitation of small scattering elements in the boundary, each of which acts as a weak source. The sum of that part of the scattered radiation detected at the receiving point R is the boundary reverberation level at any given time.

Surface scattering return (unlike bottom scatter) is Doppler shifted and therefore should be calculated separately. For either type of reverberation it is necessary to trace a set of acoustic rays from S and R, while recording travel times, intensities, and other parameters at each boundary encounter (only one ray trace is needed if there is monostatic geometry). To proceed with a model, three specific assumptions regarding scattering must be made:

- Scattering surfaces can be decomposed into elemental surfaces that are active secondary sources while they are ensonified. Intensities of secondary sources are proportional to the incident intensity, the elemental area dA, and the scattering strength.
- In determining a mean reverberation envelope, any interference effects associated with acoustic phase difference can be ignored. Scattered rays would therefore be represented as having, in effect, a random phase shift relative to the incident ray. Such an approach results in a mean reverberation envelope representative of ensemble-averaged returns. In principle, a coherent summation would lead to an envelope more indicative of a single sample return, but this would require a time-dependent representation of the surface.
- The scattering layer at the ocean surface can be approximated by a horizontal plane with an appropriate scattering coefficient, and similarly the bottom scattering surface is approximated by the (gross) bottom topography with an appropriate scattering coefficient.

For each element of the ocean boundary from which scattering reverberation is to be calculated, there is an associated set of reverberant paths, each making an elemental contribution to the reverberation. The contributions are each composed of the transmission losses associated with the ray path from the source to the scattering element and back to the receiver, being appropriately weighted by the source and receiver beam patterns, the scattering element, and the area of the element. The expected or averaged value of the instantaneous reverberation is then the sum of all of the elemental contributions active at that instant.

2.1.1 Monostatic Boundary Reverberation

A monostatic geometry is that in which the source and receiver are collocated in space. Figure 1 depicts surface reverberation with a source/receiver S/R that ensonifies a scattering element dA via path i and receives a return via a different path j. Presuming S emits a time-varying signal of an intensity $I(t)$, weighted by a beam pattern B, the intensity is reduced by the transmission loss L_i along path i from S to dA. The incident intensity at dA is then weighted by the scattering strength σ. The return is further diminished by the transmission loss L_j along path j from dA to R. At R, it is weighted by the receiver beam pattern $\overline{B}$. The time delay for the reverberation is simply the two-way travel time $T_i + T_j$. That is, the unweighted initial source intensity that results in reverberation at time t, due only to outward path i and return path j, is $I(t-T_i-T_j)$. Summing over all multipath combinations between S/R and dA, the total

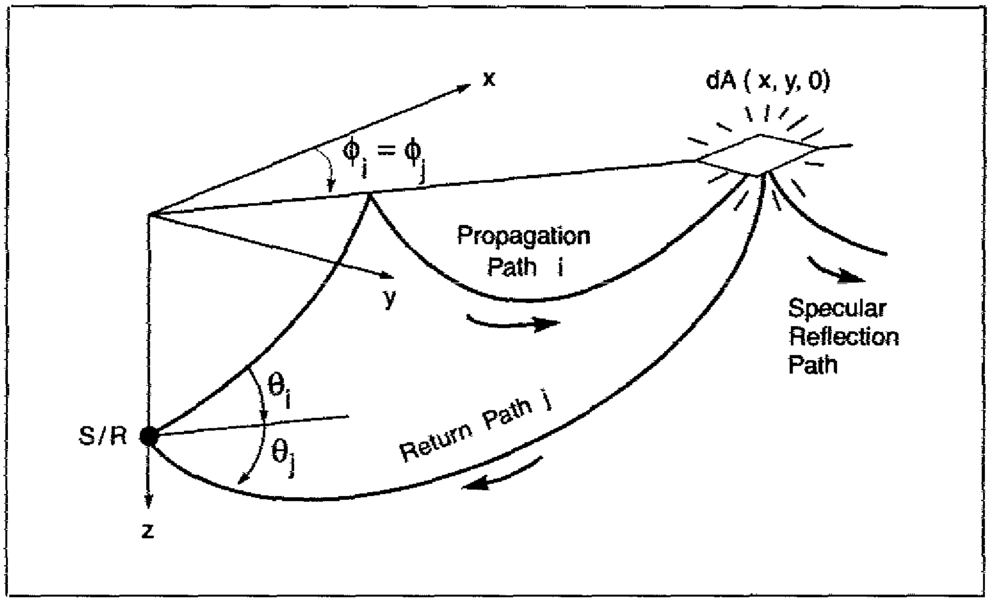

Fig. 1 – Source-receiver ensonifying a scattering element dA via propagation path i and receiving reverberation via return path j

contribution from dA is obtained. These intensities are to be summed with respect to time, but without regard to phase due to the second assumption. Finally, by integrating over all scattering points, the total reverberation $R(t)$ at t is found to be

$$R(t) = \int\int_A \sum_{i\in m(x,y)} \sum_{j\in m(x,y)} I[t - T_i(x,y) - T_j(x,y)] \, \frac{B(\theta_i,\phi_i)\ \overline{B}(\theta_j,\phi_j)}{L_i(x,y)\ L_j(x,y)} \, \sigma(\theta_i',\phi_i,\theta_j',\phi_j)\ dA \ , \quad (1)$$

where $m(x,y)$ indexes the set of rays between S/R and dA. Note that the scattering strength $\sigma(\theta_i',\phi_i,\theta_j',\phi_j)$ in Eq. (1) depends on the elevation and azimuth angles of incidence and scatter. At this level of generality, a full three-dimensional scattering pattern is implied.

Equation (1) cannot be directly evaluated without a three-dimensional acoustic propagation model. Because of this, the monostatic reverberation model has been reduced to two dimensions by assuming (1) cylindrical symmetry of the ocean environment about the z-axis (with the cylindrical coordinates being (ρ, z, ϕ)), and (2) that directions of reflected and scattered energy are confined to the vertical ρ-z plane containing the incident ray path.

By taking beam patterns of source and receiver as separable,

$$B(\theta,\phi) = a(\phi)\ b(\theta) \quad \text{and} \quad \overline{B}(\theta,\phi) = \overline{a}(\phi)\ \overline{b}(\theta) \ , \quad (2)$$

the equivalent azimuthal beamwidth of S/R can be expressed as

$$\Phi = \int_0^{2\pi} a(\phi)\ \overline{a}(\phi)\ d\phi \ . \quad (3)$$

Eq. (1) then becomes

$$R(t) = \Phi \int\int_A \sum_{i\in m(\rho)} \sum_{j\in m(\rho)} I[t - T_i(\rho) - T_j(\rho)] \, \frac{b(\theta_i)\ \overline{b}(\theta_j)}{L_i(\rho)\ L_j(\rho)} \, \sigma(\theta_i',\theta_j')\ \rho\ d\rho \ . \quad (4)$$

If we take the signal emitted by S to be a wave of constant intensity I, and duration D, that is turned on at S when $t = 0$, then only those reverberating elements at ranges ρ satisfying

$$0 \leq t - T_i(\rho) - T_j(\rho) \leq D \tag{5}$$

are active in producing reverberation at R at t. The double inequality of Eq. (5) is equivalent to

$$t - D \leq T_i(\rho) + T_j(\rho) \leq t \;. \tag{6}$$

Therefore the set $\chi_{ij}(t)$ of reverberators active via the path pair (i, j) at t is defined by

$$\chi_{ij}(t) = \{\rho \mid t - D \leq T_i(\rho) + T_j(\rho) \leq t\} \;. \tag{7}$$

Defining the characteristic function C_χ of a set χ to be

$$C_\chi(\rho) = \begin{cases} 1, & \rho \in \chi \\ 0, & \rho \notin \chi \end{cases} \;, \tag{8}$$

then the reverberation $R(t)$ at R can then be written as

$$R(t) = I\ \Phi \int_0^\infty \sum_{i \in m(\rho)} \sum_{j \in m(\rho)} C_{\chi_{ij}(t)}(\rho)\ \frac{b(\theta_i)\ \overline{b}(\theta_j)}{L_i(\rho) L_j(\rho)}\ \sigma(\theta_i', \theta_j')\ \rho\ d\rho \;. \tag{9}$$

2.1.2 Quasi-monostatic Boundary Reverberation

A quasi-monostatic geometry is defined by the source and receiver being separated only in depth. Thus the quasi-monostatic geometry is similar to the monostatic geometry of Fig. 1, except that the source S and receiver R are now physically separated on the z-axis. The development of received reverberation for a quasi-monostatic geometry parallels that for a monostatic geometry except in the former there is not a single function $m(\rho)$ that indexes the ray paths between the source and the scattering element dA, or the paths between the receiver and dA. Rather, there are two functions, defined as $m(\rho)$ and $n(\rho)$, one each for both the source and the receiver. The similarities to the monostatic case allow the following assumptions to again be made:

- the ocean environment is cylindrically symmetric about the z-axis,
- the reflected and scattered energy is confined to the vertical ρ-z plane containing the incident ray path, and
- the source and receiver beam patterns can be taken as separable.

As a result of these assumptions, the quasi-monostatic equivalent of Eq. (9) is

$$R(t) = I\ \Phi \int_0^\infty \sum_{i \in m(\rho)} \sum_{j \in n(\rho)} C_{\chi_{ij}(t)}(\rho)\ \frac{b(\theta_i)\ \overline{b}(\widetilde{\theta}_j)}{L_i(\rho)\ \widetilde{L}_j(\rho)}\ \sigma(\theta_i', \widetilde{\theta}_j')\ \rho\ d\rho \;, \tag{10}$$

where the tildes indicate quantities that differ due to the different source and receiver depths (e.g., in general, $L_i(\rho) \neq \widetilde{L}_i(\rho)$).

2.1.3 Bistatic Boundary Reverberation

A bistatic geometry is that in which the source and receiver are separated in range, and possibly separated in depth. A generalization of Eq. (1) to the case of separated source and receiver is readily accomplished. The times at which an elemental contribution of the boundary to bistatic reverberation is active are determined by the travel times along the propagation and return paths and the duration of the transmitted pulse. Again, the emitted signal is defined to be a wave of constant intensity I and duration D that is turned on at S when $t = 0$. Then a scattering point is actively contributing at time t via a propagation path i and return path j if

$$t - D \leq T_i(x,y) + \widetilde{T}_j(x,y) \leq t \;, \tag{11}$$

where T_i and $\widetilde{T}_j$ are the one-way travel times along the paths i and j. The set of points active at t via the path pair (i,j) is then

$$A_{ij}(t) = \{(x,y) \mid t - D \leq T_i(x,y) + \widetilde{T}_j(x,y) \leq t\} \;. \tag{12}$$

The reverberation $R(t)$ from the boundary area A can then be written

$$R(t) = I \int\int_A \sum_{i\in m(x,y)} \sum_{j\in n(x,y)} C_{A_{ij}(t)}(x,y) \, \frac{B(\theta_i,\phi_i)\; \overline{B}(\widetilde{\theta}_j,\widetilde{\phi}_j)}{L_i(x,y)\; \widetilde{L}_j(x,y)} \, \sigma(\theta_i',\phi_i,\widetilde{\theta}_j',\widetilde{\phi}_j)\; dA \;, \tag{13}$$

where the characteristic function $C_{A_{ij}(t)}(x,y)$ is 1 if $(x,y) \in A_{ij}(t)$ and 0 otherwise; B is the source beam pattern applied to path i; L_i is the accumulated loss along path i to the scattering point; $\widetilde{L}_j$ is the accumulated loss along the path j from the scattering point to the receiver; $\overline{B}$ is the receiver beam pattern applied to path j; and σ is a fully three dimensional scattering strength. Note that in Eq. (13), $m(x,y)$ indexes the set of rays between the source S and dA, and $n(x,y)$ indexes the set of rays between the receiver R and dA. For a bistatic reverberation calculation these two index sets are not necessarily the same. This reflects the fact that a given scattering point generally will be at different ranges from the source and receiver because of the horizontal source-receiver separation, and, therefore, a different set of rays will connect the scattering points to the source than will those to the receiver.

2.2 Target Returns

2.2.1 Monostatic Target Returns

The preceding formulations can be used to develop expressions for the echo return from a point target by assuming that the target scattering area can be described by a delta function. Thus, for a monostatic geometry, it follows from Eq. (9) that the echo return $E(\rho, z_e, t)$ from a point target located at range ρ and depth z_e is

$$E(\rho,z_e,t) = I \sum_{i\in m(\rho)} \sum_{j\in m(\rho)} C_{T_{ij(\rho)}}(t) \, \frac{b(\theta_i)\; \overline{b}(\theta_j)}{L_i(\rho,z_e)\; L_j(\rho,z_e)} \, \sigma(\theta_i',\theta_j') \;, \tag{14}$$

where

$$T_{ij}(\rho) = \{t \mid t - D \leq T_i(\rho) + T_j(\rho) \leq t\} \;. \tag{15}$$

Note that the equivalent azimuthal beamwidth Φ does not appear in the above expression. This is because of the tacit assumption that the target azimuth ϕ coincides with the maximum azimuthal response of the source and receiver beam patterns (i.e., the target is "broadside"). In this case

$$a(\phi) = \overline{a}(\phi) \text{ , and} \tag{16}$$
$$\Phi = 1 \, . \tag{17}$$

Note also, that the scattering strength σ now becomes the target strength. In reality, the target strength may be dependent on parameters in addition to those that appear in Eq. (14), such as target aspect, but that is ignored here.

Ignoring the time dependence and assuming $\sigma(\theta_i', \theta_j')$ is constant, the monostatic target return takes the form of

$$E(\rho, z_e, t) = I \left[\sum_{i \in m(\rho)} \frac{b(\theta_i)}{L_i(\rho, z_e)} \right] \left[\sum_{j \in m(\rho)} \frac{\overline{b}(\theta_j)}{L_j(\rho, z_e)} \right] \sigma \, . \tag{18}$$

Equation (18) is a sonar-equation representation except that source and receiver directivities have not been factored out of the summation over ray paths.

2.2.2 Quasi-monostatic Target Returns

As was the case for received reverberation, the expressions for target echoes in a quasi-monostatic geometry parallel those for a monostatic geometry except that in the former there is not a single function $m(\rho)$ indexing the ray paths connecting the target with the source and the target with the receiver. Rather, there are two distinct functions, $m(\rho)$ and $n(\rho)$, one each for both the source and receiver.

2.2.3 Bistatic Target Returns

For a bistatic geometry, Eq. (13) becomes

$$E(x, y, z_e, t) = I \sum_{i \in m(x,y)} \sum_{j \in n(x,y)} C_{T_{ij}(x,y)}(t) \, \frac{B(\theta_i, \phi_i) \, \overline{B}(\widetilde{\theta}_j, \widetilde{\phi}_j)}{L_i(x, y, z_e) \, \widetilde{L}_j(x, y, z_e)} \, \sigma \, . \tag{19}$$

3. MODEL OVERVIEW

RASP is based on range-dependent ray theory, which allows for both range-dependent sound speed fields and bathymetry. This ray theory or algorithm is essentially that used by the GRASS propagation model [7] which was initially developed at Hudson Laboratories [8]. Boundary reverberation is calculated by first determining the acoustic ray paths that join either the source or the receiver to each elemental scattering area on the boundary. Also, the acoustic intensity, travel time, and grazing angle at the scattering area are computed for each ray path. Next the reverberation contribution from each elemental scattering area is obtained by summing the time-dependent returns corresponding to the possible combinations of outgoing and returning paths. Finally, by integrating over the entire scattering boundary, the total time-dependent boundary reverberation is determined. Note that the current version of the RASP model is designed for sources that are either a single omnidirectional element or a vertical array of omnidirectional elements, and for receivers that are either omnidirectional or a horizontal array of omnidirectional elements. The limitation to these source and receiver configurations is due solely to the scaling procedures implemented in the last module (program ACTENV) of RASP and can be overcome by either modifying ACTENV or by judiciously specifying input scaling values.

The RASP model is a computer implementation of the foregoing ray-theoretic formulations of boundary reverberation and target echoes. It is an assemblage of six distinct programs and can be executed in whole or in part. In general, the sequence of program executions carry calculations forward from the specification of empirical sound-speed and bathymetry data to the display of predicted levels of surface reverberation, bottom reverberation, and target echoes as functions of range and time. The six programs of the RASP model are:

- PROFIL – constructs the environmental field from empirical data.
- RAYACT – computes ray paths from the source or receiver to the sea surface, bottom, and one or more target depths.
- RTHETA – organizes source- or receiver-originating ray path encounters with a boundary or target depth (into order contours) and calculates beam-weighted ray intensities.
- TLVSR – computes transmission loss vs range from the source or receiver to the fixed target depth.
- REVERB – computes (unscaled) surface or bottom reverberation vs time.
- ACTENV – computes target echoes vs range/time, scales echo and reverberation returns to absolute levels, and plots the results.

To generate a desired prediction, programs RAYACT, RTHETA, and/or REVERB must often be executed more than once. For example, if the source and receiver are physically separated, RAYACT must be run twice; once to compute ray paths from the source and once to compute them from the receiver. Also, RTHETA processes only one type of encounter (surface, bottom, or target depth) from either (but not both) the source or the receiver, during a single execution. In a monostatic case in which the transmit and receive beam patterns differ, RTHETA must be run separately for each beam pattern. Finally, REVERB computes either (but not both) surface or bottom reverberation during one execution. Figures 2 to 8 illustrate the flow of required program executions for a number of desired predictions and source/receiver geometries.

The RASP model is currently configured for operation on the VAX Model 6310. It is reasonably portable because it incorporates a minimum of VAX-specific Fortran features. Model-generated data files are sequential-binary files and all other user-supplied data are input by using ANSI-standard free-field READ statements. The model utilizes the DISSPLA graphics package and is designed to work with any version equal to or greater than 9.0. No other standard package is required. Array dimensions are specified by PARAMETER statements to ease changes in program storage requirements. These are also used to assign logical unit numbers to input and output devices.

Required space for the RASP source code is approximately 700 blocks; the executable file space is about 2000 blocks (a block is 512 bytes). A typical execution generates approximately 5000 blocks of new output file space, depending on the amount of printed information that is

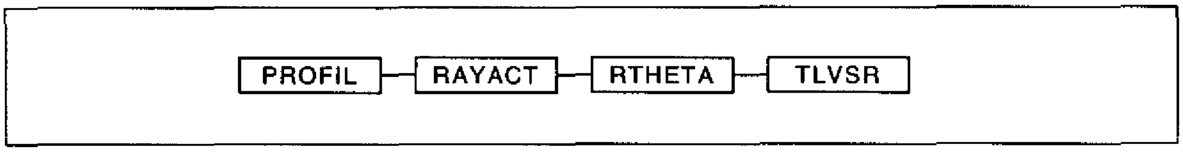

Fig. 2 – Required program executions for calculating transmission loss (one-way) vs range

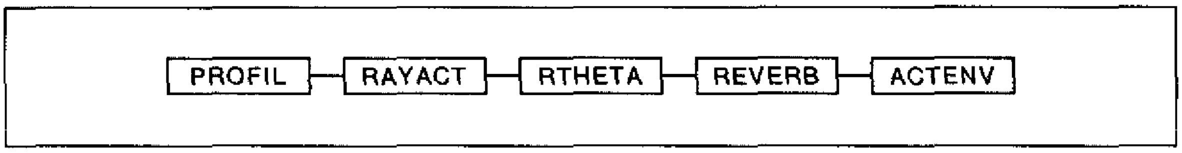

Fig. 3 – Required program executions for calculating monostatic surface or bottom reverberation (identical source/receiver beampatterns)

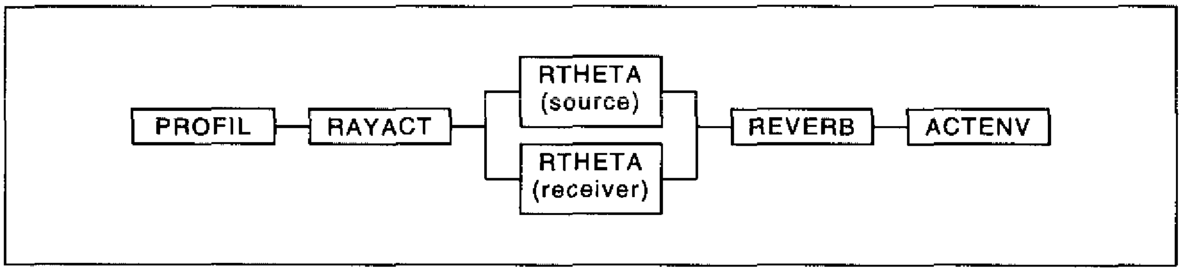

Fig. 4 – Required program executions for calculating monostatic surface or bottom reverberation (different source/receiver beampatterns)

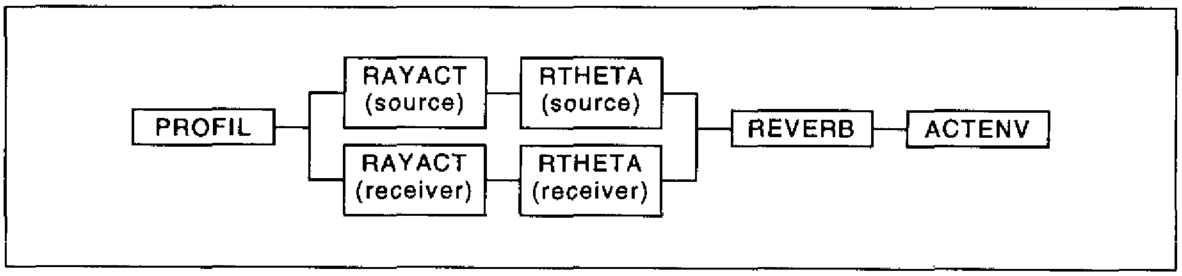

Fig. 5 – Required program executions for calculating quasi-monostatic surface or bottom reverberation

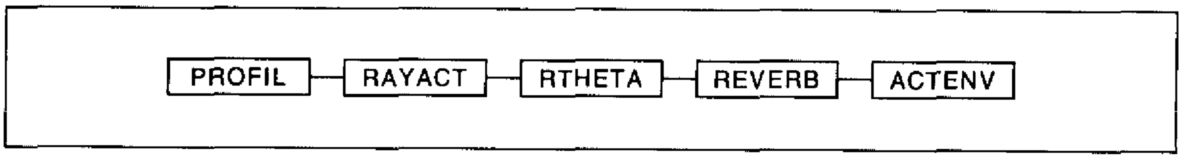

Fig. 6 – Required program executions for calculating bistatic (range-independent) surface or bottom reverberation

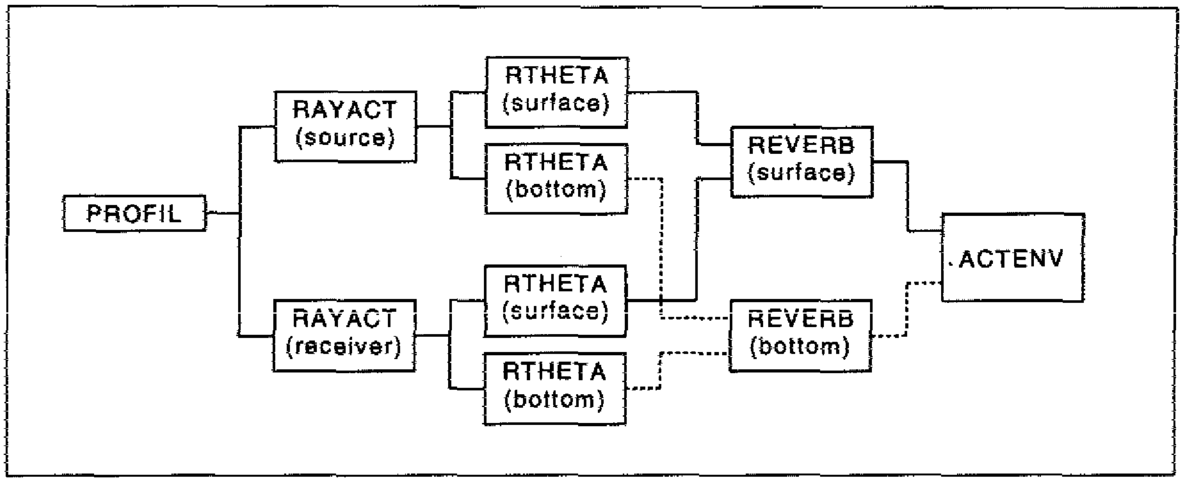

Fig. 7 – Required program executions for calculating quasi-monostatic surface and bottom reverberation

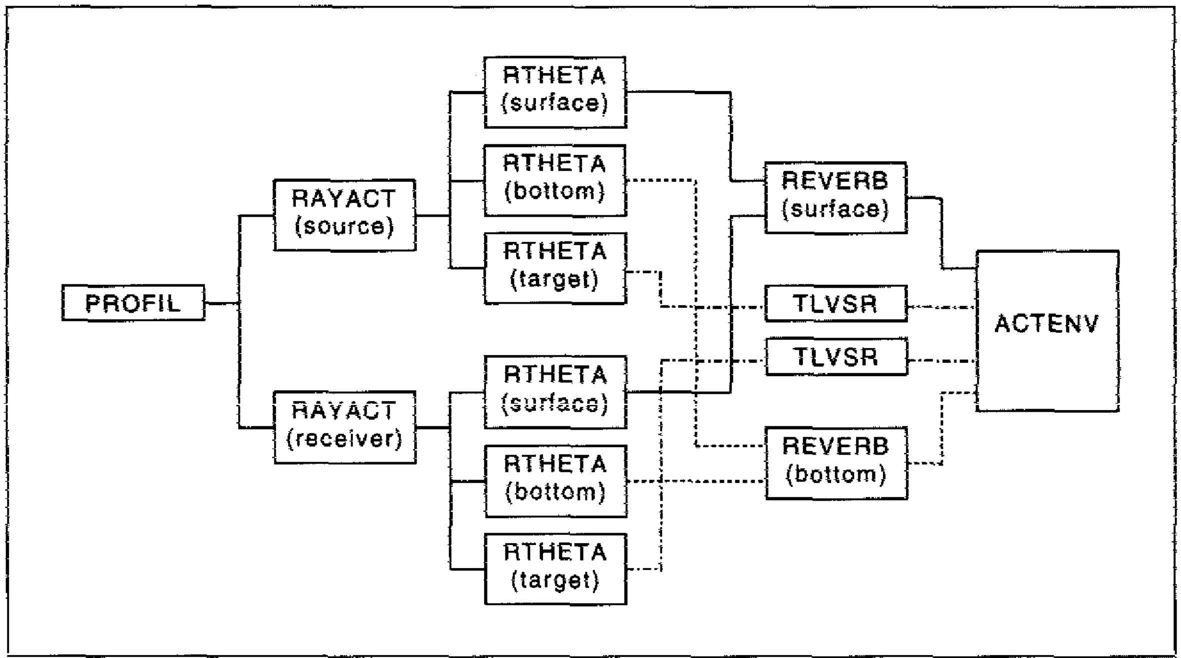

Fig. 8 – Required program executions for calculating quasi-monostatic surface and bottom reverberation with target echo returns from one depth

specified. Elapsed CPU time for a model run can vary from 3 to 15 minutes. These times are typical for ranges less than 500 nmi and depend on the complexity of the case (range, number of rays, and particularly number of print files desired). See the section on model executions for specific examples.

On the VAX Model 6310, the RASP model can be run either in an interactive mode or through the on-line or batch execution of command files (consisting of system commands and input data). The latter method is recommended because of the considerable amount of input data normally required for a RASP execution. In this case, a command file must be provided for each desired execution of any program; these files must then be sequenced in an order consistent with one of the flow charts of Figs. 2–8. The construction of a sequence of command files for a RASP model execution can be an arduous task. Therefore it is recommended that the user construct sample command files for the options diagrammed in Figs. 2–8. These file structures can then be simply edited for specific runs.

An interactive program named MENU has been developed to facilitate the construction of command files. MENU accomplishes its function in part by restricting the options available to the user. It is not a sophisticated program, but it provides a useful service.

4. PROGRAM DESCRIPTIONS

To exploit the versatility of the RASP model and to properly interpret its results, it is useful to understand how each program of the model performs its function. Therefore a moderately detailed discussion of each program is provided in the following paragraphs.

4.1 Program PROFIL

The primary function of PROFIL is to process empirical sound speed and bathymetry data and to create a range-dependent environmental data file for subsequent use by the ray-tracing program RAYACT.

The input data must describe a two-dimensional (range-depth) ocean environment along a radial track. Data are read from two distinct, and specified, input sound-speed and bathymetry data files. Each file is read by using a free-field format; this format is generally compatible with common oceanographic database formats.

Figure 9(a) is an example of a two-point bathymetric data file. The file must contain data on sequential pairs of range-depth values with a maximum of 800 pairs. Figure 9(b) illustrates a typical sound velocity profile file. This file contains data as sequential pairs of depth and sound speed values (at each range), with each complete set preceded by the range and number of depth values for that set.

Input sound-speed profiles are corrected for Earth's curvature and individually fit with a (two-prime) cubic spline function. This type of spline-fit is identical to the one used by the GRASS ray-tracing model [7]. The range-dependent bathymetry samples are connected by linear segments that are used to calculate bottom slope as a function of range. Spatial derivatives of sound-speed are required by the ray-tracing algorithm in RAYACT. Consequently, the spline fits are used to calculate the first and second derivatives of sound speed with respect to depth, as a

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200.0,	4500.0

(a)

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706.0,	1477.0
1177.0,	1480.0
2000.0,	1490.0
5000.0,	1520.0
200.0, 6	
0.0,	1495.0
424.0,	1480.0
635.0,	1477.0
1059.0,	1480.0
1800.0,	1490.0
4500.0,	1520.0

(b)

Fig. 9 – Samples of (a) bottom bathymetry file and (b) sound velocity profile (SVP) file. The bathymetry file consists of two range/depth pairs. The SVP file consists of profiles at ranges of 0 km and 200 km. Each contains six depth/sound speed pairs.

function of depth and at the fixed (relative) horizontal range location of each profile.

The first derivative with respect to range of sound speed at a fixed depth is calculated by RAYACT in either of two ways. The first linearly interpolates horizontal first-differences in the sound speed of range-adjacent sound-speed profiles. A second available approach attempts to account for range dependence in the depths of surface ducts and deep-sound channels. In this case, first the surface (zero) and maximum (made common to all profiles) depths of all the sound-speed profiles are connected by horizontal line segments. Next, the depths of the surface ducts (taken to be zero when a duct does not occur in a profile) are linearly connected between the range-distributed profiles. Thus for a profile that has a surface duct, and for which the next (in range) profile does not, a line is drawn from the depth and range of the duct in the first profile to the sea surface at the range location of the second profile. This models the "disappearance" of the surface duct. Finally, the minimum sound-speed axis of up-to-two deep sound channels are connected between consecutive profiles to model, for example, a range dependence of the depth of the SOFAR channel.

When the above "profile connections" are completed, the range-depth rectangle between each consecutive pair of sound-speed profiles will have been divided into trapezoidal regions. If requested, when running RAYACT, sound speed and its spatial derivatives will be computed between adjacent input sound-speed profiles by linear interpolation within the trapezoids. However, the automated connection procedure in PROFIL does not always produce the desired results and so the use of the profile connections for range-dependent sound speed in RAYACT should be used with caution.

In addition to creating print and data files of sound-speed and bathymetry information,

Table 1 – "Typical" RASP Fan Angles

Fan no.	Starting Launch Angles (Deg)	Final Launch Angles (Deg)	Angle Increment (Deg)
1	−84	−33	3.0
2	−30	−23	1.0
3	−22	−15	0.5
4	−14	+14	0.2
5	+15	+22	0.5
6	+23	+30	1.0
7	+33	+84	3.0
Note: angles measured positive-down from the horizontal.			

PROFIL can, as an option, produce one or more plots of the environmental data. These plots are of:

- sound-speed contours on a range-depth grid (e.g., Fig. 16 on page 72),
- a composite scene of sound-speed profiles and bathymetry on a range-depth grid (e.g., Fig. 17 on page 73), and
- one or more individual sound-speed profiles for inspecting spline fits (e.g., Figs. 18 and 19 on pages 74 and 75, respectively),

4.2 Program RAYACT

RAYACT reads an environmental data file created by PROFIL and applies a two-dimensional, range-dependent ray-tracing algorithm. The algorithm is used to determine the ranges and associated ray statistics of ray-path encounters with the (flat) sea surface, the linearly segmented, range-dependent bathymetry, and up-to-three fixed target depths. The ray statistics include initial angle, grazing angle, travel time, number of ray cycles, and accumulated bottom loss for each ray path. This information is recorded on data files (one for each boundary and target depth for subsequent use by RTHETA). As an option, a plot of ray paths can be produced. The program does not compute ray intensities or (total) transmission loss. These quantities are calculated in RTHETA and TLVSR. When the source and receiver are separated in depth, RAYACT must be executed twice: once for rays leaving from the source, and once for rays from (to) the receiver.

The source (receiver) depth, source frequency, and initial launch angles must be specified. Initial ray angles (measured positive-down from the horizontal) are specified by one or more non-overlapping ray-angle "fans", which are angular intervals of equally spaced and increasing angles (e.g., from −14 deg to +14 deg in steps of 0.2 deg). The user can input up to seven fans or angles specifying the starting and final launch angle and the angle increment. The maximum allowable angular sampling resolution is 0.1 deg. Table 1 gives "typical" ray angles used by RAYACT. These angles are used as default angles by program MENU (but not RAYACT). Also, MENU limits the user to one target depth, vs the three depths actually allowed by RAYACT.

The selection of initial ray angles is somewhat subjective, but improves with experience. A major criterion for the effective selection of initial angles is that the linear connections of the resulting samples of the range-angle contours of boundary and target-depth encounters adequately describe these contours (see the following discussion of program RTHETA). That is, the density of samples allows linear interpolation to provide a good estimate of contour slope, especially in regions of main beam interactions and near caustics.

Snell's law can be used to estimate critical angles at the surface, bottom, and target depths. With this information and the angular extent of the vertical main beam (of the source or receiver), the user is advised to generally apply a relatively fine angular resolution (e.g., 0.2 deg) for rays: (1) in a main beam, (2) that may encounter a boundary at a low grazing angle, or (3) may intercept a target depth at a low angle. The latter two generally correspond to approximately ±14 deg in the deep ocean. The angular sampling resolution can then be gradually decreased for the steeper initial angles.

Ray trajectories can be terminated in a number of ways. These include exceeding any one of the following:

- maximum propagation range,
- maximum one-way travel time,
- maximum number of bottom reflections,
- maximum accumulated bottom loss, or
- maximum ray-order (see program RTHETA).

RAYACT will either assign default values, or compute values from available information, for each of the above. Also, the maximum ray order to process can be specified later when running RTHETA.

Reference 8 describes the method of ray trace used in RAYACT. The procedure is an iterative one in which a ray is incremented from point to point along its path. This is accomplished by evaluating Taylor series expansions in arc length, of various ray parameters such as range, depth, travel time, and ray angle. These expressions are derived from the basic ray equation:

$$\frac{d}{ds}\left[\frac{1}{c(\rho,z)}\,\frac{dP}{ds}\right] = \nabla\left[\frac{1}{c(\rho,z)}\right] . \qquad (20)$$

The sound speed $c(\rho, z)$ is assumed to be known at every range ρ and depth z along the two-dimensional medium. P is the positional vector to a point on the ray, and s is arc length along the ray.

The iterative computation of ray trajectories requires the specification of certain iteration step-size and accuracy-test parameters. Program RAYACT will use internally specified default values for these parameters unless overridden by the user. Also, when using MENU to run RAYACT, the default values will automatically be used. It is recommended that the user allow these default values to be used except for special cases where extreme accuracy is sought. Reference 8 provides additional details of the iterative ray-trace algorithm.

Bottom reflection loss functions are also input in RAYACT for up to four range intervals. The user is prompted for the number of angle/loss pairs to be input and the maximum range for these pairs. The grazing angle and the corresponding bottom loss is input for the specified number of pairs, where grazing angles range from 0 to 90 deg.

Alternatively, RAYACT has bottom reflection loss functions internally stored. These functions can be specified by identifying FNWC bottom types. A user may input up to five FNWC bottom types ranging from type 1 to type 5 along with the maximum range for this bottom. It is important to note that the bottom loss functions for bottom types 1 and 2 are identical, as are those for bottom types 4 and 5 [6]. Bottom type 1 is typically a low-loss bottom while bottom type 5 is typically a high-loss bottom.)

Program RAYACT generates output in several forms, most of which are optional. These include:

- data files of surface, bottom, and target ray calculations for input to RTHETA,
- a print file of detailed ray boundary/target-depth encounter information (selected rays), and
- a plot of selected ray paths (e.g., Figs. 20 and 21 on pages 76 and 77, respectively).

4.3 Program RTHETA

The function of RTHETA is to reorganize the raytracing results of RAYACT into order contours, which is a form amenable to calculating boundary reverberation and total (ray-summed) transmission loss to a target. In addition, transmission loss (or normalized ray-intensity) is computed for each ray path encounter with a boundary or target depth. A single execution of RTHETA processes only one boundary or target depth, and generates an output file that can serve as input to either REVERB or TLVSR.

The concept of order contours is most simply illustrated for a monostatic geometry. Consider the cyclic ray propagated from the point S/R in Fig. 10. A numbering convention is adopted with respect to reversals in ray trajectories from encounters or turns: ray crests and surface encounters are numbered with odd integers, the valleys and bottom encounters are assigned even integers. The integers increase with distance from the source and are used to classify the state of the ray by the number of oscillations it has made. Rays with an equal number of oscillations are said to be of equal order. The order contours are thereby derived from the range at which rays encounter a boundary. Ranges corresponding to ray reversals that are not due to boundary encounters do not define points on order contours. In Fig. 11, order contours are shown as curves determined by the boundary encounters of a given order and plotted on an initial source angle vs range coordinate system. A given contour need not necessarily be a continuous curve but may consist of several disjoint segments separated by intervals of ray turning points.

For a given boundary, only those contours corresponding to that boundary are pertinent; they are odd for the surface and even for the bottom. For example, to determine all ray paths between the source-receiver point and the bottom at range ρ, consider a horizontal slice at ρ as shown in Fig. 12. If the three paths having initial angles θ_1, θ_2, θ_3 denoted by 1, 2, 3, respectively, then the index set $m(\rho)$ of Eq. (9) consists of the integers 1, 2, and 3. Therefore, there are 3^2 or 9 possible routes from the source-receiver point to the bottom at range ρ and back again.

A finite number of points on the order contours are computed in practice because a limited number of rays are traced. Figure 13 illustrates the construction of two order contours of the type produced by the RASP program. Here Bs represent the bottom encounters and the Vs represent the refracted turning points (valleys) determined by tracing rays with initial angles

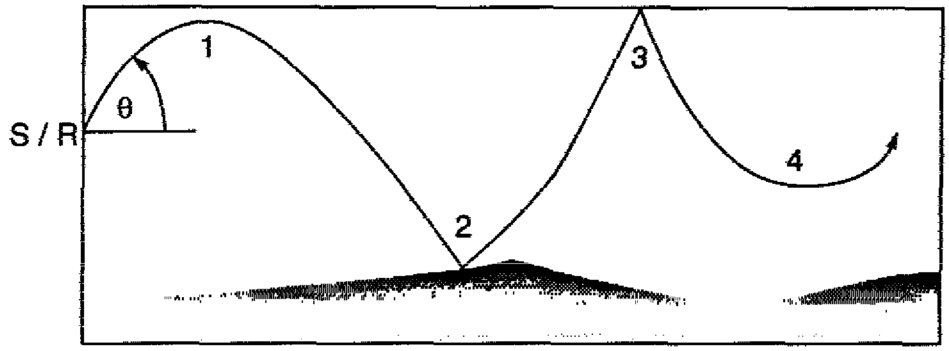

Fig. 10 – Numbering of ray crests, ray valleys, and boundary hits illustrated for one ray

$\theta_1, \theta_2, \ldots, \theta_n$. The order contours are approximated by linearly connected, consecutively computed, bottom encounters of the same order. For contour points between the computed points, the travel time, transmission loss, and the angle at which a ray encounters a boundary can be found by interpolating the corresponding computed values linearly with respect to range. The use of ray orders thus facilitates the determination of all the ray paths connecting the source-receiver point S/R with a boundary element at any range ρ.

Figure 14 illustrates a smoothed surface order contour obtained for a typical deep-ocean sound-speed profile. The two rays that just graze the bottom (corresponding to upward and downward initial angles) determine points B and B' on the contour. The two rays that just graze the surface occur at shallower angles. These rays contribute points A and A' on the contour. Thus rays corresponding to initial angles in the intervals (θ'_B, θ'_A) and (θ_B, θ_A) encounter the surface but not the bottom. These rays provide significant contributions to surface reverberation at long ranges. Rays having steeper initial angles encounter the bottom and thereby suffer bottom loss. The cumulative loss associated with several bottom reflections causes these rays to have less effect on surface reverberation at long ranges where the higher order contours are relevant.

Transmission loss is determined for points on an order contour by computing individual-ray transmission loss at the ray-encounter locations found by raytracing and applying linear interpolation between these points. Here, transmission loss consists of geometric spreading, absorption loss, bottom loss, and weighting by a vertical beam pattern. Whereas bottom loss is computed during ray tracing, the remaining losses are calculated after the order contours are constructed. Volume absorption is estimated by using Thorp's equation [9]. Geometric spreading loss under our assumption of azimuthal symmetry is given by Ref. 10:

$$L(\rho) = \left| \frac{\rho}{a^2} \, \frac{\sin\gamma}{\cos\theta} \, \frac{\partial\rho}{\partial\theta} \right| , \tag{21}$$

where a is the unit reference distance, ρ is the horizontal range, θ is the initial source angle of the ray, and γ is the angle the ray makes with the horizontal at range ρ.

The derivative $\partial\rho/\partial\theta$ in Eq. (21) is approximated numerically at each point (ρ_i, θ_i) on a contour. If θ_{i-1}, θ_i, and θ_{i+1}, are the successive initial angles of rays that are traced on this contour, and ρ_{i-1}, ρ_i, and ρ_{i+1} are the corresponding ranges, then

$$\frac{\Delta\rho_i}{\Delta\theta_i} = \frac{\Delta R_i}{\Delta R} \, \frac{\Delta R_{i-1}}{\theta_i - \theta_{i-1}} + \frac{\Delta R_{i-1}}{\Delta R} \, \frac{\Delta R_i}{\theta_{i+1} - \theta_i} , \tag{22}$$

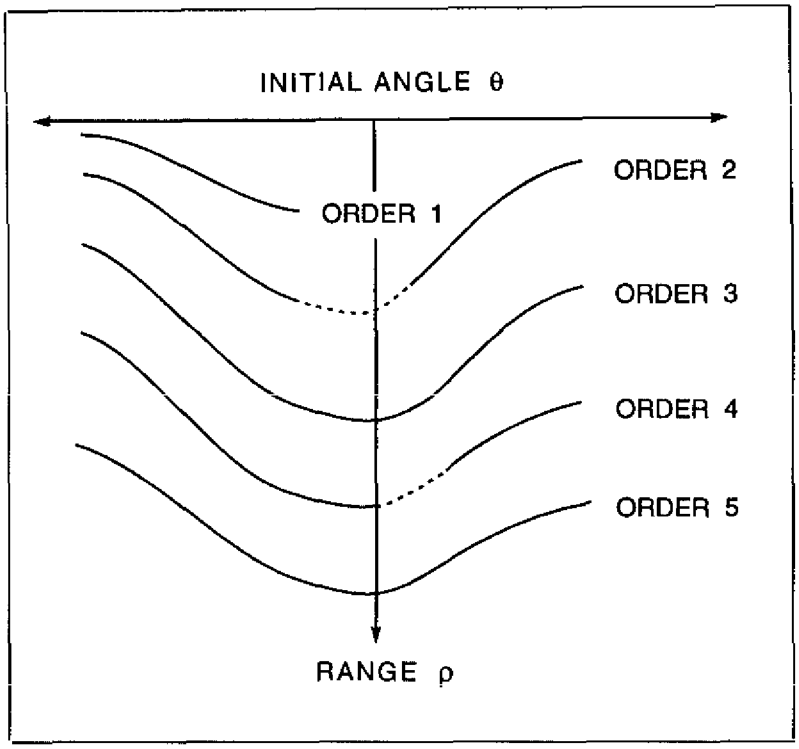

Fig. 11 – Order contours

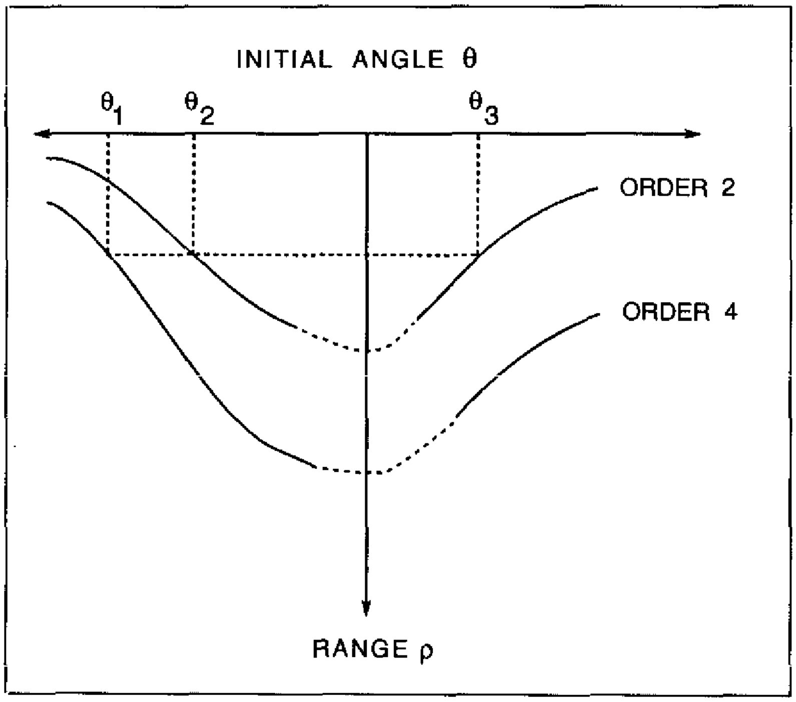

Fig. 12 – Calculation of launch angles, i.e., rays that meet bottom boundary (curves of even order) at range ρ

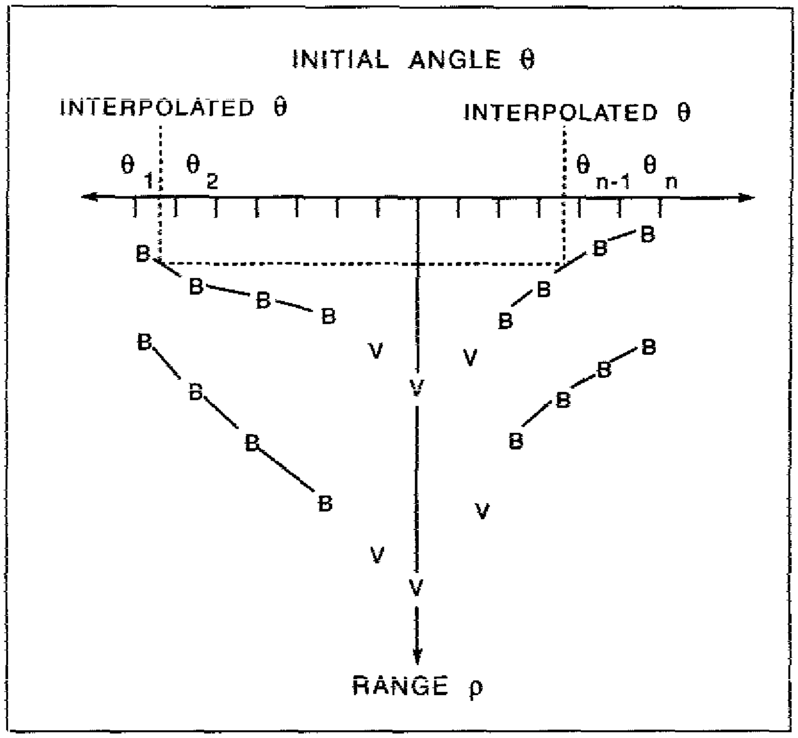

Fig. 13 – Computer construction of order contours $R(\theta, \rho)$

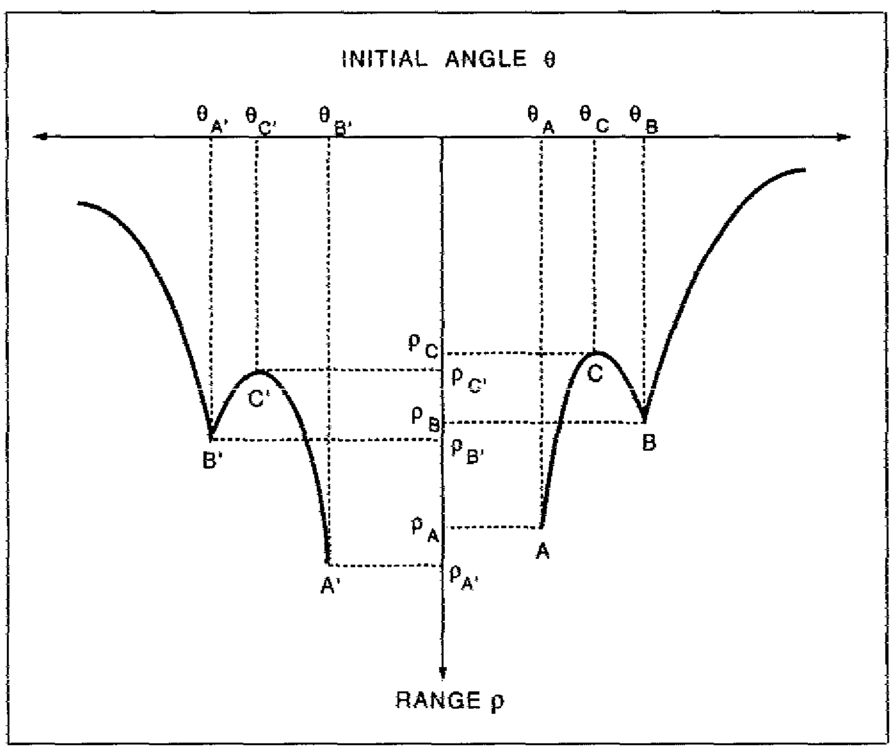

Fig. 14 – Smoothed surface order contour illustrating caustic behavior

where

$$\Delta R_{i-1} = | \rho_i - \rho_{i-1} | , \tag{23}$$

$$\Delta R_i = | \rho_{i+1} - \rho_i | , \text{ and} \tag{24}$$

$$\Delta R = \Delta R_{i-1} + \Delta R_i . \tag{25}$$

Program RTHETA applies beam weights to ray intensities, or transmission losses. As such, the user is prompted for a vertical beam pattern. This beam pattern is assumed to be normalized to unity (0 dB) at its maximum response. The beam pattern can either be: (1) read in from an ASCII file of decibel levels that are sequentially associated with angles from -90 deg to +90 deg in 1-deg increments, or (2) internally computed for equally spaced elements of a vertical line array. For internal computation of the beam pattern, the user supplies the number of elements, the element spacing as a fraction of the acoustic wavelength, and the vertical tilt (steering angle) of the array pattern. By entering a "1" for the number of elements, a unity omnidirectional pattern is computed.

In using a ray-theoretic approach to modeling sound propagation, a serious deficiency arises when attempting to calculate geometric spreading loss in near-caustic regions, that is, near locations where adjacent ray paths cross. In this region geometric spreading tends to zero, erroneously implying infinite intensity at the point of intersection. This phenomenon occurs when the $\partial\rho/\partial\theta$ is equal to zero, or as related to order contours, where the contour of order n, $\rho = f_n(\theta)$, has a stationary value. The surface order contour shown in Fig. 14 has caustics at points C and C'.

Program RTHETA determines the locations of potential caustics ($\partial\rho/\partial\theta = 0$) and attempts to distinguish between real and false caustics. The latter are often generated by irregular bathymetry or at slope discontinuities of an order contour corresponding to transitions between ray-path "types". For example, the false caustics at points B and B' of Fig. 14 separate ray paths that have been bottom reflected from those that have been refracted away from the bottom. For a real caustic, RTHETA applies a wave-theoretic smooth caustic correction in the region of the caustic. The particular formulation agrees with Spofford [11]. When the caustic correction is applied, additional discrete ray encounters are created to provide more accurate interpolation of intensity within the caustic region.

The presence of caustics corresponding to rays that have initial angles within the intervals defined by the surface grazing ray angles implies that, for surface reverberation, the greatest variations in ray intensity occur in those intervals. Thus, the initial angles of rays that contribute to the corresponding significant portions of the order contours must be sampled densely enough during ray-tracing to ensure accurate intensity calculations.

A practical problem arises when rays are traced to longer ranges over irregular bottom topography, or when a significant number of ray paths encounter a seamount or continental rise. In these cases, the corresponding order contours may tend to become highly irregular, with numerous false caustics; these contour irregularities can hamper the estimation of range derivatives needed for transmission loss calculations. To combat this problem, a statistical ray-averaging procedure has been developed that operates on an order contour and effectively smooths the irregularities in the transmission loss estimates. The procedure does not apply a caustic correction. Rather, it involves unfolding the order contour and providing an avenue around zeros in $\partial\rho/\partial\theta$. The procedure leads to an expression that is similar to the result obtained by Hardy [10]. Whereas Hardy's result calls for averaging ray intensity as a function of depth, the method used by RTHETA, developed by Palmer [12], performs ray intensity averaging as a function of range.

Therefore, program RTHETA uses two methods to compute the transmission loss of individual rays: one that uses geometric spreading with caustic corrections (called a ray bundle calculation) and another that involves statistical ray averaging. Only one of these types of calculations can be written to an output file for subsequent use by TLVSR or REVERB, and this choice is user specified. Normally, the ray bundle calculations are written to the output file. However, in cases of irregular bathymetry, it is recommended that the statistical averages be selected for contours of bottom encounters.

Occasionally, a ray will be erroneously traced in the sense that its cyclic behavior differs radically from the ray paths of neighboring initial launch angles. For example, when a source is placed below a shallow surface duct a ray may inadvertently become trapped in the duct although its immediately neighboring rays are not. Such an occurrence can significantly distort the resulting order contours. To overcome such a situation, the user has the option to delete specific ray paths from the construction of order contours.

Upon completion, RTHETA will output

- a plot of order contours (e.g., Figs. 22 thru 27 on pages 78 thru 83, respectively),
- calculations of order contours and associated transmission losses on a data file for input to programs TLVSR and REVERB, and
- a print file of data describing the order contour curves.

4.4 Program TLVSR

The purpose of TLVSR is to compute the transmission loss from either the source or receiver to a target-depth, as a function of range from the source (receiver). Here, transmission loss is defined as the total loss suffered by the multiple ray paths that propagate from the source (receiver) to the target-depth. Computed transmission loss vs range are plotted and written to an output data file. Such data files of transmission loss from the source-to-target and (by using reciprocity) from the target-to-receiver are used in ACTENV to evaluate Eq. (14) for target returns as a function of range. Additionally, TLVSR will compute and print the ray arrival structure, as a function or range.

A data file of order contours and normalized ray intensities generated by RTHETA for a specific target depth, serves as input to TLVSR. Program TLVSR, in part, mimics REVERB in that it steps out in range while interpolating source (receiver) order contours to obtain the ray arrival structure at each sampled range, where the individual ray intensities are summed (and inverted) to produce transmission loss. Actually, any data file generated by RTHETA can serve as input to TLVSR. That is, TLVSR is capable of computing transmission loss from the source (receiver) to either the sea surface or bottom.

Program TLVSR computes both coherent and incoherent transmission loss. Although both are plotted, only incoherent transmission loss is written to the output file for subsequent target-echo calculations. Incoherent transmission loss L_{incoh} at the target depth at range ρ is given by

$$\frac{1}{L_{\text{incoh}}(\rho)} = \sum_{i \in m(\rho)} \frac{b(\theta_i)}{L_i(\rho)} , \tag{26}$$

where $m(\rho)$ indexes all the ray paths at the target-depth and range location. Similarly, coherent transmission loss $L_{\text{coh}}(\rho)$ is given by

$$\frac{1}{L_{\text{coh}}(\rho)} = \left[\sum_{i \in m(\rho)} \left(\frac{b(\theta_i)}{L_i(\rho)} \right)^{1/2} \cos \Psi_i \right]^2 + \left[\sum_{i \in m(\rho)} \left(\frac{b(\theta_i)}{L_i(\rho)} \right)^{1/2} \sin \Psi_i \right]^2 , \tag{27}$$

where Ψ_i is the phase angle of the ith path.

To repeat, possible output from program TLVSR consists of:

- a data file of transmission loss to a target-depth as a function of range,
- a plot of incoherent and coherent transmission loss as a function of range (e.g., Figs. 28 and 29 on pages 84 and 85, respectively), and
- a print file of ray arrival structure as a function of range.

4.5 Program REVERB

The time history of acoustic reverberation received from either the ocean surface or bottom is calculated in program REVERB. This is accomplished by numerically evaluating the appropriate integral equation of those developed earlier for monostatic, quasi-monostatic, and bistatic geometries. Data files of order contours constructed by RTHETA serve as input to this program. Also the specifications of boundary scattering strengths and transmit-signal duration are required by REVERB. Vertical directivities of the source and receiver beam patterns are accounted for in RTHETA, and horizontal directivities are specified later, in ACTENV. Program REVERB is computationally intensive and is the only program of the RASP model that is not capable of producing a plot. The plotting (and scaling) of reverberation envelopes is performed in program ACTENV.

Before reverberation can be calculated, the reverberant boundary and source-receiver geometry must be identified. The boundary is identified automatically using information on the input data files. The geometry is user specified. If a monostatic geometry is specified, then a single input data file of order contours is used to describe (beam-weighted) propagation from both the source and receiver. If a quasi-monostatic geometry is specified, then separate files are input for the source and receiver. Two input files are also required for a bistatic geometry, as is the horizontal source-receiver separation.

The (horizontally) bistatic reverberation calculation in REVERB is valid only for range-independent environments. This is because of the assumption of azimuthal symmetry of the environment (and beam patterns) relative to two horizontally separated (source and receiver) locations. Also, bistatic reverberation is calculated by using an expression that results from a transformation of Eq. (13) to a biradial coordinate system. A description of the transformation and bistatic reverberation is calculated as given in a previous report [1] that documented the original NRLREV model. Here, discussion is restricted to the monostatic and quasi-monostatic capabilities of program REVERB.

Boundary backscattering strengths can either be entered in tabular form or derived from internally stored models. In either case, on purely backscattering strengths, $\sigma_b(\theta)$ for identical incident and scattering grazing angle θ is specified. This restriction is more the result of available models than software capability. In those cases where the incident and scattering angles θ_i' and $\widetilde{\theta}_j'$ of Eqs. (9) and (10) differ, the scattering strengths is estimated by $\sigma_b(\overline{\theta}'_{ij})$ where $\overline{\theta}'_{ij} = (\theta_i' + \widetilde{\theta}_j')/2$.

In the case of surface reverberation, the user can either enter a numerical table, or specify the use of the Chapman-Harris empirical model [2] to describe surface backscattering. For the latter, either sea state, wind speed, or wave height must be specified. For bottom reverberation calculation, the user can either enter a numerical table, specify the use of Lambert's law, or specify the use of one of four empirical bottom-type models from Urick [3, 4], to describe bottom backscattering. Lambert's law is a backscattering strength model given by

$$10 \log_{10} \sigma(\theta) = V + 10 \log_{10} \sin^2 \theta \,, \qquad \text{(dB)} \qquad (28)$$

where V is a constant and θ is the grazing angle. V is either input by the user or a default value of -29 dB is used. The four (Urick) bottom backscattering models correspond to bottom compositions of rock, sand, silt, and clay. Also in the case of bottom reverberation, bottom backscattering strengths can be varied with range. Different models of backscatter strengths can be specified for up to four range intervals.

The transmit signal is specified only by its duration, or pulse length. For CW and broadband noise signals the definition of pulse length is simple. However, for complex waveforms, such as an FM sweep (which is processed by pulse compression matched filtering), the duration parameter required by REVERB is the pulse length of the equivalent CW pulse, i.e., $1/W$ where W is the frequency bandwidth (Hz) of the transmitted waveform.

Once the reverberant boundary, source-receiver geometry, backscattering function, and pulse-duration have been specified, the envelope of received reverberation is calculated. In the case of monostatic and quasi-monostatic geometries this is accomplished by evaluating an expression of the form

$$R(t_l) = I \; \Phi \sum_{k=1}^{N} \sum_{i \in m(\rho)} \sum_{j \in n(\rho)} C_{\chi_{ij(t_l)}}(\rho_k) \; \frac{b(\theta_i) \; \widetilde{b}(\widetilde{\theta}_j)}{L_i(\rho_k) \; \widetilde{L}_j(\rho_k)} \; \sigma(\theta_i', \widetilde{\theta}_j') \; \rho_k \; \Delta\rho_k$$

$$\text{for } l = 1, 2, 3, \ldots, M \,. \qquad (29)$$

This is a discretized form of Eq. (10) for boundary reverberation received in a quasi-monostatic geometry. It is also valid for a monostatic geometry when $m(\rho) = n(\rho)$ (and the tildes are no longer necessary to distinguish source quantities from receiver quantities). In program REVERB it is assumed that

$$\begin{aligned} I &= 1 \\ \Phi &= 2\pi \\ \sigma(\theta_i', \widetilde{\theta}_j') &= \sigma_b(\overline{\theta}'_{ij}) \\ \Delta\rho_k &= \text{constant} \\ \rho_k &= \rho_0 + (k-1)\Delta\rho_k \\ \Delta t &= \text{constant} \\ t_l &= t_0 + (l-1)\Delta t \,. \end{aligned} \qquad (30)$$

Now, Eq. (29) becomes

$$R(t_l) = 2\pi \sum_{k=1}^{N} \sum_{i \in m(\rho)} \sum_{j \in n(\rho)} C_{\chi_{ij(t_l)}(\rho_k)} \frac{b(\theta_i)\ \overline{b}(\widetilde{\theta}_j)}{L_i(\rho_k)\ \widetilde{L}_j(\rho_k)}\ \sigma_b(\overline{\theta}'_{ij})\ \rho_k\ \Delta\rho_k \tag{31}$$

$$\text{for } l = 1, 2, 3, \ldots, M\ .$$

Equation (31) is evaluated by stepping out in range in equal steps of $\Delta\rho$ from an initial range (nominally zero) to some maximum range. At each range ρ_k, the multiple paths connecting the source, receiver, and scattering element at ρ_k are determined by interpolating the order contours at range ρ_k. Then the reverberant contribution of each (i, j) transmit and return path-pair is computed and added to an accumulation of returns of those $R(t_l)$ that correspond to the active times of the return, i.e.,

$$t_i + \widetilde{t}_j \le t_l \le t_i + \widetilde{t}_j + D\ . \tag{32}$$

Note that horizontal range is stepped/sampled in equal steps of $\Delta\rho$, which corresponds to the range extent of a scattering element. Thus $\Delta\rho$ must be small enough that the multipath structure over the interval does not change appreciably from that found at its midpoint. Also, the round-trip ray path travel times must not vary over the interval to more than the pulse duration. Otherwise, erroneous reverberant dropouts (times of no received reverberation) may result from the computations. The latter constraint can be expressed by

$$\Delta\rho < \frac{c\ D}{2}\ , \tag{33}$$

where c is the sound speed and D is the pulse duration in seconds. A simple approximation to Eq. (33) is to equate $\Delta\rho$ to D where the latter is interpreted as being expressed in units of kilometers.

The length of the step size $\Delta\rho$ will directly impact the CPU time required for an execution of program REVERB. For reverberation calculations over long ranges and for pulse lengths greater than a second, a step size between 0.5 and 1.0 km is recommended. For pulse lengths of less than a second, Eq. (33) should guide the length of step size.

The reverberation $R(t_l)$ calculated for time t_l is not instantaneous power. Rather, it is reverberant energy received over the Δt time interval preceding t_l, divided by Δt which is an average power. For small Δt on the order of a second, the difference between instantaneous power and average power should be insignificant. Larger Δt will act to smooth the reverberation envelope. The time interval Δt corresponds to an averaging time.

Program REVERB is also capable of determining the vertical-angle distribution of the temporal envelope of received reverberation, for angular intervals specified by the user. The results are written to a data file. However, the version of RASP reported here, contains no capability for plotting these results.

As mentioned previously, REVERB is a computationally intensive program. Its output is generally restricted to a data file containing a computed boundary-reverberation envelope to be scaled and plotted by program ACTENV. Nevertheless, additional outputs are available, primarily as options. In total, available output includes

- a data file of the reverberation envelope,
- a data file of the vertical-angle distribution of the reverberation envelope, and
- a print file of the reverberation envelope and its angular distribution.

4.6 Program ACTENV

Program ACTENV predicts the performance of a monostatic, quasi-monostatic, or horizontally bistatic active sonar system by assembling, scaling, and plotting the results of other programs of the RASP model, primarily program REVERB. Its primary output is a plot that overlays the individual mean received-power vs time-after-transmission envelopes of surface reverberation, bottom reverberation, ambient noise, and target echoes on a common level-vs-time grid. Not all of these envelopes need to be processed and plotted, except ambient noise. For example, ACTENV is capable of plotting only surface reverberation (and ambient noise). Reverberation envelopes are constructed from the results of REVERB. The target-echo envelope is constructed from the sonar equation representation of either Eq. (14) or Eq. (19), where vertical-beam-weighted transmission losses have been computed by TLVSR. Target echoes are initially computed as a function of range and then converted to a function of time-after-transmission by using the approximation of 1480 m/s. Ambient noise is assumed to be omnidirectional and time-independent, and is determined from a user-specified constant.

Program ACTENV allows for a variety of signal types although prior to ACTENV, all calculations assume a finite-duration (gated) continuous wave (CW) pulse. Also, an omnidirectional or vertical source array is assumed, whereas the receiving array may be omnidirectional or in the case of monostatic or quasi-monostatic geometries, horizontal. In the latter case, horizontal directivity is accounted for by applying a horizontal-receiving directivity index. (Also a reverberation envelope averaging option can be used to simulate the receiving beam pattern.) Regarding target strength, a constant value is used although RASP could easily be modified to account for more complex target scattering functions. Results are presented in (quasi-) absolute rather than relative units of measure. Acoustic quantities are calculated in units of total mean-acoustic-power in the processing band after beamforming and matched, or FFT- filtering. Furthermore, these quantities are normalized by the power of a plane-wave having a rms amplitude of one micropascal (μPa) and expressed in decibels. It is important to note that quantities are not expressed on a per-Hertz basis, nor in terms of energy (which results from time-integration).

4.6.1 Waveform Types and Processing Gains

Reverberation and target-echo envelopes are scaled according to one of three generic pulse types: gated-CW, impulsive, or frequency-modulation (FM) slide. In each case a value for the transmit source level SL is required. Here, SL is defined as the total transmitted acoustic intensity on the main-beam axis of the source beam pattern (not on a per-Hertz basis), which is referenced to a unit distance of 1 m from the acoustic center of the source. Program ACTENV requests the input of a source level SL_e of a single (and common) element and the number N of elements in the vertical source array, then computes SL from the relationship

$$SL = SL_e + 20 \ \log_{10} N \ . \tag{34}$$

Also, an analysis bandwidth W is input. For CW and FM pulses, W is also taken to be the signal bandwidth. For a CW pulse, W is actually calculated from an input signal duration. W is also used to scale an input omnidirectional noise level (per Hertz) to the analysis band.

A finite-duration CW pulse is the case for which the RASP model is primarily designed. In ACTENV, the pulse duration, or length, D is input and the matched signal and analysis bandwidths are found from $W = 1/D$.

Although traditionally an energy calculation, the RASP model approximates the performance of an impulsive source in terms of power by using a short CW pulse (in program REVERB) having a duration of $D = 1/f_b$ where f_b is the fundamental bubble-pulse frequency. Typically, D will range between 5 and 40 ms. For the impulsive signal case, ACTENV requests the value of the analysis bandwidth W. The strength of an impulsive source is usually available in units of energy-flux-density S_e. The user is advised to derive and input an equivalent-CW source level from the relationship

$$SL = 10 \ \log_{10}(S_e \ W/D) \ . \tag{35}$$

The FM signal option is intended to account for the matched filtering of a controlled waveform of duration D and bandwidth W. Calculations by REVERB should be made by using an equivalent-CW pulse of duration $D_e = 1/W$. Program ACTENV internally increases SL by $10 \ \log_{10}(WD)$, which is the intended effect of pulse-compression and is the source of the WD processing gain of a matched filter.

Wideband controlled pulses require a relatively short range-integration step-size in program REVERB (see Eq.(33) with $D = D_e = 1/W$) and consequently can result in a significantly increased computation time. As an alternative, one can use the actual pulse duration D in REVERB and the actual source level SL in ACTENV, then specify the signal as being an impulsive type in ACTENV. The resulting reverberation envelope will require less computation time (because of larger range-integration step-size) and will be approximately the same level, but will exhibit less fine structure than the compressed-pulse result because of the range averaging effect of the longer pulse length). Unfortunately, target echoes will not be increased by the $10\log_{10} WD$ processing gain. However, this can be rectified by artificially increasing the target strength.

4.6.2 Spatial Scaling

The RASP model is designed primarily for an omnidirectional or vertical source array and for a omnidirectional or horizontal receiver. The vertical directivity of the source is accounted for in program RTHETA. Program ACTENV accounts for any horizontal directivity of the receiver by applying an input (horizontal) receiver-directivity index (RDI) to received reverberation and ambient noise. An additional way of accounting for the horizontal directivity of reverberation is to use the option of performing a weighted-average of several reverberation envelopes. For example, envelopes calculated along different bearings (e.g., main and sidelobes) of the receiver beam pattern can be appropriately weighted by the beam pattern response and summed to approximate the horizontal directivity of the receiver. This is particularly useful in situations of potential sidelobe contamination. Other purposes of averaging reverberation envelopes include accounting for distinct reverberation returns in the ambiquous main beams of a horizontal receiver and averaging over several bearings within a relativley wide main beam.

The exception to the preceding is the case of a horizontally separated bistatic receiver,

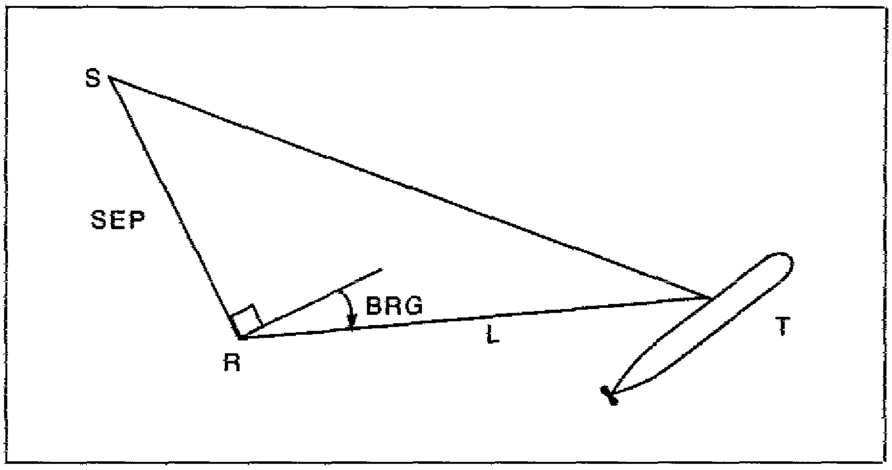

Fig. 15 – Source-receiver-target geometry

which assumes azimuthal symmetry about both the source and receiver. In this case, a horizontal directivity index should not be applied.

4.6.3 Temporal Averaging

It is often desirable to include the smoothing effects of averaging received reverberation over the analysis time. However, temporal averaging is not performed in ACTENV; it is accomplished in program REVERB. The averaging is performed over the interval Δt between the equally spaced times at which reverberation is calculated. Therefore, it is particularly recommended that the interval Δt in REVERB be set to the analysis time in the case of an impulsive source.

4.6.4 Target-Echo Returns

As an option, a target-echo return envelope will be computed and plotted using transmission losses computed by program TLVSR. Specifically, echo returns (ER) are computed from the simple sonar equation

$$ER = SL - TLS + TS - TLR + PG \tag{36}$$

where SL is total source level, TS is (a constant) target strength, TLS and TLR are transmission losses from source-to-target and target-to-receiver respectively, PG is processing gain (if any), and all quantities are expressed in decibels. SL (actually found from SL_e and N), TS, and (indirectly) PG are user-supplied constants. Further, calculations are made for the general source-target-receiver geometry depicted in Fig. 15, where SEP is the horizontal-range separation between the source and receiver and BRG is a receiver-to-target bearing measured clockwise in degrees from a line perpendicular to the baseline S/R connecting the source and receiver. For monostatic and quasi-monostatic geometrics, $SEP = 0$ and BRG is meaningless. Note that two (source and receiver) transmission loss files are required. The exception is the monostatic case (with identical source and receiver vertical beam patterns) where a single transmission loss file may be used.

Reverberation is calculated as a function of time (after transmission). Transmission loss is calculated as a function of range. To put echo returns on a common basis with reverberation, a source-to-target-to-receiver range is approximated at the discrete times for which received reverberation is calculated. Next, the geometry of Fig. 15 is used to determine the source-to-target and target-to-receiver components of this range. Then the appropriate transmission-loss vs range files are interpolated to the respective component ranges, and an echo level is computed from Eq. (14) [or (19)] and plotted.

Upon completion, ACTENV will output

- a plot of surface and bottom reverberation, ambient noise, and target echo (e.g., Fig. 30 on page 86),
- a print file of data detailing the time series for the surface and bottom reverberation envelopes and for the target echo.

5. THE MENU PROGRAM AND A SAMPLE RASP EXECUTION

This section describes the MENU preprocessing routine and illustrates the use of MENU, as well as the RASP model, by stepping through a model execution.

5.1 The MENU Preprocessing Routine

As mentioned earlier, MENU is an interactive stand-alone program that constructs command files to be used to run the RASP routines on a VAX Model 6310 computing system. The MENU preprocessor was written to ease the burden of running the RASP modules individually. The front end of MENU is a driver that prompts the user for the run geometry and the type of reverberation desired. Depending on these inputs, the driver will call the MENU subroutines in an order that satisfies the geometry and reverberation. Each MENU subroutine simply prompts the user for the input that is required by the individual RASP module. The prompts are then stored in command files that are subsequently executed by the user.

The MENU preprocessor consists of the following main subroutines:

- PROSUB - creates the command file required by PROFIL
- RAYSUB - creates the command file required by RAYACT
- RTTSUB - creates the command file required by RTHETA
- TLVSUB - creates the command file required by TLVSR
- RVVSUB - creates the command file required by REVERB
- ACTSUB - creates the command file required by ACTENV
- SCATT - contains the Chapman-Harris boundary backscattering formula and the Urick-Mackenzie bottom loss approach.

Additionally, there are various utility subroutines for processing user inputs, e.g., presenting a default or current value with each prompt that the user can easily accept.

To demonstrate the order in which the MENU subroutines are called, consider the following: a quasi-monostatic geometry run (see Fig. 8). MENU will call:

- PROSUB - called once, for the PROFIL inputs
- RAYSUB - called twice, once for the source, and once for the receiver raytrace inputs to RAYACT
- RTTSUB - called six times (1) source-to-bottom rays, (2) source-to-surface rays, (3) source-to-target rays, (4) receiver-to-bottom rays, (5) receiver-to-surface rays, and (6) receiver-to-target rays for input to RTHETA
- TLVSUB - called twice, once for the source-to-target transmission loss, and once for the receiver-to-target transmission loss inputs to TLVSR
- RVVSUB - called twice, once for the surface reverberation, and once for the bottom reverberation inputs to REVERB
- ACTSUB - called once, for the target and reverberation inputs to ACTENV.

MENU is also capable of creating a command file for an individual module. That is, if the user wants to run only the RAYACT module, the front end driver of MENU will call only RAYSUB to prompt the user with the RAYACT inputs. These inputs will be stored in the RAYACT.COM file, which the user must submit for the RAYACT execution. This same logic holds true for the execution of any of the other individual modules, each module has its own ".COM" file. If the user chooses to make a complete RASP model run (e.g., quasi-monostatic geometry with surface and bottom reverberation and target echo), then all of the commands will be stored in a single command file, TOTAL.COM. The user must then execute this command file to calculate the desired reverberation types. TOTAL.COM is created, by the MENU routine, anytime a complete RASP execution is indicated (i.e., execution starts with PROFIL and ends with ACTENV). The user then submits the TOTAL.COM file for processing by the RASP model.

A word of caution: The MENU program is not sophisticated, and in general, for each call to one of MENU's main subroutines, the user is prompted for all the inputs to the corresponding RASP module. This creates a tremendous amount of redundancy. For example, with each call to RTHETA (and subsequently to RTTSUB), the user is prompted for the maximum and minimum range on the contour plot as well as for the maximum and minimum angles on the plot. For the quasi-monostatic example above, the user would have to respond to these prompts six times! Experienced users avoid the redundancy inherent in the MENU program by simply editing the TOTAL.COM file manually. The file is well annotated, making such a task feasible.

Note that when MENU is executed, a file MENUECHO.COM is also created. This file contains all the inputs provided to the MENU program by the user.

5.2 Sample Execution

The remainder of this section is dedicated to a sample execution of RASP. Surface and bottom reverberation, and target echo will be calculated for a quasi-monostatic geometry. Figure 8 on page 10 is a flow chart of the program execution. Table 2 lists the source, receiver, target and environmental parameters that are used.

Subsection 5.3 presents the transcript of the execution of the MENU program, and subsection 5.4 lists the VAX command file, TOTAL.COM, that it creates. When command files

Table 2 – Parameters Used in the Quasi-Monostatic Sample Execution

SOURCE	
Frequency	: 500 Hz
Type	: vertical array of three elements
Steering	: 0 deg (broadside)
Element spacing	: $\lambda/2$ (λ = acoustic wavelength)
Element source level	: 200 dB
Depth	: 200 m (at center of array)
Pulse type	: CW
Pulse duration	: 5 s
RECEIVER	
Directivity	: horizontal/omnidirectional
Depth	: 250 m (at center of array)
Directivity index	: 10 dB
TARGET	
Depth	: 100 m
Strength	: 15 dB//μPa
Bearing	: 0 deg (relative to receiver, see Fig. 15, page 26)
ENVIRONMENTAL	
Ambient noise	: 65 db/Hz//μPa
Range	: 200 km
Sound velocity profiles	: Range-dependent – see Fig. 9b, page 12.
Bottom bathymetry	: Linear upslope – see Fig. 9a, page 12.
Bottom loss (FNWC table)	: 3
Bottom backscatter	: Urick clay
Surface backscatter	: Chapman-Harris
Scattering strength at 0 deg	: −100 dB//μPa
Wind speed	: 20 kts

are executed by using the VAX batch mode, all of the program prompts and user responses can be recorded in a file. This file, TOTAL.LOG, is listed in subsection 5.5. Finally, the plots are presented in subsection 5.6.

To appreciate the run time constraints of the RASP model, the quasi-monostatic geometry was run under two different conditions. The first run was made by using no standard default values and requesting the maximum number of plot and print files. These choices are reflected in the .LOG and .COM files presented below. The second run made used all the default values, and a minimum of plot and print files were requested. The maximum case required 06:43 minutes of CPU time, and the minimum case required 05:31 minutes of CPU time.

Although the run time of this model is fairly short, the space required for the print and plot files ranges from 6218 blocks (maximum case) to 2913 blocks (minimum case). Each block is 512 bytes long. As mentioned earlier, the source programs for the EXPORT version of the RASP model require 700 blocks of disk space, and the executable images require another 2000 blocks. The large increase from the source code to the executable code is largely due to the linking of the DISSPLA package to this model.

Tables 3 and 4 break down each module by output filename and give the size, in blocks, of each output file. This information is presented for the maximum and minimum run conditions respectively. The file naming scheme is explained in detail in Appendix A of this document. Files with extension .PNT are print files; files with the .DAT extension are data files that will be inputted to the succeeding module. The PLT2.DAT;# files are DISSPLA plot files, where # represents the version number assigned by the VAX operating system.

5.3 Sample Execution of MENU

This subsection contains the transcript of the run of the MENU program for the quasi-monostatic full-run geometry described above. The user should be able to duplicate the contents of this listing by accepting all of the default values presented by the MENU program. The TOTAL.COM file generated is listed in the next subsection.

```
$RUN MENU
 *** NRL RASP Command File Generator ***

 Enter the title of this run (limit 72 characters) :

Quasi Monostatic Sample Execution
 Enter the directory name of the *.exe files :
[USER.EXPORT.EXECUTABLES]
 Enter the directory name of the *.dat files :
[USER.EXPORT]


 Do you wish to :

 (1)       Compute Transmission Loss Versus Range
 (2)       Compute Surface and/or Bottom Reverberation
           (with no target return)
 (3)       Compute Surface and/or Bottom Reverberation
           with a target return.
```

Table 3 – File Block Sizes for a Quasi-monostatic Run Geometry*

		PROFIL	
Input Files	Size	Output Files	Size
S0000.PRO;1	1	PR0000.DAT;1	2
B0000.PRO;1	1	PR0000.PNT;1	5
		PLT2.DAT;1	214
		RAYACT Output Files	
Receiver Files	Size	Source Files	Size
RA000R.PNT;1	5	RA000S.PNT;1	5
RA0STR.PNT;1	80	RA0STS.PNT;1	81
RA00RB.DAT;1	52	RA00SB.DAT;1	52
RA00RS.DAT;1	61	RA00SS.DAT;1	63
RA00RT.DAT;1	124	RA00ST.DAT;1	128
PLT2.DAT;2;1	63	PLT2.DAT;3	61
		RTHETA Output Files	
Receiver Files	Size	Source Files	Size
RT00RB.PNT;1	162	RT00SB.PNT;1	171
RT00RT.PNT;1	405	RT00ST.PNT;1	423
RT00RS.PNT;1	194	RT00SS.PNT;1	204
RT00RB.DAT;1	50	RT00SB.DAT;1	51
RT00RS.DAT;1	60	RT00SS.DAT;1	61
RT00RT.DAT;1	126	RT00ST.DAT;1	130
PLT2.DAT;6	51	PLT2.DAT;9	53
PLT2.DAT;5	39	PLT2.DAT;8	39
PLT2.DAT;4	40	PLT2.DAT;7	40
		TLVSR Output Files	
Receiver Files	Size	Source Files	Size
TL00RT.PNT;1	1136	TL00ST.PNT;1	1129
TL00RT.DAT;1	5	TL00ST.DAT;1	5
PLT2.DAT;10	165	PLT2.DAT;11	163
		REVERB Output Files	
Bottom Files	Size	Surface Files	Size
RV000B.PNT;1	21	RV000S.PNT;1	21
RV000B.DAT;1	10	RV000S.DAT;1	10
		ACTENV Output Files	
	Size		
AE0000.PNT;1	45		
PLT2.DAT;12	211		

*In the MENU program, the maximum number of plot and print files were requested, and the no-standard-defaults option was used. Note that the PLT2.DAT files are DISSPLA plot files.

Table 4 – File Block Sizes for a Quasi-monostatic Run Geometry*

		PROFIL	
Input Files	Size	Output Files	Size
S0000.PRO;1	1	PR0000.DAT;1	2
B0000.PRO;1	1	PR0000.PNT;1	5
		RAYACT Output Files	
Receiver Files	Size	Source Files	Size
RA000R.PNT;1	5	RA000S.PNT;1	5
RA00RB.DAT;1	52	RA00SB.DAT;1	53
RA00RS.DAT;1	62	RA00SS.DAT;1	63
RA00RT.DAT;1	124	RA00ST.DAT;1	128
		RTHETA Output Files	
Receiver Files	Size	Source Files	Size
RT00RB.PNT;1	164	RT00SB.PNT;1	173
RT00RS.PNT;1	195	RT00SS.PNT;1	206
RT00RT.PNT;1	408	RT00ST.PNT;1	426
RT00RB.DAT;1	51	RT00SB.DAT;1	51
RT00RS.DAT;1	61	RT00SS.DAT;1	62
RT00RT.DAT;1	127	RT00ST.DAT;1	130
		TLVSR Output Files	
Receiver Files	Size	Source Files	Size
TL00RT.PNT;1	17	TL00ST.PNT;1	17
TL00RT.DAT;1	5	TL00ST.DAT;1	5
		REVERB Output Files	
Bottom Files	Size	Surface Files	Size
RV000B.PNT;1	21	RV000S.PNT;1	21
RV000B.DAT;1	10	RV000S.DAT;1	10
		ACTENV Output Files	
	Size		
AE0000.PNT;1	45		
PLT2.DAT;1	207		

*In the MENU program, the minimum number of plot and print files were requested, and the standard-defaults option was used. Note that the PLT2.DAT files are DISSPLA plot files.

```
 (4)      Execute a single subprogram of the RASP model
 (5)      Quit

 Enter corresponding integer code :
3

 Types of reverberation :

  (1)  surface only
  (2)  bottom only
  (3)  surface & bottom

 Enter integer code for desired reverberation :
3

 Types of source/receiver geometry:

  (1)  monostatic
  (2)  quasimonostatic
  (3)  bistatic

 Enter integer code for source/receiver geometry:
2

Do you wish a minimal set of print files (1=yes): Current value = 0
Enter a value, or just hit return to retain current value:
0

Do you wish a minimal set of plot files (1=yes): Current value = 0
Enter a value, or just hit return to retain current value:
0

Do you wish to use "standard" defaults (1=yes): Current value = 0
Enter a value, or just hit return to retain current value:
0

 !*********************************************
 !
 !  PROFIL - BOTTOM AND SOUNDSPEED PROFILE
 !
 !*********************************************
Plot titles will be...
Quasi Monostatic Sample Execution

Enter new title or carriage return to use title above


Enter file name of bathymetric data(max 10 char):
b0000.pro

Enter code of bottom range units (0=km,1=n mi): Current value = 0
Enter a value, or just hit return to retain current value:
0

Enter file name of sound-speed data(max 11 char):
s0000.pro

Enter code of sound speed profile range units (0=km,1=n mi): Current value = 0
Enter a value, or just hit return to retain current value:
```

```
0

Do you want a composite environment plot? (combined bottom and ss profiles, 1=yes):
Current value = 1
Enter a value, or just hit return to retain current value:
1

Do you want a plot of sound-speed contours? (1=yes): Current value = 1
Enter a value, or just hit return to retain current value:
1

Do you want plots of selected profiles? (1=yes): Current value = 1
Enter a value, or just hit return to retain current value:
1

Enter number of first profile to be plotted: Current value = 1
Enter a value, or just hit return to retain current value:
1

Enter increment of profiles to be plotted: Current value = 1
Enter a value, or just hit return to retain current value:
1

Enter number of last profile to be plotted: Current value = 2
Enter a value, or just hit return to retain current value:
2

Enter code for range units for composite environment plot (0=km,1=nm):
Current value = 0
Enter a value, or just hit return to retain current value:
0

 !*********************************************
 !
 !  RAYACT - RECEIVER RAYTRACES
 !
 !*********************************************
Plot title will be...
Quasi Monostatic Sample Execution

Enter new title or carriage return to use title above



Enter the receiver depth in meters: Current value = 250.
Enter a value, or just hit return to retain current value:
250.0

Enter the target depth in meters: Current value = 100.
Enter a value, or just hit return to retain current value:
100.0

Enter initial amd maximum ranges relative to the initial position
in the bathymetric file (km): Current values = 0., 200.
Enter 2 values, or return to retain current values:
0.0  200.0

Enter maximum bottom loss which a ray is allowed to accumulate (dB) [default = 175 dB]:
Current value = 175.
```

```
Enter a value, or just hit return to retain current value:
175.0

Ray launch angles are specified by one or more fans,
each of which is an increasing sequence of equally-
spaced angles.  Angles spacing must be an integer
multiple of 0.1 deg.

Enter number of fans (must be positive, max 7): Current value = 7
Enter a value, or just hit return to retain current value:
7

Please enter the following arguments           7           times
  angst  = starting launch angle (>-90 degrees)
           negative values indicate upwardly launched rays.
  anginc = angle increment used to generate rays.
           (an integral multiple of 0.1 degrees)
  angend = final launch angle (<90)
           positive angles indicate downwardly launched rays.

Fan  1 -  angst,anginc,angend: Current values = -84., 3., -33.
Enter 3 values, or return to retain current values:
-84.0    3.0  -33.0

Fan  2 -  angst,anginc,angend: Current values = -30., 1., -23.
Enter 3 values, or return to retain current values:
-30.0    1.0  -23.0

Fan  3 -  angst,anginc,angend: Current values = -22., 0.5, -15.
Enter 3 values, or return to retain current values:
-22.0    0.50  -15.0

Fan  4 -  angst,anginc,angend: Current values = -14., 0.2, 14.
Enter 3 values, or return to retain current values:
-14.0    0.20   14.0

Fan  5 -  angst,anginc,angend: Current values = 15., 0.5, 22.
Enter 3 values, or return to retain current values:
15.0    0.50   22.0

Fan  6 -  angst,anginc,angend: Current values = 23., 1., 30.
Enter 3 values, or return to retain current values:
23.0    1.0   30.0

Fan  7 -  angst,anginc,angend: Current values = 33., 3., 84.
Enter 3 values, or return to retain current values:
33.0    3.0   84.0

Bottom loss tables may be specified for up to  four
  range intervals. Range intervals are determined from
  maximum ranges for each table. Each table may be either
  for a specified fnwc bottom type, or input by the user

For fnwc data : enter bottom type (1,2,3,4,5), freq(hz), maximum range (km)

For user data : enter -1, number of angle-loss pairs to be input, maximum range (km)

To stop, enter 99,0,0
Table 1 :klf,kfr,max range (km): Current values = 3., 500., 200.
```

```
Enter 3 values, or return to retain current values:
3, 500, 200.0

Table 2 :klf,kfr,max range (km): Current values = 99., 0., 0.
Enter 3 values, or return to retain current values:
99,   0,   0.0

Do you wish a plot of raypaths with every nth ray plotted?
(+n,-n=yes;0=no): Current value = 10
Enter a value, or just hit return to retain current value:
10

 !*********************************************
 !
 !  RAYACT - SOURCE RAYTRACES
 !
 !*********************************************
Plot title will be...
Quasi Monostatic Sample Execution

Enter new title or carriage return to use title above



Enter the source depth in meters: Current value = 200.
Enter a value, or just hit return to retain current value:
200.0

Enter initial amd maximum ranges relative to the initial position
in the bathymetric file (km): Current values = 0., 200.
Enter 2 values, or return to retain current values:
0.0  200.0

Enter maximum bottom loss which a ray is allowed to accumulate (dB) [default = 175 dB]:
Current value = 175.
Enter a value, or just hit return to retain current value:
175.0

Ray launch angles are specified by one or more fans,
each of which is an increasing sequence of equally-
spaced angles.  Angles spacing must be an integer
multiple of 0.1 deg.

Enter number of fans (must be positive, max 7): Current value = 7
Enter a value, or just hit return to retain current value:
7

Please enter the following arguments           7            times
  angst  = starting launch angle (>-90 degrees)
           negative values indicate upwardly launched rays.
  anginc = angle increment used to generate rays.
           (an integral multiple of 0.1 degrees)
  angend = final launch angle (<90)
           positive angles indicate downwardly launched rays.

Fan  1 -  angst,anginc,angend: Current values = -84., 3., -33.
Enter 3 values, or return to retain current values:
-84.0    3.0  -33.0
```

```
Fan  2 -  angst,anginc,angend: Current values = -30., 1., -23.
Enter 3 values, or return to retain current values:
-30.0    1.0  -23.0

Fan  3 -  angst,anginc,angend: Current values = -22., 0.5, -15.
Enter 3 values, or return to retain current values:
-22.0    0.50  -15.0

Fan  4 -  angst,anginc,angend: Current values = -14., 0.2, 14.
Enter 3 values, or return to retain current values:
-14.0    0.20   14.0

Fan  5 -  angst,anginc,angend: Current values = 15., 0.5, 22.
Enter 3 values, or return to retain current values:
15.0    0.50   22.0

Fan  6 -  angst,anginc,angend: Current values = 23., 1., 30.
Enter 3 values, or return to retain current values:
23.0    1.0   30.0

Fan  7 -  angst,anginc,angend: Current values = 33., 3., 84.
Enter 3 values, or return to retain current values:
33.0    3.0   84.0

Bottom loss tables may be specified for up to  four
  range intervals. Range intervals are determined from
  maximum ranges for each table. Each table may be either
  for a specified fnwc bottom type, or input by the user

For fnwc data : enter bottom type (1,2,3,4,5), freq(hz), maximum range (km)

For user data : enter -1, number of angle-loss pairs to be input, maximum range (km)

To stop, enter 99,0,0
Table 1 :klf,kfr,max range (km): Current values = 3., 500., 200.
Enter 3 values, or return to retain current values:
3, 500, 200.0

Table 2 :klf,kfr,max range (km): Current values = 99., 0., 0.
Enter 3 values, or return to retain current values:
99,   0,   0.0

Do you wish a plot of raypaths with every nth ray plotted?
(+n,-n=yes;0=no): Current value = 10
Enter a value, or just hit return to retain current value:
10

 !*********************************************
 !
 !  RTHETA - SURFACE CONTOURS - RECEIVER
 !
 !*********************************************
Plot title will be...
Quasi Monostatic Sample Execution

Enter new title or carriage return to use title above


Do you want a plot of contours? (1=yes): Current value = 1
```

```
Enter a value, or just hit return to retain current value:
1

Enter rngax(in), initial, increment, maximum ranges (km) for plot:
Current values = 8., 0., 25., 200.
Enter 4 values, or return to retain current values:
8.0    0.0   25.0  200.0

Enter angax(in), initial, increment, maximum angles (deg) for plot:
Current values = 5., -90., 10., 90.
Enter 4 values, or return to retain current values:
5.0  -90.0   10.0   90.0

Enter KBP, vertical beam pattern of source
 KBP=0: indicates beam pattern will be read in
 KBP=1: omnidirectional pattern
 KBP>1: for computed pattern of a discrete (vertical)
        line array of KBP equally spaced elements: Current value = 1
Enter a value, or just hit return to retain current value:
1

What type of transmission loss estimates are output?
 <=0: no storage calculations
   1: to save R(0,z.) curves and spatially-averaged
      transmission loss estimates
   2: to save R(0,z.) curves and ray-bundle transmission
      loss estimates: Current value = 2
Enter a value, or just hit return to retain current value:
2

Enter minimum order of R(0,z.) curve to process.(norm=1): Current value = 1
Enter a value, or just hit return to retain current value:
1

Enter maximum order of R(0,z.) curve to process (norm=120): Current value = 120
Enter a value, or just hit return to retain current value:
120

Enter IFANG, determines source angles to be processed
  <=0: all available angles are processed
  >=1: angles bounded by given limits: Current value = 0
Enter a value, or just hit return to retain current value:
0

Enter IFDEL, number of discrete source angles to be deleted
in construction of R(0,z.) curves: Current value = 0
Enter a value, or just hit return to retain current value:
0

 !*********************************************
 !
 !  RTHETA - BOTTOM CONTOURS - RECEIVER
 !
 !*********************************************
Plot title will be...
Quasi Monostatic Sample Execution

Enter new title or carriage return to use title above
```

```
Do you want a plot of contours? (1=yes): Current value = 1
Enter a value, or just hit return to retain current value:
1

Enter rngax(in), initial, increment, maximum ranges (km) for plot:
Current values = 8., 0., 25., 200.
Enter 4 values, or return to retain current values:
8.0    0.0   25.0  200.0

Enter angax(in), initial, increment, maximum angles (deg) for plot:
Current values = 5., -90., 10., 90.
Enter 4 values, or return to retain current values:
5.0  -90.0   10.0   90.0

What type of transmission loss estimates are output?
 <=0: no storage calculations
   1: to save R(0,z.) curves and spatially-averaged
      transmission loss estimates
   2: to save R(0,z.) curves and ray-bundle transmission
      loss estimates: Current value = 2
Enter a value, or just hit return to retain current value:
2

Enter minimum order of R(0,z.) curve to process.(norm=1): Current value = 1
Enter a value, or just hit return to retain current value:
1

Enter maximum order of R(0,z.) curve to process (norm=120): Current value = 1
Enter a value, or just hit return to retain current value:
120

Enter IFANG, determines source angles to be processed
  <=0: all available angles are processed
  >=1: angles bounded by given limits: Current value = 0
Enter a value, or just hit return to retain current value:
0

Enter IFDEL, number of discrete source angles to be deleted
in construction of R(0,z.) curves: Current value = 0
Enter a value, or just hit return to retain current value:
0

 !*********************************************
 !
 !  RTHETA - TARGET CONTOURS - RECEIVER
 !
 !*********************************************
Plot title will be...
Quasi Monostatic Sample Execution

Enter new title or carriage return to use title above


Do you want a plot of contours? (1=yes): Current value = 1
Enter a value, or just hit return to retain current value:
1

Enter rngax(in), initial, increment, maximum ranges (km) for plot:
```

```
Current values = 8., 0., 25., 200.
Enter 4 values, or return to retain current values:
8.0    0.0   25.0  200.0

Enter angax(in), initial, increment, maximum angles (deg) for plot:
Current values = 5., -90., 10., 90.
Enter 4 values, or return to retain current values:
5.0  -90.0   10.0   90.0

What type of transmission loss estimates are output?
 <=0: no storage calculations
   1: to save R(0,z.) curves and spatially-averaged
      transmission loss estimates
   2: to save R(0,z.) curves and ray-bundle transmission
      loss estimates: Current value = 2
Enter a value, or just hit return to retain current value:
2

Enter minimum order of R(0,z.) curve to process.(norm=1): Current value = 1
Enter a value, or just hit return to retain current value:
1

Enter maximum order of R(0,z.) curve to process (norm=120): Current value = 1
Enter a value, or just hit return to retain current value:
120

Enter IFANG, determines source angles to be processed
  <=0: all available angles are processed
  >=1: angles bounded by given limits: Current value = 0
Enter a value, or just hit return to retain current value:
0

Enter IFDEL, number of discrete source angles to be deleted
in construction of R(0,z.) curves: Current value = 0
Enter a value, or just hit return to retain current value:
0

 !********************************************
 !
 !  RTHETA - SURFACE CONTOURS - SOURCE
 !
 !********************************************
Plot title will be...
Quasi Monostatic Sample Execution

Enter new title or carriage return to use title above


Do you want a plot of contours? (1=yes): Current value = 1
Enter a value, or just hit return to retain current value:
1

Enter rngax(in), initial, increment, maximum ranges (km) for plot:
Current values = 8., 0., 25., 200.
Enter 4 values, or return to retain current values:
8.0    0.0   25.0  200.0

Enter angax(in), initial, increment, maximum angles (deg) for plot:
Current values = 5., -90., 10., 90.
```

```
Enter 4 values, or return to retain current values:
5.0  -90.0   10.0   90.0

Enter KBP, vertical beam pattern of source
 KBP=0: indicates beam pattern will be read in
 KBP=1: omnidirectional pattern
 KBP>1: for computed pattern of a discrete (vertical)
        line array of KBP equally spaced elements: Current value = 3
Enter a value, or just hit return to retain current value:
3

What type of transmission loss estimates are output?
 <=0: no storage calculations
   1: to save R(0,z.) curves and spatially-averaged
      transmission loss estimates
   2: to save R(0,z.) curves and ray-bundle transmission
      loss estimates: Current value = 2
Enter a value, or just hit return to retain current value:
2

Enter minimum order of R(0,z.) curve to process.(norm=1): Current value = 1
Enter a value, or just hit return to retain current value:
1

Enter maximum order of R(0,z.) curve to process (norm=120): Current value = 1
Enter a value, or just hit return to retain current value:
120

Enter IFANG, determines source angles to be processed
  <=0: all available angles are processed
  >=1: angles bounded by given limits: Current value = 0
Enter a value, or just hit return to retain current value:
0

Enter IFDEL, number of discrete source angles to be deleted
in construction of R(0,z.) curves: Current value = 0
Enter a value, or just hit return to retain current value:
0

Enter element spacing in wavelengths used in converting vertical beam pattern:
Current value = 0.5
Enter a value, or just hit return to retain current value:
  0.5

Enter vertical tilt of array pattern in degrees (positive is down):
Current value = 0.
Enter a value, or just hit return to retain current value:
0.0

 !*********************************************
 !
 !  RTHETA - BOTTOM CONTOURS - SOURCE
 !
 !*********************************************
Plot title will be...
Quasi Monostatic Sample Execution

Enter new title or carriage return to use title above
```

```
Do you want a plot of contours? (1=yes): Current value = 1
Enter a value, or just hit return to retain current value:
1

Enter rngax(in), initial, increment, maximum ranges (km) for plot:
Current values = 8., 0., 25., 200.
Enter 4 values, or return to retain current values:
8.0    0.0   25.0  200.0

Enter angax(in), initial, increment, maximum angles (deg) for plot:
Current values = 5., -90., 10., 90.
Enter 4 values, or return to retain current values:
5.0  -90.0   10.0   90.0

What type of transmission loss estimates are output?
 <=0: no storage calculations
   1: to save R(0,z.) curves and spatially-averaged
      transmission loss estimates
   2: to save R(0,z.) curves and ray-bundle transmission
      loss estimates: Current value = 2
Enter a value, or just hit return to retain current value:
2

Enter minimum order of R(0,z.) curve to process.(norm=1): Current value = 1
Enter a value, or just hit return to retain current value:
1

Enter maximum order of R(0,z.) curve to process (norm=120): Current value = 1
Enter a value, or just hit return to retain current value:
120

Enter IFANG, determines source angles to be processed
  <=0: all available angles are processed
  >=1: angles bounded by given limits: Current value = 0
Enter a value, or just hit return to retain current value:
0

Enter IFDEL, number of discrete source angles to be deleted
in construction of R(0,z.) curves: Current value = 0
Enter a value, or just hit return to retain current value:
0

 !*********************************************
 !
 !  RTHETA - TARGET CONTOURS - SOURCE
 !
 !*********************************************
Plot title will be...
Quasi Monostatic Sample Execution

Enter new title or carriage return to use title above


Do you want a plot of contours? (1=yes): Current value = 1
Enter a value, or just hit return to retain current value:
1

Enter rngax(in), initial, increment, maximum ranges (km) for plot:
```

```
Current values = 8., 0., 25., 200.
Enter 4 values, or return to retain current values:
8.0    0.0   25.0  200.0

Enter angax(in), initial, increment, maximum angles (deg) for plot:
Current values = 5., -90., 10., 90.
Enter 4 values, or return to retain current values:
5.0  -90.0   10.0   90.0

What type of transmission loss estimates are output?
 <=0: no storage calculations
   1: to save R(0,z.) curves and spatially-averaged
      transmission loss estimates
   2: to save R(0,z.) curves and ray-bundle transmission
      loss estimates: Current value = 2
Enter a value, or just hit return to retain current value:
2

Enter minimum order of R(0,z.) curve to process.(norm=1): Current value = 1
Enter a value, or just hit return to retain current value:
1
Enter maximum order of R(0,z.) curve to process (norm=120): Current value = 1
Enter a value, or just hit return to retain current value:
120

Enter IFANG, determines source angles to be processed
  <=0: all available angles are processed
  >=1: angles bounded by given limits: Current value = 0
Enter a value, or just hit return to retain current value:
0

Enter IFDEL, number of discrete source angles to be deleted
in construction of R(0,z.) curves: Current value = 0
Enter a value, or just hit return to retain current value:
0

 !*********************************************
 !
 !  TLVSR - TARGET-RECEIVER TRANSMISSION LOSS
 !
 !*********************************************
Plot title will be...
Quasi Monostatic Sample Execution

Enter new title or carriage return to use title above


Enter initial and maximum ranges for calculations (km): Current values = 0., 200.
Enter 2 values, or return to retain current values:
0.0  200.0

Enter range step (km): Current value = 1.
Enter a value, or just hit return to retain current value:
1.0

Do you want a vertical arrival structure? (1=yes): Current value = 1
Enter a value, or just hit return to retain current value:
1
```

```
Enter maximum number of arrivals to be found at each range
(<=48 or 0 to default to maximum of 48): Current value = 48
Enter a value, or just hit return to retain current value:
48

Do you want a plot? (1=yes): Current value = 1
Enter a value, or just hit return to retain current value:
1

Enter initial, increment, and maximum plot ranges (km): Current values = 0., 25., 200.
Enter 3 values, or return to retain current values:
0.0  25.0  200.0

Enter initial, increment, and maximum plot TLs (dB): Current values = 0., 20., 180.
Enter 3 values, or return to retain current values:
0.0 20.0  180.0

Do you want an output file? (1=yes): Current value = 1
Enter a value, or just hit return to retain current value:
1

 !*********************************************
 !
 !  TLVSR - SOURCE-TARGET TRANSMISSION LOSS
 !
 !*********************************************
Plot title will be...
Quasi Monostatic Sample Execution

Enter new title or carriage return to use title above


Enter initial and maximum ranges for calculations (km): Current values = 0., 200.
Enter 2 values, or return to retain current values:
0.0  200.0

Enter range step (km): Current value = 1.
Enter a value, or just hit return to retain current value:
1.0

Do you want a vertical arrival structure? (1=yes): Current value = 1
Enter a value, or just hit return to retain current value:
1

Enter maximum number of arrivals to be found at each range
(<=48 or 0 to default to maximum of 48): Current value = 48
Enter a value, or just hit return to retain current value:
48

Do you want a plot? (1=yes): Current value = 1
Enter a value, or just hit return to retain current value:
1
Enter initial, increment, and maximum plot ranges (km): Current values = 0., 25., 200.
Enter 3 values, or return to retain current values:
0.0  25.0  200.0

Enter initial, increment, and maximum plot TLs (dB): Current values = 0., 20., 180.
Enter 3 values, or return to retain current values:
0.0  20.0  180.0
```

```
Do you want an output file? (1=yes): Current value = 1
Enter a value, or just hit return to retain current value:
1

 !********************************************
 !
 !  REVERB - SURFACE REVERBERATION
 !
 !********************************************
Enter maximum number of receiver ray boundary intersections (default=48):
Current value = 48
Enter a value, or just hit return to retain current value:
48

Enter maximum number of source ray boundary intersections (default=48):
Current value = 48
Enter a value, or just hit return to retain current value:
48

Do you want a vertical distribution of reverberation?
   0 = no vertical distribution
  -1 = range of times for distribution will be read
  +n = n discrete times for distribution will be read
Enter NVERT: Current value = 0
Enter a value, or just hit return to retain current value:
0

Enter initial, and maximum ranges from receiver (km): Current values = 0., 200.
Enter 2 values, or return to retain current values:
0.0  200.0

Enter range step (km): Current value = 1.
Enter a value, or just hit return to retain current value:
1.0

Enter pulse duration (sec): Current value = 5.
Enter a value, or just hit return to retain current value:
5.0

Enter initial and final times for which reverberation envelope is calculated (sec):
Current values = 0., 300.
Enter 2 values, or return to retain current values:
0.0  300.0

Enter time step (sec): Current value = 1.
Enter a value, or just hit return to retain current value:
1.0

Enter surface backscatter type.
 This is a flag indicating type of boundary
  backscattering model to be used.
  0 = Table of backscattering models to be read in
  1 = Chapmann & Harris model used
Enter surface backscatter type: Current value = 1
Enter a value, or just hit return to retain current value:
1

Enter backscattering strength(dB) at grazing angle = 0. (norm) = -100 dB):
```

```
Current value = -100.
Enter a value, or just hit return to retain current value:
-100.0

Enter wind speed (kt) (Norm=15): Current value = 20.
Enter a value, or just hit return to retain current value:
20.0

 !*********************************************
 !
 !  REVERB - BOTTOM REVERBERATION
 !
 !*********************************************
Enter maximum number of receiver ray boundary intersections (default=48):
Current value = 48
Enter a value, or just hit return to retain current value:
48

Enter maximum number of source ray boundary intersections (default=48):
Current value = 48
Enter a value, or just hit return to retain current value:
48

Do you want a vertical distribution of reverberation?
   0 = no vertical distribution
  -1 = range of times for distribution will be read
  +n = n discrete times for distribution will be read
Enter NVERT: Current value = 0
Enter a value, or just hit return to retain current value:
0

Enter initial, and maximum ranges from receiver (km): Current values = 0., 200.
Enter 2 values, or return to retain current values:
0.0  200.0

Enter range step (km): Current value = 1.
Enter a value, or just hit return to retain current value:
1.0

Enter pulse duration (sec): Current value = 5.
Enter a value, or just hit return to retain current value:
5.0

Enter initial and final times for which reverberation envelope is calculated (sec):
Current values = 0., 300.
Enter 2 values, or return to retain current values:
0.0  300.0

Enter time step (sec): Current value = 1.
Enter a value, or just hit return to retain current value:
1.0

Enter number of backscatter types to be used: Current value = 1
Enter a value, or just hit return to retain current value:
1

Enter            1 backscatter types along with
  range out to which each type will be used
 This is a flag indicating type of boundary
```

```
  backscattering model to be used.
  0 = Table of backscattering models to be read in
  1 = Lambert's Law model used
  2 = Urick rock bottom data used
  3 = Urick sand bottom data used
  4 = Urick silt bottom data used
  5 = Urick clay bottom data used
Enter bottom backscatter type, max range for type number  1:
Current values = 5., 200.
Enter 2 values, or return to retain current values:
5  200.0

 !*********************************************
 !
 !  ACTENV - TL AND REVERBERATION PLOT
 !
 !*********************************************
Plot title will be...
Quasi Monostatic Sample Execution

Enter new title or carriage return to use title above


Enter ping type (1=CW,2=PULSE,3=HFM): Current value = 1
Enter a value, or just hit return to retain current value:
1

Enter initial and maximum times for which envelopes will be calculated (sec):
Current values = 0., 300.
Enter 2 values, or return to retain current values:
0.0  300.0

Enter the number of source elements: Current value = 3
Enter a value, or just hit return to retain current value:
3

Enter source level per element (dB): Current value = 200.
Enter a value, or just hit return to retain current value:
200.0

Enter ambient noise level (dB/Hz): Current value = 65.
Enter a value, or just hit return to retain current value:
65.0

Enter receiver directivity index: Current value = 10.
Enter a value, or just hit return to retain current value:
10.0

Enter start time (sec) for plot envelope: Current value = 0.
Enter a value, or just hit return to retain current value:
0.0

Enter time increments of plot labels (sec): Current value = 30.
Enter a value, or just hit return to retain current value:
30.0

Enter end time (sec) for plot of envelope: Current value = 300.
Enter a value, or just hit return to retain current value:
300.0
```

```
Enter minimum power (dB) plotted: Current value = 0.
Enter a value, or just hit return to retain current value:
0.0

Enter (dB) labels per inch on plot: Current value = 20.
Enter a value, or just hit return to retain current value:
20.0

Enter maximum power (dB) plotted: Current value = 180.
Enter a value, or just hit return to retain current value:
180.0

 Enter BRG,TGTS:
   BRG = angle(rcvr -> tgt line, rcvr -> src line) (deg)
   TGTS = target strength in (dB/m**2)
Current values = 0., 15.
Enter 2 values, or return to retain current values:
    0.0  15.0

FORTRAN STOP
```

5.4 Sample TOTAL.COM File

The following pages contain the contents of the TOTAL.COM file for the quasi-monostatic full-run geometry that was created by the execution of the MENU program given in the preceding subsection. Appendix B provides a complete description of all the inputs to each of the program modules.

```
$SET DEFAULT [USER.EXPORT]
$ASSIGN [USER.EXPORT.EXECUTABLES] EXEDIR
$ASSIGN [USER.EXPORT] DATDIR
$ !*********************************************
$ !
$ !  PROFIL - BOTTOM AND SOUNDSPEED PROFILE
$ !
$ !*********************************************
$RUN EXEDIR:PROFIL
Quasi Monostatic Sample Execution
DATDIR:PRO000.PNT                          ! output print file
DATDIR:PRO000.DAT                          ! output data file
 1                                         ! composite environment plot?
 1                                         ! sound speed contour plot?
 1                                         ! selected profiles plotted?
DATDIR:b0000.pro                           ! input bathymetry file
 0                                         ! bottom range units 0=km,1=nmi
DATDIR:s0000.pro                           ! input sound speed file
 0                                         ! profile range units 0=km,1=nmi
    1    2    1                            ! first,last,inc profiles plotted
 0                                         ! profile range units 0=km,1=nmi
$ !*********************************************
$ !
$ !  RAYACT - RECEIVER RAYTRACES
$ !
$ !*********************************************
$RUN EXEDIR:RAYACT
Quasi Monostatic Sample Execution
```

```
DATDIR:RA000R.PNT                               ! output print file
10                                              ! status for every nth ray printed (0=none)
DATDIR:RA0STR.PNT                               ! print file of ray statistics
DATDIR:PR0000.DAT                               ! input environment file
  250.00                                        ! source or receiver depth
  100.00                                        ! target depth (or zero to stop)
    0.00                                        ! target depth (or zero to stop)
     0.   200.  0   96     0.   175.  198       ! rinit,rmax,noduc,nbb,tmax,blmax,maxord
 0                                              ! redefine default iteration parameters?
  7                                             ! number of rayfans
  -84.00    3.00  -33.00                        ! start, inc, end, for fan
  -30.00    1.00  -23.00                        ! start, inc, end, for fan
  -22.00    0.50  -15.00                        ! start, inc, end, for fan
  -14.00    0.20   14.00                        ! start, inc, end, for fan
   15.00    0.50   22.00                        ! start, inc, end, for fan
   23.00    1.00   30.00                        ! start, inc, end, for fan
   33.00    3.00   84.00                        ! start, inc, end, for fan
 3, 500, 200.00                                 ! bottom type(klf),freg(hz),max range(km)
99,   0,    0.00                                ! bottom type(klf),freg(hz),max range(km)
 10                                             ! plot of ray paths?
 1                                              ! save surface file?
DATDIR:RA00RS.DAT                               ! output surface file
 1                                              ! save bottom file?
DATDIR:RA00RB.DAT                               ! output bottom file
 1                                              ! save target file?
DATDIR:RA00RT.DAT                               ! output target file
$ !*********************************************
$ !
$ !  RAYACT - SOURCE RAYTRACES
$ !
$ !*********************************************
$RUN EXEDIR:RAYACT
Quasi Monostatic Sample Execution
DATDIR:RA000S.PNT                               ! output print file
10                                              ! status for every nth ray printed (0=none)
DATDIR:RA0STS.PNT                               ! print file of ray statistics
DATDIR:PR0000.DAT                               ! input environment file
  200.00                                        ! source or receiver depth
  100.00                                        ! target depth (or zero to stop)
    0.00                                        ! target depth (or zero to stop)
     0.   200.  0   96     0.   175.  198       ! rinit,rmax,noduc,nbb,tmax,blmax,maxord
 0                                              ! redefine default iteration parameters?
  7                                             ! number of rayfans
  -84.00    3.00  -33.00                        ! start, inc, end, for fan
  -30.00    1.00  -23.00                        ! start, inc, end, for fan
  -22.00    0.50  -15.00                        ! start, inc, end, for fan
  -14.00    0.20   14.00                        ! start, inc, end, for fan
   15.00    0.50   22.00                        ! start, inc, end, for fan
   23.00    1.00   30.00                        ! start, inc, end, for fan
   33.00    3.00   84.00                        ! start, inc, end, for fan
 3, 500, 200.00                                 ! bottom type(klf),freg(hz),max range(km)
99,   0,    0.00                                ! bottom type(klf),freg(hz),max range(km)
 10                                             ! plot of ray paths?
 1                                              ! save surface file?
DATDIR:RA00SS.DAT                               ! output surface file
 1                                              ! save bottom file?
DATDIR:RA00SB.DAT                               ! output bottom file
 1                                              ! save target file?
DATDIR:RA00ST.DAT                               ! output target file
```

```
$ !*******************************************
$ !
$ !  RTHETA - SURFACE CONTOURS - RECEIVER
$ !
$ !*******************************************
$RUN EXEDIR:RTHETA
Quasi Monostatic Sample Execution
 1                                           ! full contour print file?
DATDIR:RTOORS.PNT                            ! output print file
DATDIR:RAOORS.DAT                            ! input raytrace file
 1                                           ! plot of rtheta contours?
  8.00    0.00   25.00  200.00               ! rngax(IN), rmin, rstep, rmax
  5.00  -90.00   10.00   90.00               ! angax(IN),angmin,angstep,angmax
 500   1   2   1 120   0   0                 ! kfrq,kbp,ifout,mino,maxo,ifang,ifdel
DATDIR:RTOORS.DAT                            ! output contour file
$ !*******************************************
$ !
$ !  RTHETA - BOTTOM CONTOURS - RECEIVER
$ !
$ !*******************************************
$RUN EXEDIR:RTHETA
Quasi Monostatic Sample Execution
 1                                           ! full contour print file?
DATDIR:RTOORB.PNT                            ! output print file
DATDIR:RAOORB.DAT                            ! input raytrace file
 1                                           ! plot of rtheta contours?
  8.00    0.00   25.00  200.00               ! rngax(IN), rmin, rstep, rmax
  5.00  -90.00   10.00   90.00               ! angax(IN),angmin,angstep,angmax
 500   1   2   1 120   0   0                 ! kfrq,kbp,ifout,mino,maxo,ifang,ifdel
DATDIR:RTOORB.DAT                            ! output contour file
$ !*******************************************
$ !
$ !  RTHETA - TARGET CONTOURS - RECEIVER
$ !
$ !*******************************************
$RUN EXEDIR:RTHETA
Quasi Monostatic Sample Execution
 1                                           ! full contour print file?
DATDIR:RTOORT.PNT                            ! output print file
DATDIR:RAOORT.DAT                            ! input raytrace file
 1                                           ! plot of rtheta contours?
  8.00    0.00   25.00  200.00               ! rngax(IN), rmin, rstep, rmax
  5.00  -90.00   10.00   90.00               ! angax(IN),angmin,angstep,angmax
 500   1   2   1 120   0   0                 ! kfrq,kbp,ifout,mino,maxo,ifang,ifdel
DATDIR:RTOORT.DAT                            ! output contour file
$ !*******************************************
$ !
$ !  RTHETA - SURFACE CONTOURS - SOURCE
$ !
$ !*******************************************
$RUN EXEDIR:RTHETA
Quasi Monostatic Sample Execution
 1                                           ! full contour print file?
DATDIR:RTOOSS.PNT                            ! output print file
DATDIR:RAOOSS.DAT                            ! input raytrace file
 1                                           ! plot of rtheta contours?
  8.00    0.00   25.00  200.00               ! rngax(IN), rmin, rstep, rmax
  5.00  -90.00   10.00   90.00               ! angax(IN),angmin,angstep,angmax
 500   3   2   1 120   0   0                 ! kfrq,kbp,ifout,mino,maxo,ifang,ifdel
```

```
DATDIR:RT00SS.DAT                                  ! output contour file
   0.50   0.00                                     ! spacing (wavelengths), tilt
$ !********************************************
$ !
$ !  RTHETA - BOTTOM CONTOURS - SOURCE
$ !
$ !********************************************
$RUN EXEDIR:RTHETA
Quasi Monostatic Sample Execution
 1                                                 ! full contour print file?
DATDIR:RT00SB.PNT                                  ! output print file
DATDIR:RA00SB.DAT                                  ! input raytrace file
 1                                                 ! plot of rtheta contours?
  8.00    0.00   25.00  200.00                     ! rngax(IN), rmin, rstep, rmax
  5.00  -90.00   10.00   90.00                     ! angax(IN),angmin,angstep,angmax
 500    3    2    1 120    0    0                  ! kfrq,kbp,ifout,mino,maxo,ifang,ifdel
DATDIR:RT00SB.DAT                                  ! output contour file
   0.50   0.00                                     ! spacing (wavelengths), tilt
$ !********************************************
$ !
$ !  RTHETA - TARGET CONTOURS - SOURCE
$ !
$ !********************************************
$RUN EXEDIR:RTHETA
Quasi Monostatic Sample Execution
 1                                                 ! full contour print file?
DATDIR:RT00ST.PNT                                  ! output print file
DATDIR:RA00ST.DAT                                  ! input raytrace file
 1                                                 ! plot of rtheta contours?
  8.00    0.00   25.00  200.00                     ! rngax(IN), rmin, rstep, rmax
  5.00  -90.00   10.00   90.00                     ! angax(IN),angmin,angstep,angmax
 500    3    2    1 120    0    0                  ! kfrq,kbp,ifout,mino,maxo,ifang,ifdel
DATDIR:RT00ST.DAT                                  ! output contour file
   0.50   0.00                                     ! spacing (wavelengths), tilt
$ !********************************************
$ !
$ !  TLVSR - TARGET-RECEIVER TRANSMISSION LOSS
$ !
$ !********************************************
$RUN EXEDIR:TLVSR
Quasi Monostatic Sample Execution
DATDIR:RT00RT.DAT                                  ! input file from rtheta
    0.00    1.00  200.00                           ! min,inc,max range
    1                                              ! ifarr
  48                                               ! max number of arrivals to find
DATDIR:TL00RT.PNT                                  ! output print file
    1                                              ! ifplt
  8.00     0.00    25.00  200.00                   ! rngax(IN),rmin,rinc,rmax to plot
  5.00     0.00    20.00  180.00 -999.00           ! tlax(IN),tlmin,tlinc,tlmax,dely
    1                                              ! ifout
DATDIR:TL00RT.DAT                                  ! output tl file
$ !********************************************
$ !
$ !  TLVSR - SOURCE-TARGET TRANSMISSION LOSS
$ !
$ !********************************************
$RUN EXEDIR:TLVSR
Quasi Monostatic Sample Execution
DATDIR:RT00ST.DAT                                  ! input file from rtheta
```

```
   0.00    1.00  200.00                       ! min,inc,max range
   1                                          ! ifarr
  48                                          ! max number of arrivals to find
DATDIR:TLOOST.PNT                             ! output print file
   1                                          ! ifplt
  8.00     0.00    25.00  200.00              ! rngax(IN),rmin,rinc,rmax to plot
  5.00     0.00    20.00  180.00 -999.00      ! tlax(IN),tlmin,tlinc,tlmax,dely
   1                                          ! ifout
DATDIR:TLOOST.DAT                             ! output tl file
$ !**********************************************
$ !
$ !  REVERB - SURFACE REVERBERATION
$ !
$ !**********************************************
$RUN EXEDIR:REVERB
Quasi Monostatic Sample Execution
DATDIR:RV000S.PNT                             ! output print file
 2                                            ! key for type of geometry
   48                                         ! mxhitr
   48                                         ! mxhits
    0                                         ! nvert
    0.00    1.00  200.00                      ! min,inc,max range from receiver
    5.00                                      ! pulse duration (sec)
    0.00    1.00  300.00                      ! start,step,end times
DATDIR:RTOORS.DAT                             ! input receiver contours
 1                                            ! surface backscatter type
-100.   1.  20.   0.                          ! sso, ss, ws, wh
DATDIR:RTOOSS.DAT                             ! input source contours
 1                                            ! save results on file?
DATDIR:RV000S.DAT                             ! output file of reverb envelope
$ !**********************************************
$ !
$ !  REVERB - BOTTOM REVERBERATION
$ !
$ !**********************************************
$RUN EXEDIR:REVERB
Quasi Monostatic Sample Execution
DATDIR:RV000B.PNT                             ! output print file
 2                                            ! key for type of geometry
   48                                         ! mxhitr
   48                                         ! mxhits
    0                                         ! nvert
    0.00    1.00  200.00                      ! min,inc,max range from receiver
    5.00                                      ! pulse duration (sec)
    0.00    1.00  300.00                      ! start,step,end times
DATDIR:RTOORB.DAT                             ! input receiver contours
 1                                            ! number of backscatter types to use
 5  200.00                                    ! bottom backscatter type, range
DATDIR:RTOOSB.DAT                             ! input source contours
 1                                            ! save results on file?
DATDIR:RV000B.DAT                             ! output file of reverb envelope
$ !**********************************************
$ !
$ !  ACTENV - TL AND REVERBERATION PLOT
$ !
$ !**********************************************
$RUN EXEDIR:ACTENV
Quasi Monostatic Sample Execution
DATDIR:AE0000.PNT                             ! output print file
```

```
 1
    5.00                                       ! ping duration
    0.00  300.00                               ! tmin, tmax
  200.00    3.00   65.00   10.00               ! sle, # of elements, anl, rdi
    8.00    0.00   30.00  300.00               ! taxis(in), tmin, tinc, tmax
    5.00    0.00   20.00  180.00               ! yaxis(in), ymin, yinc, ymax
 1 0                                           ! norev, ifwgt
DATDIR:RV000S.DAT                              ! input reverberation file
 1 0                                           ! norev, ifwgt
DATDIR:RV000B.DAT                              ! input reverberation file
 1                                             ! include target echo?
DATDIR:TL00RT.DAT                              ! tl file target-receiver
 1                                             ! different tl file for source-target?
DATDIR:TL00ST.DAT                              ! tl file source-target
    0.00                                       ! source-receiver separation(km)
    0.00                                       ! bearing(deg)
   15.00                                       ! target strength
```

5.5 Sample Execution of TOTAL.COM File

This subsection lists the program prompts and user responses (contained in the TOTAL.LOG file) that result from the execution of the sample TOTAL.COM file in section 5.4 for the quasi-monostatic full-run geometry.

```
$SET DEFAULT [USER.EXPORT]
$ASSIGN [USER.EXPORT.EXECUTABLES] EXEDIR
$ASSIGN [USER.EXPORT] DATDIR
$ !*********************************************
$ !
$ !  PROFIL - BOTTOM AND SOUNDSPEED PROFILE
$ !
$ !*********************************************
$RUN EXEDIR:PROFIL


NRL EXPORT-RASP MODEL, VERSION 1.1 :  PROGRAM PROFIL


ENTER TITLE FOR THIS RUN (up to 68 characters):
Quasi Monostatic Sample Execution
ENTER NAME FOR THE PRINT FILE (up to 30 characters):
DATDIR:PR0000.PNT                              ! output print file
ENTER FILE NAME FOR OUTPUT ENVIRONMENT FIELD (up to 30 characters):
DATDIR:PR0000.DAT                              ! output data file
DO YOU WISH A COMPOSITE ENVIRONMENT PLOT? (1=yes,0=no):
 1                                             ! composite environment plot?
DO YOU WISH A PLOT OF SOUND-SPEED CONTOURS? (1=yes,0=no):
 1                                             ! sound speed contour plot?
DO YOU WISH PLOTS OF SELECTED PROFILES? (1=yes,0=no):
 1                                             ! selected profiles plotted?
ENTER FILE NAME OF BATHYMETRIC DATA (up to 30 characters):
DATDIR:b0000.pro                               ! input bathymetry file
ENTER CODE OF BOTTOM RANGE UNITS (0=km,1=nm):
 0                                             ! bottom range units 0=km,1=nmi
THERE ARE    2 INPUT BOTTOM DEPTHS
ENTER FILE NAME OF SOUND-SPEED DATA (up to 30 characters):
DATDIR:s0000.pro                               ! input sound speed file
```

```
ENTER CODE OF PROFILE RANGE UNITS (0=km,1=nm):
 0                                             ! profile range units 0=km,1=nmi
THERE ARE   2 SOUND-SPEED PROFILES

** OPTION TO PLOT INDIVIDUAL PROFILES SELECTED **

ENTER INITIAL, INCREMENT, AND FINAL PROFILES TO BE PLOTTED:
   1    2    1                                 ! first,last,inc profiles plotted
DO YOU WANT KM OR NM FOR THE PLOT RANGE? (0=km,1=nm)
 0                                             ! profile range units 0=km,1=nmi
FORTRAN STOP
$ !*********************************************
$ !
$ !  RAYACT - RECEIVER RAYTRACES
$ !
$ !*********************************************
$RUN EXEDIR:RAYACT


NRL EXPORT-RASP MODEL, VERSION 1 :  PROGRAM RAYACT


ENTER TITLE FOR THIS RUN (up to 68 characters):
Quasi Monostatic Sample Execution
ENTER NAME FOR OUTPUT PRINT FILE (up to 30 characters):
DATDIR:RA000R.PNT                              ! output print file
DO YOU WISH A PRINT FILE OF RAY STATISTICS?
   0 = no print file of ray statistics
   n = status printed for every nTH ray
ENTER KPRNT:
10                                             ! status for every nth ray printed (0=none)
ENTER NAME FOR PRINT FILE OF RAY STATISTICS (up to 30 characters):
DATDIR:RA0STR.PNT                              ! print file of ray statistics
ENTER FILE NAME OF INPUT ENVIRONMENT FIELD (up to 30 characters):
DATDIR:PR0000.DAT                              ! input environment file
ENTER SOURCE DEPTH (m):
  250.00                                       ! source or receiver depth
ENTER UP TO 3 TARGET DEPTHS (m) (0 TO STOP):
TARGET DEPTH 1
  100.00                                       ! target depth (or zero to stop)
TARGET DEPTH 2
    0.00                                       ! target depth (or zero to stop)
RAY TRACING PARAMETERS -
RINIT(KM) -- INITIAL RANGE (IN KILOMETERS)
RMAX(KM) -- MAXIMUM RANGE (IN KILOMETERS)
NODUC -- 0 SPECIFIES USING THE CALCULATED SOUND SPEED
         CONNECTIONS, 1 DO NOT USE THE CONNECTIONS
NBB -- NUMBER OF BOTTOM BOUNCES (LESS THAN 97)
TMAX -- MAXIMUM TRAVEL TIME ALLOWED FOR A RAY PATH
BLMAX -- MAXIMUM BOTTOM LOSS THAT IS ALLOWED FOR A RAY
MAXORD -- MAXIMUM OF THE TOTAL NUMBER OF BOUNDARY
       INTERACTIONS AND TURNING POINTS (LESS THAN 199)
ENTER RAY TRACING PARAMETERS :
   RINIT(KM),RMAX(KM),NODUC,NBB,  TMAX(SEC),BLMAX(DB),MAXORD
     0.   200.  0    96      0.    175.  198       ! rinit,rmax,noduc,nbb,tmax,blmax,maxord
DO YOU WISH TO REDEFINE DEFAULT RAY ITERATION  PARAMETERS? (1=yes.0=no):
 0                                             ! redefine default iteration parameters?
RAY LAUNCH ANGLES ARE SPECIFIED BY ONE OR MORE FANS, EACH OF WHICH
 IS AN INCREASING SEQUENCE OF EQUALLY-SPACED ANGLES. ANGLE SPACING MUST
```

```
 BE AN INTEGER MULTIPLE OF 0.1 DEG.  ANGLES ARE MEASURED POSITIVE
 DOWN AND IN DEGREES.
ENTER NO. OF FANS:
  7                                              ! number of rayfans
 7 ANGLE FANS WILL BE REQUESTED
 (maximum resolution of 0.1 deg.)
FAN  1   ENTER ANGST, ANGINC, ANGEND:
  -84.00    3.00  -33.00                         ! start, inc, end, for fan
FAN  2   ENTER ANGST, ANGINC, ANGEND:
  -30.00    1.00  -23.00                         ! start, inc, end, for fan
FAN  3   ENTER ANGST, ANGINC, ANGEND:
  -22.00    0.50  -15.00                         ! start, inc, end, for fan
FAN  4   ENTER ANGST, ANGINC, ANGEND:
  -14.00    0.20   14.00                         ! start, inc, end, for fan
FAN  5   ENTER ANGST, ANGINC, ANGEND:
   15.00    0.50   22.00                         ! start, inc, end, for fan
FAN  6   ENTER ANGST, ANGINC, ANGEND:
   23.00    1.00   30.00                         ! start, inc, end, for fan
FAN  7   ENTER ANGST, ANGINC, ANGEND:
   33.00    3.00   84.00                         ! start, inc, end, for fan
BOTTOM LOSS TABLES MAY BE SPECIFIED FOR UP TO FOUR
RANGE INTERVALS. RANGE INTERVALS ARE DETERMINED FROM
MAXIMUM RANGES FOR EACH TABLE. EACH TABLE MAY BE EITHER
FOR A SPECIFIED FNWC BOTTOM TYPE, OR INPUT BY THE USER
TABLE           1
FOR FNWC DATA : ENTER BOTTOM TYPE (1,2,3,4,5), FREQ(HZ),
MAXIMUM RANGE (KM)

FOR USER DATA : ENTER -1, NUMBER OF ANGLE-LOSS PAIRS TO
BE INPUT, MAXIMUM RANGE (KM)

TO STOP, ENTER 99,0,0
 3, 500, 200.00                                  ! bottom type(klf),freg(hz),max range(km)
TABLE           2
FOR FNWC DATA : ENTER BOTTOM TYPE (1,2,3,4,5), FREQ(HZ),
MAXIMUM RANGE (KM)

FOR USER DATA : ENTER -1, NUMBER OF ANGLE-LOSS PAIRS TO
BE INPUT, MAXIMUM RANGE (KM)

TO STOP, ENTER 99,0,0
99,   0,    0.00                                 ! bottom type(klf),freg(hz),max range(km)
DO YOU WISH A PLOT OF RAYPATHS?
   0 = no plot of raypaths
  +n = plot every nTH ray processed
  -n = plot every nTH ray between a given min and max
ENTER KPLT:
 10                                              ! plot of ray paths?
PROFILE            1 AT RANGE OF  0.0000000E+00 km
PROFILE            2 AT RANGE OF   200.0000     km
DO YOU WISH TO SAVE SURFACE ENCOUNTERS? (1=yes,0=n0):
 1                                               ! save surface file?
ENTER FILE NAME FOR STORING SURFACE ENCOUNTERS (up to 30 characters):
DATDIR:RAOORS.DAT                                ! output surface file
DO YOU WISH TO SAVE BOTTOM ENCOUNTERS? (1=yes,0=no):
 1                                               ! save bottom file?
ENTER FILE NAME FOR STORING BOTTOM ENCOUNTERS (up to 30 characters):
DATDIR:RAOORB.DAT                                ! output bottom file
DO YOU WISH TO SAVE TARGET DEPTH =  100.00(m) ARRIVALS? (1=yes,0=no):
```

```
 1                                              ! save target file?
ENTER FILE NAME FOR STORING ARRIVALS AT THIS DEPTH (up to 30 characters):
DATDIR:RAOORT.DAT                               ! output target file
FORTRAN STOP
$ !*********************************************
$ !
$ !  RAYACT - SOURCE RAYTRACES
$ !
$ !*********************************************
$RUN EXEDIR:RAYACT


NRL EXPORT-RASP MODEL, VERSION 1 :  PROGRAM RAYACT


ENTER TITLE FOR THIS RUN (up to 68 characters):
Quasi Monostatic Sample Execution
ENTER NAME FOR OUTPUT PRINT FILE (up to 30 characters):
DATDIR:RA000S.PNT                               ! output print file
DO YOU WISH A PRINT FILE OF RAY STATISTICS?
   0 = no print file of ray statistics
   n = status printed for every nTH ray
ENTER KPRNT:
10                                              ! status for every nth ray printed (0=none)
ENTER NAME FOR PRINT FILE OF RAY STATISTICS (up to 30 characters):
DATDIR:RAOSTS.PNT                               ! print file of ray statistics
ENTER FILE NAME OF INPUT ENVIRONMENT FIELD (up to 30 characters):
DATDIR:PR0000.DAT                               ! input environment file
ENTER SOURCE DEPTH (m):
  200.00                                        ! source or receiver depth
ENTER UP TO 3 TARGET DEPTHS (m) (0 TO STOP):
TARGET DEPTH 1
  100.00                                        ! target depth (or zero to stop)
TARGET DEPTH 2
    0.00                                        ! target depth (or zero to stop)
RAY TRACING PARAMETERS -
RINIT(KM) -- INITIAL RANGE (IN KILOMETERS)
RMAX(KM) -- MAXIMUM RANGE (IN KILOMETERS)
NODUC -- 0 SPECIFIES USING THE CALCULATED SOUND SPEED
         CONNECTIONS, 1 DO NOT USE THE CONNECTIONS
NBB -- NUMBER OF BOTTOM BOUNCES (LESS THAN 97)
TMAX -- MAXIMUM TRAVEL TIME ALLOWED FOR A RAY PATH
BLMAX -- MAXIMUM BOTTOM LOSS THAT IS ALLOWED FOR A RAY
MAXORD -- MAXIMUM OF THE TOTAL NUMBER OF BOUNDARY
       INTERACTIONS AND TURNING POINTS (LESS THAN 199)
ENTER RAY TRACING PARAMETERS :
   RINIT(KM),RMAX(KM),NODUC,NBB,  TMAX(SEC),BLMAX(DB),MAXORD
     0.   200.  0   96     0.   175.  198       ! rinit,rmax,noduc,nbb,tmax,blmax,maxord
DO YOU WISH TO REDEFINE DEFAULT RAY ITERATION  PARAMETERS? (1=yes.0=no):
 0                                              ! redefine default iteration parameters?
RAY LAUNCH ANGLES ARE SPECIFIED BY ONE OR MORE FANS, EACH OF WHICH
 IS AN INCREASING SEQUENCE OF EQUALLY-SPACED ANGLES. ANGLE SPACING MUST
 BE AN INTEGER MULTIPLE OF 0.1 DEG.  ANGLES ARE MEASURED POSITIVE
 DOWN AND IN DEGREES.
ENTER NO. OF FANS:
  7                                             ! number of rayfans
 7 ANGLE FANS WILL BE REQUESTED
 (maximum resolution of 0.1 deg.)
FAN  1   ENTER ANGST, ANGINC, ANGEND:
```

```
  -84.00    3.00  -33.00                      ! start, inc, end, for fan
FAN  2   ENTER ANGST, ANGINC, ANGEND:
  -30.00    1.00  -23.00                      ! start, inc, end, for fan
FAN  3   ENTER ANGST, ANGINC, ANGEND:
  -22.00    0.50  -15.00                      ! start, inc, end, for fan
FAN  4   ENTER ANGST, ANGINC, ANGEND:
  -14.00    0.20   14.00                      ! start, inc, end, for fan
FAN  5   ENTER ANGST, ANGINC, ANGEND:
   15.00    0.50   22.00                      ! start, inc, end, for fan
FAN  6   ENTER ANGST, ANGINC, ANGEND:
   23.00    1.00   30.00                      ! start, inc, end, for fan
FAN  7   ENTER ANGST, ANGINC, ANGEND:
   33.00    3.00   84.00                      ! start, inc, end, for fan
BOTTOM LOSS TABLES MAY BE SPECIFIED FOR UP TO FOUR
RANGE INTERVALS. RANGE INTERVALS ARE DETERMINED FROM
MAXIMUM RANGES FOR EACH TABLE. EACH TABLE MAY BE EITHER
FOR A SPECIFIED FNWC BOTTOM TYPE, OR INPUT BY THE USER
TABLE           1
FOR FNWC DATA : ENTER BOTTOM TYPE (1,2,3,4,5), FREQ(HZ),
MAXIMUM RANGE (KM)

FOR USER DATA : ENTER -1, NUMBER OF ANGLE-LOSS PAIRS TO
BE INPUT, MAXIMUM RANGE (KM)

TO STOP, ENTER 99,0,0
 3, 500, 200.00                               ! bottom type(klf),freg(hz),max range(km)
TABLE           2
FOR FNWC DATA : ENTER BOTTOM TYPE (1,2,3,4,5), FREQ(HZ),
MAXIMUM RANGE (KM)

FOR USER DATA : ENTER -1, NUMBER OF ANGLE-LOSS PAIRS TO
BE INPUT, MAXIMUM RANGE (KM)

TO STOP, ENTER 99,0,0
99,   0,   0.00                               ! bottom type(klf),freg(hz),max range(km)
DO YOU WISH A PLOT OF RAYPATHS?
   0 = no plot of raypaths
  +n = plot every nTH ray processed
  -n = plot every nTH ray between a given min and max
ENTER KPLT:
 10                                           ! plot of ray paths?
PROFILE          1 AT RANGE OF  0.0000000E+00 km
PROFILE          2 AT RANGE OF   200.0000     km
DO YOU WISH TO SAVE SURFACE ENCOUNTERS? (1=yes,0=n0):
 1                                            ! save surface file?
ENTER FILE NAME FOR STORING SURFACE ENCOUNTERS (up to 30 characters):
DATDIR:RA00SS.DAT                             ! output surface file
DO YOU WISH TO SAVE BOTTOM ENCOUNTERS? (1=yes,0=no):
 1                                            ! save bottom file?
ENTER FILE NAME FOR STORING BOTTOM ENCOUNTERS (up to 30 characters):
DATDIR:RA00SB.DAT                             ! output bottom file
DO YOU WISH TO SAVE TARGET DEPTH =  100.00(m) ARRIVALS? (1=yes,0=no):
 1                                            ! save target file?
ENTER FILE NAME FOR STORING ARRIVALS AT THIS DEPTH (up to 30 characters):
DATDIR:RA00ST.DAT                             ! output target file
FORTRAN STOP
$ !**********************************************
$ !
$ !  RTHETA - SURFACE CONTOURS - RECEIVER
```

```
$ !
$ !*********************************************
$RUN EXEDIR:RTHETA


 NRL EXPORT-RASP MODEL, VERSION 1 :  PROGRAM RTHETA


ENTER TITLE FOR THIS RUN (up to 68 characters):
Quasi Monostatic Sample Execution
DO YOU WANT A FULL RTHETA CONTOUR PRINT FILE? (1=yes,0=no):
 1                                             ! full contour print file?
ENTER NAME FOR PRINT FILE (up to 30 characters):
DATDIR:RTOORS.PNT                              ! output print file
ENTER NAME OF INPUT FILE FROM RAYACT (up to 30 characters):
DATDIR:RAOORS.DAT                              ! input raytrace file
DO YOU WISH A PLOT OF ORDER CONTOURS? (1=yes,0=no):
 1                                             ! plot of rtheta contours?

** PLOTTING OPTION REQUESTED **

ENTER PLOTTING PARAMETERS:
  **** NO DEFAULTS ****
RNGAX(IN) -- X AXIS LENGTH IN INCHES
RMIN(KM) -- MINIMUM RANGE IN KILOMETERS
RSTEP -- RANGE INCREMENT IN KILOMETERS
RMAX -- MAXIMUM RANGE IN KILOMETERS
ENTER RNGAX(IN),RMIN(KM),RSTEP,RMAX
  8.00     0.00   25.00  200.00                ! rngax(IN), rmin, rstep, rmax
ANGAX(IN) -- Y AXIS LENGTH IN INCHES
ANGMN(DGS) -- MINIMUM ANGLE IN DEGREES
ANGSTEP -- ANGLE INCREMENT IN DEGREES
ANGMX -- MAXIMUM ANGLE IN DEGREES
ENTER ANGAX(IN),ANGMN(DGS),ANGSTEP,ANGMX
  5.00  -90.00   10.00   90.00                 ! angax(IN),angmin,angstep,angmax
CONTROL PARAMETERS
KFRQ -- FREQUENCY (HZ)
KBP -- BEAM PATTERN TYPE
       0 INDICATES BEAM FILE TO BE READ
       1 OMNI DIRECTIONAL BEAM PATTERN
       N(>1) N EQUISPACED ELEMENTS
IFOUT -- FILE SAVE PARAMETER
         0 INDICATES NO DATA FILE SAVED
         1 INDICATES RAY AVERAGED DATA SAVED
         2 INDICATES RAY BUNDLE DATA SAVED
MINO -- MINIMUM ORDER TO PROCESS
MAXO -- MAXIMUM ORDER TO PROCESS
IFANG -- SOURCE ANGLES TO BE PROCESSED
         0 ALL ANGLES ARE PROCESSED
         1 USER DETERMINES ANGLES TO PROCESS
IFDEL -- NUMBER OF DISCRETE SOURCE ANGLES TO
         DELETE
ENTER KFRQ,KBP,IFOUT,MINO,MAXO,IFANG,IFDEL :
 500    1    2    1 120    0    0              ! kfrq,kbp,ifout,mino,maxo,ifang,ifdel
ENTER NAME FOR OUTPUT DATA FILE (up to 30 characters):
DATDIR:RTOORS.DAT                              ! output contour file
FORTRAN STOP
$ !*********************************************
$ !
```

```
$ !  RTHETA - BOTTOM CONTOURS - RECEIVER
$ !
$ !*********************************************
$RUN EXEDIR:RTHETA


 NRL EXPORT-RASP MODEL, VERSION 1 :  PROGRAM RTHETA


ENTER TITLE FOR THIS RUN (up to 68 characters):
Quasi Monostatic Sample Execution
DO YOU WANT A FULL RTHETA CONTOUR PRINT FILE? (1=yes,0=no):
 1                                          ! full contour print file?
ENTER NAME FOR PRINT FILE (up to 30 characters):
DATDIR:RTOORB.PNT                           ! output print file
ENTER NAME OF INPUT FILE FROM RAYACT (up to 30 characters):
DATDIR:RAOORB.DAT                           ! input raytrace file
DO YOU WISH A PLOT OF ORDER CONTOURS? (1=yes,0=no):
 1                                          ! plot of rtheta contours?

** PLOTTING OPTION REQUESTED **

ENTER PLOTTING PARAMETERS:
  **** NO DEFAULTS ****
RNGAX(IN) -- X AXIS LENGTH IN INCHES
RMIN(KM) -- MINIMUM RANGE IN KILOMETERS
RSTEP -- RANGE INCREMENT IN KILOMETERS
RMAX -- MAXIMUM RANGE IN KILOMETERS
ENTER RNGAX(IN),RMIN(KM),RSTEP,RMAX
  8.00    0.00   25.00  200.00              ! rngax(IN), rmin, rstep, rmax
ANGAX(IN) -- Y AXIS LENGTH IN INCHES
ANGMN(DGS) -- MINIMUM ANGLE IN DEGREES
ANGSTEP -- ANGLE INCREMENT IN DEGREES
ANGMX -- MAXIMUM ANGLE IN DEGREES
ENTER ANGAX(IN),ANGMN(DGS),ANGSTEP,ANGMX
  5.00  -90.00   10.00   90.00              ! angax(IN),angmin,angstep,angmax
CONTROL PARAMETERS
KFRQ -- FREQUENCY (HZ)
KBP -- BEAM PATTERN TYPE
       0 INDICATES BEAM FILE TO BE READ
       1 OMNI DIRECTIONAL BEAM PATTERN
       N(>1) N EQUISPACED ELEMENTS
IFOUT -- FILE SAVE PARAMETER
         0 INDICATES NO DATA FILE SAVED
         1 INDICATES RAY AVERAGED DATA SAVED
         2 INDICATES RAY BUNDLE DATA SAVED
MINO -- MINIMUM ORDER TO PROCESS
MAXO -- MAXIMUM ORDER TO PROCESS
IFANG -- SOURCE ANGLES TO BE PROCESSED
         0 ALL ANGLES ARE PROCESSED
         1 USER DETERMINES ANGLES TO PROCESS
IFDEL -- NUMBER OF DISCRETE SOURCE ANGLES TO
         DELETE
ENTER KFRQ,KBP,IFOUT,MINO,MAXO,IFANG,IFDEL :
 500   1   2   1 120   0   0                ! kfrq,kbp,ifout,mino,maxo,ifang,ifdel
ENTER NAME FOR OUTPUT DATA FILE (up to 30 characters):
DATDIR:RTOORB.DAT                           ! output contour file
FORTRAN STOP
$ !*********************************************
```

```
$ !
$ !  RTHETA - TARGET CONTOURS - RECEIVER
$ !
$ !**********************************************
$RUN EXEDIR:RTHETA


 NRL EXPORT-RASP MODEL, VERSION 1 :  PROGRAM RTHETA


ENTER TITLE FOR THIS RUN (up to 68 characters):
Quasi Monostatic Sample Execution
DO YOU WANT A FULL RTHETA CONTOUR PRINT FILE? (1=yes,0=no):
 1                                           ! full contour print file?
ENTER NAME FOR PRINT FILE (up to 30 characters):
DATDIR:RTOORT.PNT                            ! output print file
ENTER NAME OF INPUT FILE FROM RAYACT (up to 30 characters):
DATDIR:RAOORT.DAT                            ! input raytrace file
DO YOU WISH A PLOT OF ORDER CONTOURS? (1=yes,0=no):
 1                                           ! plot of rtheta contours?

** PLOTTING OPTION REQUESTED **

ENTER PLOTTING PARAMETERS:
  **** NO DEFAULTS ****
RNGAX(IN) -- X AXIS LENGTH IN INCHES
RMIN(KM) -- MINIMUM RANGE IN KILOMETERS
RSTEP -- RANGE INCREMENT IN KILOMETERS
RMAX -- MAXIMUM RANGE IN KILOMETERS
ENTER RNGAX(IN),RMIN(KM),RSTEP,RMAX
  8.00    0.00   25.00  200.00               ! rngax(IN), rmin, rstep, rmax
ANGAX(IN) -- Y AXIS LENGTH IN INCHES
ANGMN(DGS) -- MINIMUM ANGLE IN DEGREES
ANGSTEP -- ANGLE INCREMENT IN DEGREES
ANGMX -- MAXIMUM ANGLE IN DEGREES
ENTER ANGAX(IN),ANGMN(DGS),ANGSTEP,ANGMX
  5.00  -90.00   10.00   90.00               ! angax(IN),angmin,angstep,angmax
CONTROL PARAMETERS
KFRQ -- FREQUENCY (HZ)
KBP -- BEAM PATTERN TYPE
       0 INDICATES BEAM FILE TO BE READ
       1 OMNI DIRECTIONAL BEAM PATTERN
       N(>1) N EQUISPACED ELEMENTS
IFOUT -- FILE SAVE PARAMETER
         0 INDICATES NO DATA FILE SAVED
         1 INDICATES RAY AVERAGED DATA SAVED
         2 INDICATES RAY BUNDLE DATA SAVED
MINO -- MINIMUM ORDER TO PROCESS
MAXO -- MAXIMUM ORDER TO PROCESS
IFANG -- SOURCE ANGLES TO BE PROCESSED
         0 ALL ANGLES ARE PROCESSED
         1 USER DETERMINES ANGLES TO PROCESS
IFDEL -- NUMBER OF DISCRETE SOURCE ANGLES TO
         DELETE
ENTER KFRQ,KBP,IFOUT,MINO,MAXO,IFANG,IFDEL :
 500   1   2   1 120   0   0                 ! kfrq,kbp,ifout,mino,maxo,ifang,ifdel
ENTER NAME FOR OUTPUT DATA FILE (up to 30 characters):
DATDIR:RTOORT.DAT                            ! output contour file
FORTRAN STOP
```

```
$ !*********************************************
$ !
$ !  RTHETA - SURFACE CONTOURS - SOURCE
$ !
$ !*********************************************
$RUN EXEDIR:RTHETA


 NRL EXPORT-RASP MODEL, VERSION 1 :  PROGRAM RTHETA


ENTER TITLE FOR THIS RUN (up to 68 characters):
Quasi Monostatic Sample Execution
DO YOU WANT A FULL RTHETA CONTOUR PRINT FILE? (1=yes,0=no):
 1                                            ! full contour print file?
ENTER NAME FOR PRINT FILE (up to 30 characters):
DATDIR:RT0OSS.PNT                             ! output print file
ENTER NAME OF INPUT FILE FROM RAYACT (up to 30 characters):
DATDIR:RA0OSS.DAT                             ! input raytrace file
DO YOU WISH A PLOT OF ORDER CONTOURS? (1=yes,0=no):
 1                                            ! plot of rtheta contours?

** PLOTTING OPTION REQUESTED **

ENTER PLOTTING PARAMETERS:
  **** NO DEFAULTS ****
RNGAX(IN) -- X AXIS LENGTH IN INCHES
RMIN(KM) -- MINIMUM RANGE IN KILOMETERS
RSTEP -- RANGE INCREMENT IN KILOMETERS
RMAX -- MAXIMUM RANGE IN KILOMETERS
ENTER RNGAX(IN),RMIN(KM),RSTEP,RMAX
  8.00    0.00   25.00  200.00                ! rngax(IN), rmin, rstep, rmax
ANGAX(IN) -- Y AXIS LENGTH IN INCHES
ANGMN(DGS) -- MINIMUM ANGLE IN DEGREES
ANGSTEP -- ANGLE INCREMENT IN DEGREES
ANGMX -- MAXIMUM ANGLE IN DEGREES
ENTER ANGAX(IN),ANGMN(DGS),ANGSTEP,ANGMX
  5.00  -90.00   10.00   90.00                ! angax(IN),angmin,angstep,angmax
CONTROL PARAMETERS
KFRQ -- FREQUENCY (HZ)
KBP -- BEAM PATTERN TYPE
       0 INDICATES BEAM FILE TO BE READ
       1 OMNI DIRECTIONAL BEAM PATTERN
       N(>1) N EQUISPACED ELEMENTS
IFOUT -- FILE SAVE PARAMETER
         0 INDICATES NO DATA FILE SAVED
         1 INDICATES RAY AVERAGED DATA SAVED
         2 INDICATES RAY BUNDLE DATA SAVED
MINO -- MINIMUM ORDER TO PROCESS
MAXO -- MAXIMUM ORDER TO PROCESS
IFANG -- SOURCE ANGLES TO BE PROCESSED
         0 ALL ANGLES ARE PROCESSED
         1 USER DETERMINES ANGLES TO PROCESS
IFDEL -- NUMBER OF DISCRETE SOURCE ANGLES TO
         DELETE
ENTER KFRQ,KBP,IFOUT,MINO,MAXO,IFANG,IFDEL :
 500   3   2   1 120   0   0                  ! kfrq,kbp,ifout,mino,maxo,ifang,ifdel
ENTER NAME FOR OUTPUT DATA FILE (up to 30 characters):
DATDIR:RT0OSS.DAT                             ! output contour file
```

```
VERTICAL APERTURE ASSUMED TOBE    3 EQUALLY-SPACED ELEMENTS
ENTER VERTICAL PHONE SPACING OF ARRAY (wavelengths), AND
DEGREES OF TILT FROM HORIZONTAL (+ is down):
   0.50   0.00                                ! spacing (wavelengths), tilt
FORTRAN STOP
$ !*******************************************
$ !
$ !  RTHETA - BOTTOM CONTOURS - SOURCE
$ !
$ !*******************************************
$RUN EXEDIR:RTHETA


 NRL EXPORT-RASP MODEL, VERSION 1 :  PROGRAM RTHETA


ENTER TITLE FOR THIS RUN (up to 68 characters):
Quasi Monostatic Sample Execution
DO YOU WANT A FULL RTHETA CONTOUR PRINT FILE? (1=yes,0=no):
 1                                            ! full contour print file?
ENTER NAME FOR PRINT FILE (up to 30 characters):
DATDIR:RT00SB.PNT                             ! output print file
ENTER NAME OF INPUT FILE FROM RAYACT (up to 30 characters):
DATDIR:RA00SB.DAT                             ! input raytrace file
DO YOU WISH A PLOT OF ORDER CONTOURS? (1=yes,0=no):
 1                                            ! plot of rtheta contours?

** PLOTTING OPTION REQUESTED **

ENTER PLOTTING PARAMETERS:
  **** NO DEFAULTS ****
RNGAX(IN) -- X AXIS LENGTH IN INCHES
RMIN(KM) -- MINIMUM RANGE IN KILOMETERS
RSTEP -- RANGE INCREMENT IN KILOMETERS
RMAX -- MAXIMUM RANGE IN KILOMETERS
ENTER RNGAX(IN),RMIN(KM),RSTEP,RMAX
  8.00    0.00   25.00  200.00                ! rngax(IN), rmin, rstep, rmax
ANGAX(IN) -- Y AXIS LENGTH IN INCHES
ANGMN(DGS) -- MINIMUM ANGLE IN DEGREES
ANGSTEP -- ANGLE INCREMENT IN DEGREES
ANGMX -- MAXIMUM ANGLE IN DEGREES
ENTER ANGAX(IN),ANGMN(DGS),ANGSTEP,ANGMX
  5.00  -90.00   10.00   90.00                ! angax(IN),angmin,angstep,angmax
CONTROL PARAMETERS
KFRQ -- FREQUENCY (HZ)
KBP -- BEAM PATTERN TYPE
       0 INDICATES BEAM FILE TO BE READ
       1 OMNI DIRECTIONAL BEAM PATTERN
       N(>1) N EQUISPACED ELEMENTS
IFOUT -- FILE SAVE PARAMETER
         0 INDICATES NO DATA FILE SAVED
         1 INDICATES RAY AVERAGED DATA SAVED
         2 INDICATES RAY BUNDLE DATA SAVED
MINO -- MINIMUM ORDER TO PROCESS
MAXO -- MAXIMUM ORDER TO PROCESS
IFANG -- SOURCE ANGLES TO BE PROCESSED
         0 ALL ANGLES ARE PROCESSED
         1 USER DETERMINES ANGLES TO PROCESS
IFDEL -- NUMBER OF DISCRETE SOURCE ANGLES TO
```

```
        DELETE
ENTER KFRQ,KBP,IFOUT,MINO,MAXO,IFANG,IFDEL :
 500   3   2   1 120   0   0                 ! kfrq,kbp,ifout,mino,maxo,ifang,ifdel
ENTER NAME FOR OUTPUT DATA FILE (up to 30 characters):
DATDIR:RTOOSB.DAT                            ! output contour file
VERTICAL APERTURE ASSUMED TOBE    3 EQUALLY-SPACED ELEMENTS
ENTER VERTICAL PHONE SPACING OF ARRAY (wavelengths), AND
DEGREES OF TILT FROM HORIZONTAL (+ is down):
   0.50   0.00                               ! spacing (wavelengths), tilt
FORTRAN STOP
$ !**********************************************
$ !
$ !  RTHETA - TARGET CONTOURS - SOURCE
$ !
$ !**********************************************
$RUN EXEDIR:RTHETA


 NRL EXPORT-RASP MODEL, VERSION 1 :  PROGRAM RTHETA


ENTER TITLE FOR THIS RUN (up to 68 characters):
Quasi Monostatic Sample Execution
DO YOU WANT A FULL RTHETA CONTOUR PRINT FILE? (1=yes,0=no):
 1                                           ! full contour print file?
ENTER NAME FOR PRINT FILE (up to 30 characters):
DATDIR:RTOOST.PNT                            ! output print file
ENTER NAME OF INPUT FILE FROM RAYACT (up to 30 characters):
DATDIR:RAOOST.DAT                            ! input raytrace file
DO YOU WISH A PLOT OF ORDER CONTOURS? (1=yes,0=no):
 1                                           ! plot of rtheta contours?

** PLOTTING OPTION REQUESTED **

ENTER PLOTTING PARAMETERS:
  **** NO DEFAULTS ****
RNGAX(IN) -- X AXIS LENGTH IN INCHES
RMIN(KM) -- MINIMUM RANGE IN KILOMETERS
RSTEP -- RANGE INCREMENT IN KILOMETERS
RMAX -- MAXIMUM RANGE IN KILOMETERS
ENTER RNGAX(IN),RMIN(KM),RSTEP,RMAX
  8.00    0.00   25.00  200.00               ! rngax(IN), rmin, rstep, rmax
ANGAX(IN) -- Y AXIS LENGTH IN INCHES
ANGMN(DGS) -- MINIMUM ANGLE IN DEGREES
ANGSTEP -- ANGLE INCREMENT IN DEGREES
ANGMX -- MAXIMUM ANGLE IN DEGREES
ENTER ANGAX(IN),ANGMN(DGS),ANGSTEP,ANGMX
  5.00  -90.00   10.00   90.00               ! angax(IN),angmin,angstep,angmax
CONTROL PARAMETERS
KFRQ -- FREQUENCY (HZ)
KBP -- BEAM PATTERN TYPE
       0 INDICATES BEAM FILE TO BE READ
       1 OMNI DIRECTIONAL BEAM PATTERN
       N(>1) N EQUISPACED ELEMENTS
IFOUT -- FILE SAVE PARAMETER
         0 INDICATES NO DATA FILE SAVED
         1 INDICATES RAY AVERAGED DATA SAVED
         2 INDICATES RAY BUNDLE DATA SAVED
MINO -- MINIMUM ORDER TO PROCESS
```

```
MAXO -- MAXIMUM ORDER TO PROCESS
IFANG -- SOURCE ANGLES TO BE PROCESSED
         0 ALL ANGLES ARE PROCESSED
         1 USER DETERMINES ANGLES TO PROCESS
IFDEL -- NUMBER OF DISCRETE SOURCE ANGLES TO
         DELETE
ENTER KFRQ,KBP,IFOUT,MINO,MAXO,IFANG,IFDEL :
 500   3   2   1 120   0   0                 ! kfrq,kbp,ifout,mino,maxo,ifang,ifdel
ENTER NAME FOR OUTPUT DATA FILE (up to 30 characters):
DATDIR:RTOOST.DAT                            ! output contour file
VERTICAL APERTURE ASSUMED TOBE    3 EQUALLY-SPACED ELEMENTS
ENTER VERTICAL PHONE SPACING OF ARRAY (wavelengths), AND
DEGREES OF TILT FROM HORIZONTAL (+ is down):
   0.50   0.00                               ! spacing (wavelengths), tilt
FORTRAN STOP
$ !********************************************
$ !
$ !  TLVSR - TARGET-RECEIVER TRANSMISSION LOSS
$ !
$ !********************************************
$RUN EXEDIR:TLVSR


NRL EXPORT-RASP MODEL, VERSION 1 :  PROGRAM TLVSR


ENTER TITLE FOR THIS RUN (up to 68 characters):
Quasi Monostatic Sample Execution
ENTER NAME OF INPUT FILE FROM RTHETA (up to 30 characters):
DATDIR:RTOORT.DAT                            ! input file from rtheta
ENTER MIN RANGE, RANGE INCREMENT, MAX RANGE OF COMPUTATIONS (km):
    0.00    1.00  200.00                     ! min,inc,max range
DO YOU WANT ARRIVAL STRUCTURE AT EACH RANGE? (1=yes,0=no):
 (printing mandatory, plotting not available)
    1                                        ! ifarr

*** VERTICAL ARRIVAL STRUCTURE HAS BEEN REQUESTED...

ENTER MAX NUMBER OF ARRIVALS PRINTED AT EACH RANGE:
  (<=48 or 0 to default to maximum of 48)
  48                                         ! max number of arrivals to find
ENTER NAME FOR PRINT FILE (up to 30 characters):
DATDIR:TLOORT.PNT                            ! output print file

DO YOU WANT TO PLOT TRANSMISSION LOSS vs RANGE? (1=yes,0=no):
    1                                        ! ifplt

*** OPTION TO PLOT TRANSMISSION LOSS HAS BEEN INVOKED...

X-AXIS PLOT PARAMETERS ARE DEFINED AS FOLLOWS; (0=defaults):
  XAXIS = LENGTH OF HORIZONTAL PLOT AXIS (in), default=10.
  RGMN  = MIN RANGE OF PLOT (km), default=0.
  RINC  = PLOT LABEL RANGE INCREMENT (km/in), default computed.
  RGMX  = MAX RANGE OF PLOT (km), default=max range of computations.

ENTER XAXIS(in),RGMN(km),RINC(km/in),RGMX(km):
  8.00    0.00   25.00  200.00               ! rngax(IN),rmin,rinc,rmax to plot

Y-AXIS PLOT PARAMETERS ARE DEFINED AS FOLLOWS; (0=defaults):
```

```
  YAXIS = LENGTH OF VERTICAL PLOT AXIS (in < 8.0), default computed.
  TLMIN = MIN TL FOR TOP OF PLOT (dB), default computed.
  DBINC = PLOT LABEL TL INCREMENT (dB/in), default computed.
  TLMAX = MAX TL FOR BOTTOM OF PLOT (dB), default computed.

ENTER YAXIS(in),TLMIN(dB),DBINC(dB/in),TLMAX(dB):
  5.00    0.00   20.00  180.00 -999.00          ! tlax(IN),tlmin,tlinc,tlmax,dely
DO YOU WISH AN OUTPUT FILE OF COMPUTED TRANSMISSION LOSSES? (1=yes,0=no):
    1                                           ! ifout
ENTER NAME FOR OUTPUT FILE (up to 30 characters):
DATDIR:TLOORT.DAT                               ! output tl file
FORTRAN STOP
$ !**********************************************
$ !
$ !  TLVSR - SOURCE-TARGET TRANSMISSION LOSS
$ !
$ !**********************************************
$RUN EXEDIR:TLVSR


NRL EXPORT-RASP MODEL, VERSION 1 :  PROGRAM TLVSR


ENTER TITLE FOR THIS RUN (up to 68 characters):
Quasi Monostatic Sample Execution
ENTER NAME OF INPUT FILE FROM RTHETA (up to 30 characters):
DATDIR:RTOOST.DAT                               ! input file from rtheta
ENTER MIN RANGE, RANGE INCREMENT, MAX RANGE OF COMPUTATIONS (km):
    0.00     1.00  200.00                       ! min,inc,max range
DO YOU WANT ARRIVAL STRUCTURE AT EACH RANGE? (1=yes,0=no):
 (printing mandatory, plotting not available)
    1                                           ! ifarr

*** VERTICAL ARRIVAL STRUCTURE HAS BEEN REQUESTED...

ENTER MAX NUMBER OF ARRIVALS PRINTED AT EACH RANGE:
  (<=48 or 0 to default to maximum of 48)
  48                                            ! max number of arrivals to find
ENTER NAME FOR PRINT FILE (up to 30 characters):
DATDIR:TLOOST.PNT                               ! output print file

DO YOU WANT TO PLOT TRANSMISSION LOSS vs RANGE? (1=yes,0=no):
    1                                           ! ifplt

*** OPTION TO PLOT TRANSMISSION LOSS HAS BEEN INVOKED...

X-AXIS PLOT PARAMETERS ARE DEFINED AS FOLLOWS; (0=defaults):
  XAXIS = LENGTH OF HORIZONTAL PLOT AXIS (in), default=10.
  RGMN  = MIN RANGE OF PLOT (km), default=0.
  RINC  = PLOT LABEL RANGE INCREMENT (km/in), default computed.
  RGMX  = MAX RANGE OF PLOT (km), default=max range of computations.

ENTER XAXIS(in),RGMN(km),RINC(km/in),RGMX(km):
  8.00     0.00    25.00  200.00                ! rngax(IN),rmin,rinc,rmax to plot

Y-AXIS PLOT PARAMETERS ARE DEFINED AS FOLLOWS; (0=defaults):
  YAXIS = LENGTH OF VERTICAL PLOT AXIS (in < 8.0), default computed.
  TLMIN = MIN TL FOR TOP OF PLOT (dB), default computed.
  DBINC = PLOT LABEL TL INCREMENT (dB/in), default computed.
```

```
  TLMAX = MAX TL FOR BOTTOM OF PLOT (dB), default computed.

ENTER YAXIS(in),TLMIN(dB),DBINC(dB/in),TLMAX(dB):
  5.00    0.00   20.00  180.00 -999.00         ! tlax(IN),tlmin,tlinc,tlmax,dely
DO YOU WISH AN OUTPUT FILE OF COMPUTED TRANSMISSION LOSSES? (1=yes,0=no):
    1                                          ! ifout
ENTER NAME FOR OUTPUT FILE (up to 30 characters):
DATDIR:TLOOST.DAT                              ! output tl file
FORTRAN STOP
$ !*********************************************
$ !
$ !  REVERB - SURFACE REVERBERATION
$ !
$ !*********************************************
$RUN EXEDIR:REVERB


NRL EXPORT-RASP MODEL, VERSION 1 :  PROGRAM REVERB


ENTER TITLE FOR THIS RUN (up to 68 characters):
Quasi Monostatic Sample Execution
ENTER FILE NAME FOR PRINT FILE (up to 30 characters):
DATDIR:RV000S.PNT                              ! output print file
ENTER KEY FOR TYPE OF CALCULATIONS:
   KEY=1,   MONOSTATIC
   KEY=2,   QUASI-MONOSTATIC
   KEY=3,   BISTATIC
 2                                             ! key for type of geometry
ENTER MAXIMUM NUMBER OF RECEIVER RAY BOUNDARY INTERSECTIONS (default=48):
   48                                          ! mxhitr
ENTER MAXIMUM NUMBER OF SOURCE RAY BOUNDARY INTERSECTIONS (default=48):
   48                                          ! mxhits
DO YOU WANT A VERTICAL DISTRIBUTION OF REVERBERATION?
   0 = no vertical distribution
  -1 = range of times for distribution will be read in
  +n = n discrete times for distribution will be read in
ENTER NVERT:
    0                                          ! nvert
ENTER INITIAL, INCREMENT, AND MAXIMUM RANGES FROM RECEIVER (km):
    0.00    1.00  200.00                       ! min,inc,max range from receiver
ENTER DURATION OF CW (OR CW EQUIVALENT) PULSE (sec):
    5.00                                       ! pulse duration (sec)
ENTER INITIAL, INCREMENT, AND LAST TIMES OF COMPUTED REVERBERATION ENVELOPE:
    0.00    1.00  300.00                       ! start,step,end times
ENTER FILE NAME OF RECEIVER CONTOURS FROM RTHETA (up to 30 characters):
DATDIR:RTOORS.DAT                              ! input receiver contours

** SURFACE (RANGE vs THETA) CONTOUR HAS BEEN SELECTED **

ENTER SURFACE BACKSCATTER TYPE:
 KSCAT = flag indicating type of surface backscattering model to be used.
    0=table of backscattering models to be read in.
    1=Chapmann & Harris model used
ENTER SURFACE BACKSCATTER TYPE:
 1                                             ! surface backscatter type
ENTER SCATTERING STRENGTH AT 0 DEGREES, SEA STATE,
 WIND SPEED, AND WAVE HEIGHT FOR CHAPMANN & HARRIS:
-100.   1.  20.   0.                           ! sso, ss, ws, wh
```

```
ENTER FILE NAME OF SOURCE CONTOURS FROM RTHETA (up to 30 characters):
DATDIR:RTOOSS.DAT                               ! input source contours
DO YOU WISH TO SAVE RESULTS ON OUTPUT FILE? (1=yes,0=no):
 1                                              ! save results on file?
ENTER NAME FOR OUTPUT FILE OF REVERBERATION ENVELOPE (up to 30 characters):
DATDIR:RV000S.DAT                               ! output file of reverb envelope
FORTRAN STOP
$ !*********************************************
$ !
$ !  REVERB - BOTTOM REVERBERATION
$ !
$ !*********************************************
$RUN EXEDIR:REVERB


NRL EXPORT-RASP MODEL, VERSION 1 :  PROGRAM REVERB


ENTER TITLE FOR THIS RUN (up to 68 characters):
Quasi Monostatic Sample Execution
ENTER FILE NAME FOR PRINT FILE (up to 30 characters):
DATDIR:RV000B.PNT                               ! output print file
ENTER KEY FOR TYPE OF CALCULATIONS:
   KEY=1,    MONOSTATIC
   KEY=2,    QUASI-MONOSTATIC
   KEY=3,    BISTATIC
 2                                              ! key for type of geometry
ENTER MAXIMUM NUMBER OF RECEIVER RAY BOUNDARY INTERSECTIONS (default=48):
   48                                           ! mxhitr
ENTER MAXIMUM NUMBER OF SOURCE RAY BOUNDARY INTERSECTIONS (default=48):
   48                                           ! mxhits
DO YOU WANT A VERTICAL DISTRIBUTION OF REVERBERATION?
   0 = no vertical distribution
  -1 = range of times for distribution will be read in
  +n = n discrete times for distribution will be read in
ENTER NVERT:
    0                                           ! nvert
ENTER INITIAL, INCREMENT, AND MAXIMUM RANGES FROM RECEIVER (km):
    0.00    1.00  200.00                        ! min,inc,max range from receiver
ENTER DURATION OF CW (OR CW EQUIVALENT) PULSE (sec):
    5.00                                        ! pulse duration (sec)
ENTER INITIAL, INCREMENT, AND LAST TIMES OF COMPUTED REVERBERATION ENVELOPE:
    0.00    1.00  300.00                        ! start,step,end times
ENTER FILE NAME OF RECEIVER CONTOURS FROM RTHETA (up to 30 characters):
DATDIR:RTOORB.DAT                               ! input receiver contours

** BOTTOM (RANGE vs THETA) CONTOUR HAS BEEN SELECTED **

ENTER NUMBER OF BOTTOM BACKSCATTER MODELS TO BE USED:
 1                                              ! number of backscatter types to use
ENTER  1 BOTTOM BACKSCATTER TYPE(S) ALONG WITH
 RANGE TO WHICH THIS TYPE WILL BE USED:
 KSCAT = flag indicating type of boundary backscattering model to be used.
    0=table of backscattering models to be read in.
    1=Lambert's Law model used
    2=URICK ROCK bottom data used
    3=URICK SAND bottom data used
    4=URICK SILT bottom data used
    5=URICK CLAY bottom data used
```

```
ENTER BOTTOM BACKSCATTER TYPE 1, MAX RANGE:
 5  200.00                                 ! bottom backscatter type, range
ENTER FILE NAME OF SOURCE CONTOURS FROM RTHETA (up to 30 characters):
DATDIR:RT00SB.DAT                          ! input source contours
DO YOU WISH TO SAVE RESULTS ON OUTPUT FILE? (1=yes,0=no):
 1                                         ! save results on file?
ENTER NAME FOR OUTPUT FILE OF REVERBERATION ENVELOPE (up to 30 characters):
DATDIR:RV000B.DAT                          ! output file of reverb envelope
FORTRAN STOP
$ !********************************************
$ !
$ !  ACTENV - TL AND REVERBERATION PLOT
$ !
$ !********************************************
$RUN EXEDIR:ACTENV


NRL EXPORT-RASP MODEL, VERSION 1 :  PROGRAM ACTENV


ENTER TITLE FOR THIS RUN (up to 68 characters):
Quasi Monostatic Sample Execution

ENTER NAME FOR PRINT FILE (up to 30 characters):
DATDIR:AE0000.PNT                          ! output print file

ENTER PING TYPE (1=CW,2=IMPULSIVE,3=FM)
 1

ENTER SIGNAL DURATION (S)
    5.00                                   ! ping duration

ENTER INITIAL & FINAL TIMES FOR CALCULATIONS (sec)
    0.00  300.00                           ! tmin, tmax

ENTER SOURCE LEVEL PER ELEMENT (dB), NUMBER OF ARRAY ELEMENTS,
 AMBIENT NOISE LEVEL (dB/HZ), HORIZONTAL RECEIVER DIRECTIVITY INDEX (dB):
  200.00    3.00   65.00   10.00           ! sle, # of elements, anl, rdi

** PLOT PARAMETERS **

HORIZONTAL AXIS PLOT PARAMETERS ARE DEFINED AS FOLLOWS; (0=defaults):
  TAXIS = LENGTH OF HORIZONTAL PLOT AXIS (in), default=10.
  TMN   = MIN TIME FOR PLOT (sec), default=0.
  DT    = PLOT LABEL TIME INCREMENT (sec/in), default computed.
  TMX   = MAX TIME FOR PLOT (sec), default=max time of computations.

ENTER TAXIS(in), TMN(s), DT(s/in), TMX(s):
    8.00    0.00   30.00  300.00           ! taxis(in), tmin, tinc, tmax

VERTICAL AXIS PLOT PARAMETERS ARE DEFINED AS FOLLOWS; (0=defaults):
  ZAXIS = LENGTH OF VERTICAL PLOT AXIS (in < 8.0), default computed.
  ZMIN  = MIN LEVEL FOR BOTTOM OF PLOT (dB), default computed.
  DZ    = PLOT LABEL LEVEL INCREMENT (dB/in), default computed.
  ZMAX  = MAX LEVEL FOR TOP OF PLOT (dB), default computed.

ENTER ZAXIS(in), ZMIN(dB), DZ(dB/in), ZMAX(dB):
    5.00    0.00   20.00  180.00           ! yaxis(in), ymin, yinc, ymax
```

```
** SELECT  SURFACE  REVERBERATION ENVELOPES **
ENTER NUMBER OF ENVELOPES TO AVERAGE AND WEIGHTING FLAG.
(1=weighting,0=no weighting):
 1 0                                   ! norev, ifwgt
ENTER FILE NAME OF REVERBERATION ENVELOPE (up to 30 characters):
DATDIR:RV000S.DAT                      ! input reverberation file

** SELECT  BOTTOM  REVERBERATION ENVELOPES **
ENTER NUMBER OF ENVELOPES TO AVERAGE AND WEIGHTING FLAG.
(1=weighting,0=no weighting):
 1 0                                   ! norev, ifwgt
ENTER FILE NAME OF REVERBERATION ENVELOPE (up to 30 characters):
DATDIR:RV000B.DAT                      ! input reverberation file

IS TARGET ECHO TO BE INCLUDED? (1=yes,0=no):
 1                                     ! include target echo?

ENTER FILE NAME OF TRANSMISSION LOSS FROM THE
  TARGET TO THE RECEIVER (up to 30 characters):
DATDIR:TLOORT.DAT                      ! tl file target-receiver

IS A DIFFERENT FILE TO BE USED FOR TRANSMISSION
  LOSS FROM THE SOURCE TO THE TARGET? (1=yes,0=no):
 1                                     ! different tl file for source-target?

ENTER FILE NAME OF TRANSMISSION LOSS FROM THE
  SOURCE TO THE TARGET (up to 30 characters):
DATDIR:TLOOST.DAT                      ! tl file source-target

ENTER HORIZONTAL BISTATIC SOURCE-RECEIVER SEPARATION (km):
    0.00                               ! source-receiver separation(km)

ENTER TARGET BEARING, i.e. THE ANGLE (DEG) THE RECEIVER-TO-TARGET LINE MAKES
WITH THE RECEIVER-TO-SOURCE LINE. (DEFAULT=0 IN A (QUASI-)MONOSTATIC CASE.)
    0.00                               ! bearing(deg)

ENTER TARGET STRENGTH (dB/M**2):
   15.00                               ! target strength
FORTRAN STOP
```

5.6 Sample Execution Plot Files

This section contains the output of the plot files for both the quasi-monostatic full run (i.e., no standard defaults and maximum number of plot and print files) and the short run (defaults used with a minimum of plotting and printing files). The following brief descriptions are provided to orient the reader. Complete information is found in section 4.

The full run execution contains 15 plots. Figures 16 thru 19 are the plots from the PROFIL module. Figure 16 is a sound speed contour plot over the range specified. Figure 17 presents a composite environment plot, that is, the sound speed profiles for the ranges chosen are plotted on the same graph. Additionally, the minimum sound speed and the bottom depth on the profiles are connected to one another. Figures 18 and 19 are plots of selected sound speed profiles. In this case, only two profiles were present and both were plotted.

Figures 20 and 21 are plots of the raytraces that are generated in the RAYACT module.

Figure 20 shows the raytraces from the source to the target; Fig. 21 shows the traces from the target to the receiver. In each case, the user chose to plot only every tenth ray.

Figures 22 thru 27 are the order contours generated in the RTHETA module. Figure 22 shows the source-to-surface contours; Fig. 23 shows the source-to-bottom contours; Fig. 24 shows the source-to-target contours. Figures 25, 26, and 27 present the receiver-to-surface, receiver-to-bottom and receiver-to-target contours respectively. In each case the minimum ray order is 0, and the maximum ray order is 120. Additionally, each case processed all of the fan angles.

Figures 28 and 29 are the transmission loss plots generated in the TLVSR module. Figure 28 presents the transmission loss of the coherent and incoherent energy from the source to the target. The transmission loss of the energy from the target to the receiver is presented in Fig. 29. Note that the transmission loss plotted includes the beam pattern response as applied in program RTHETA.

Finally, the ACTENV module generates the reverberation plot shown in Fig. 30. This plot shows the surface and bottom reverberation and the target echo levels. These levels are presented as the total beampower at the output of the receiver and are a function of the time after transmission. Also shown on this plot is the ambient noise. Because ambient noise is independent of range, it is a straight line. Since the receiver is omnidirectional, neither the surface or bottom reverberation envelopes are weighted.

For the case of the short run execution, only one plot is generated. ACTENV is the only module that produces a plot file when a minimum of plot files is requested. Figure 30 shows the ACTENV output for the short run execution.

6. ACKNOWLEDGMENTS

This work was supported by the Office of Naval Technology, Code 234. The authors are grateful to Dr. James Fulford of the Naval Research Laboratory, Stennis Space Center, Mississippi, and Mr. P. Edward Powell the Naval Research Laboratory, Washington, DC. Also numerous staff members of Planning Systems, Inc. made substantial contributions.

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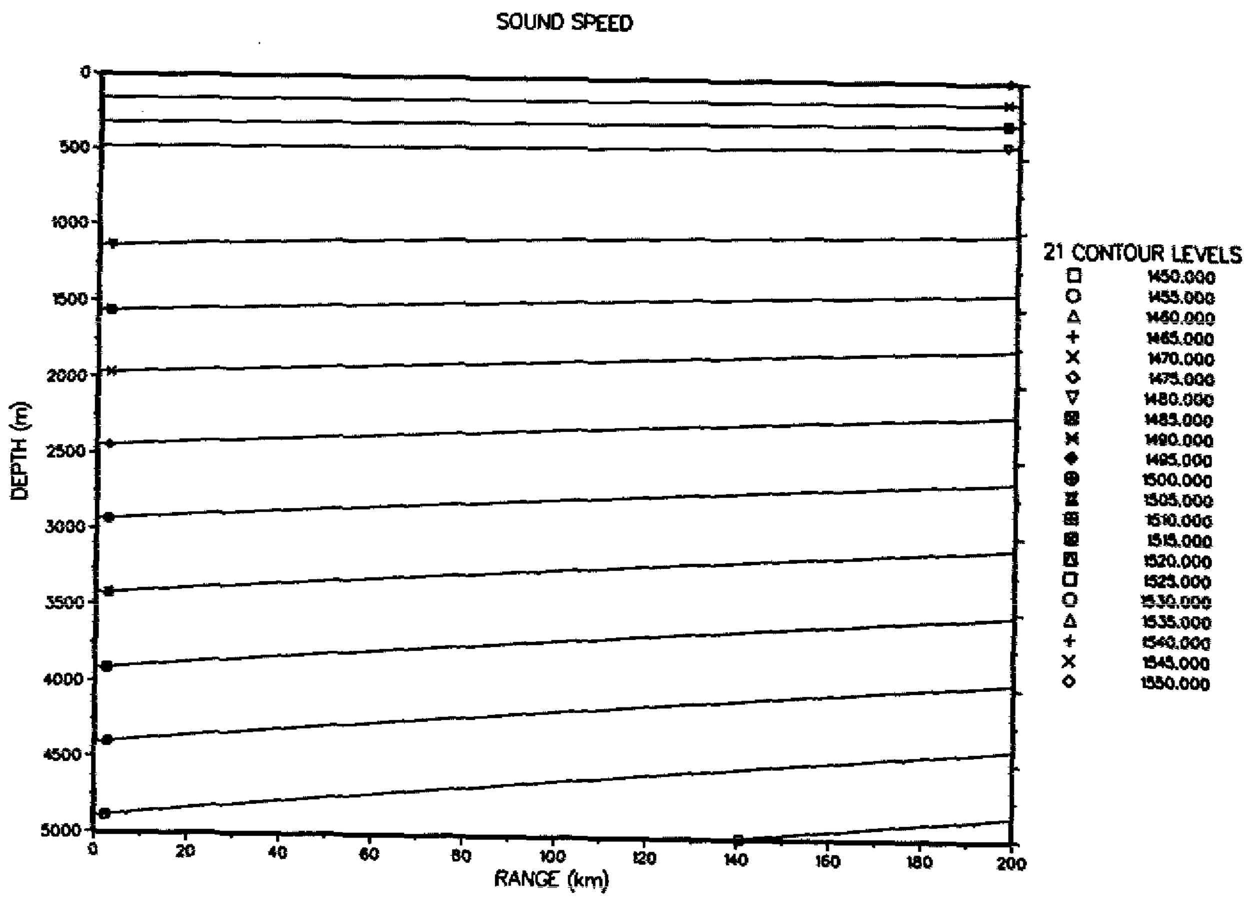

Fig. 16 – Sound speed contour plot

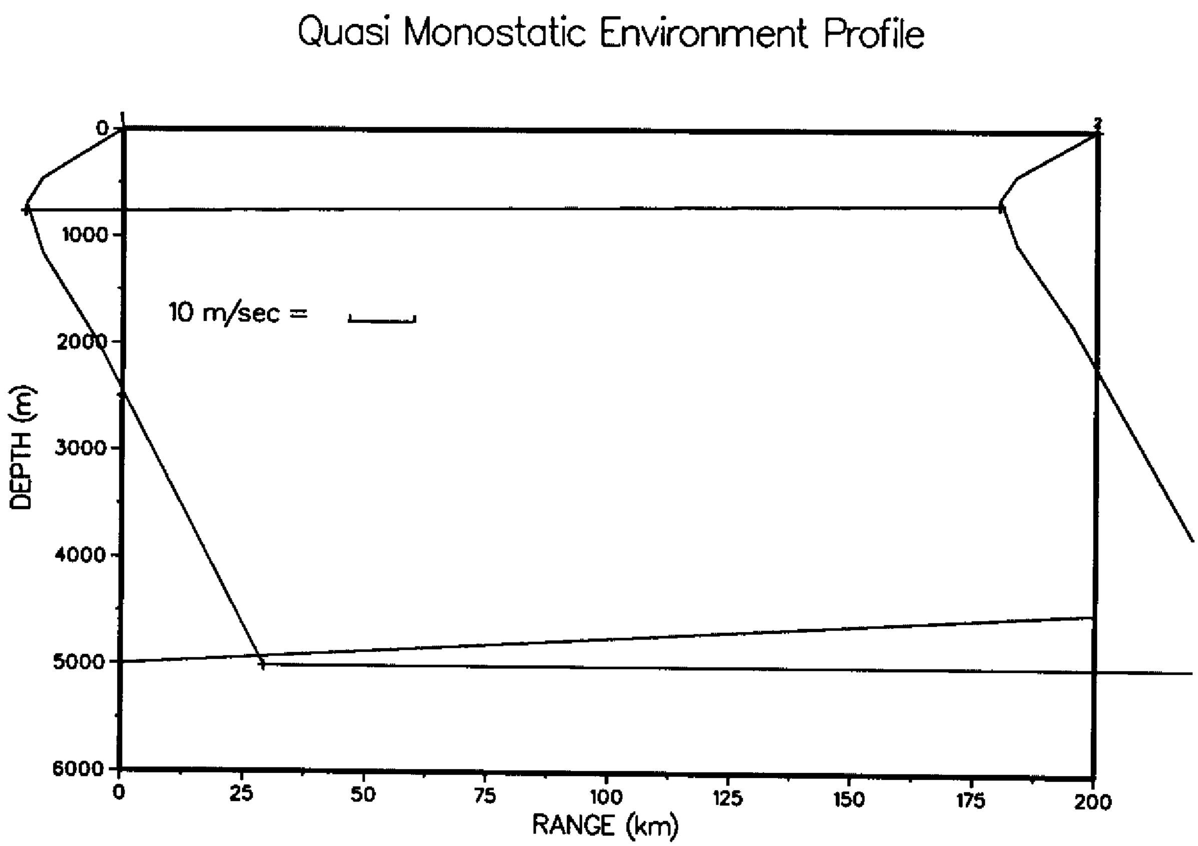

Fig. 17 – Composite environmental plot

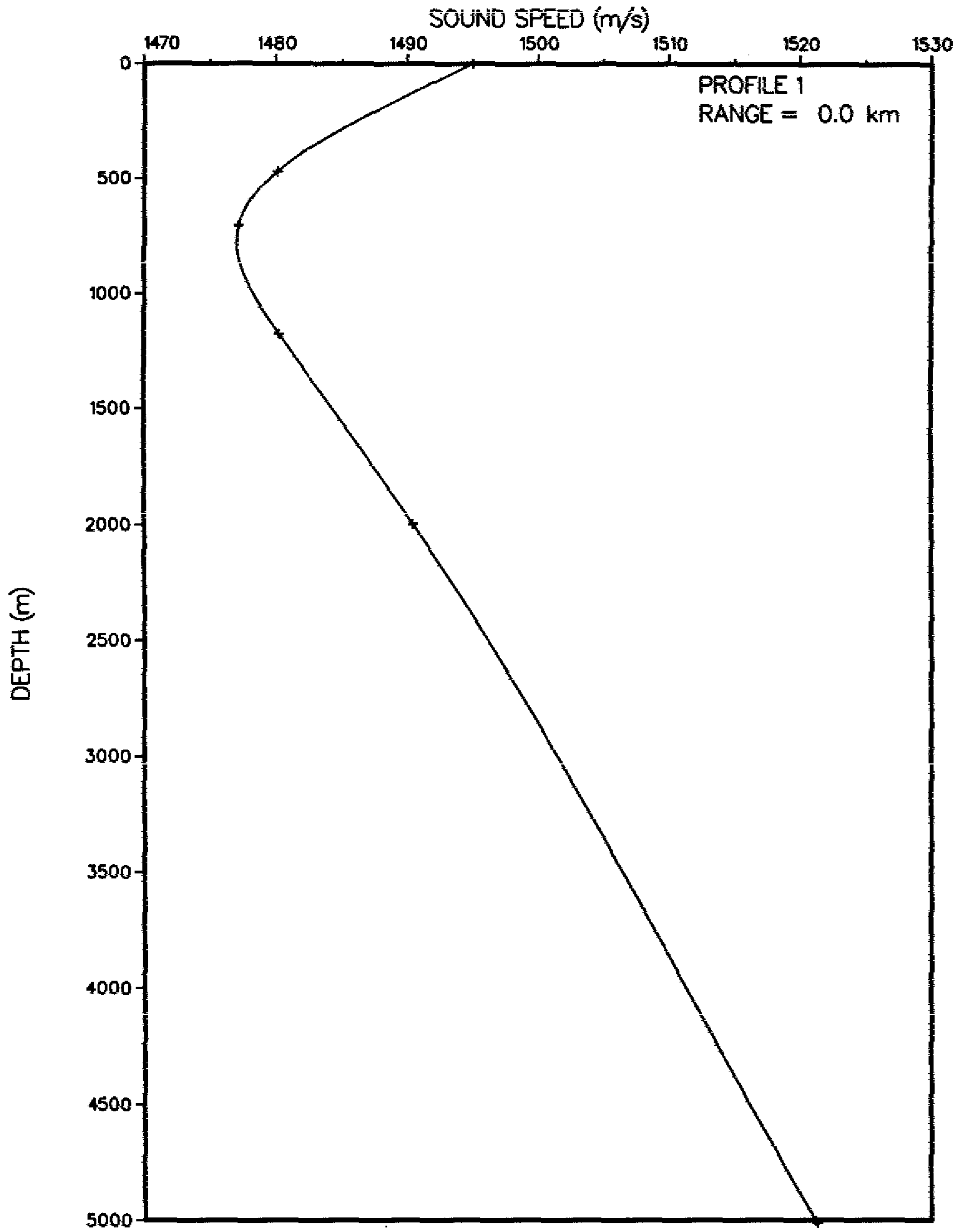

Fig. 18 – First selected sound speed profile

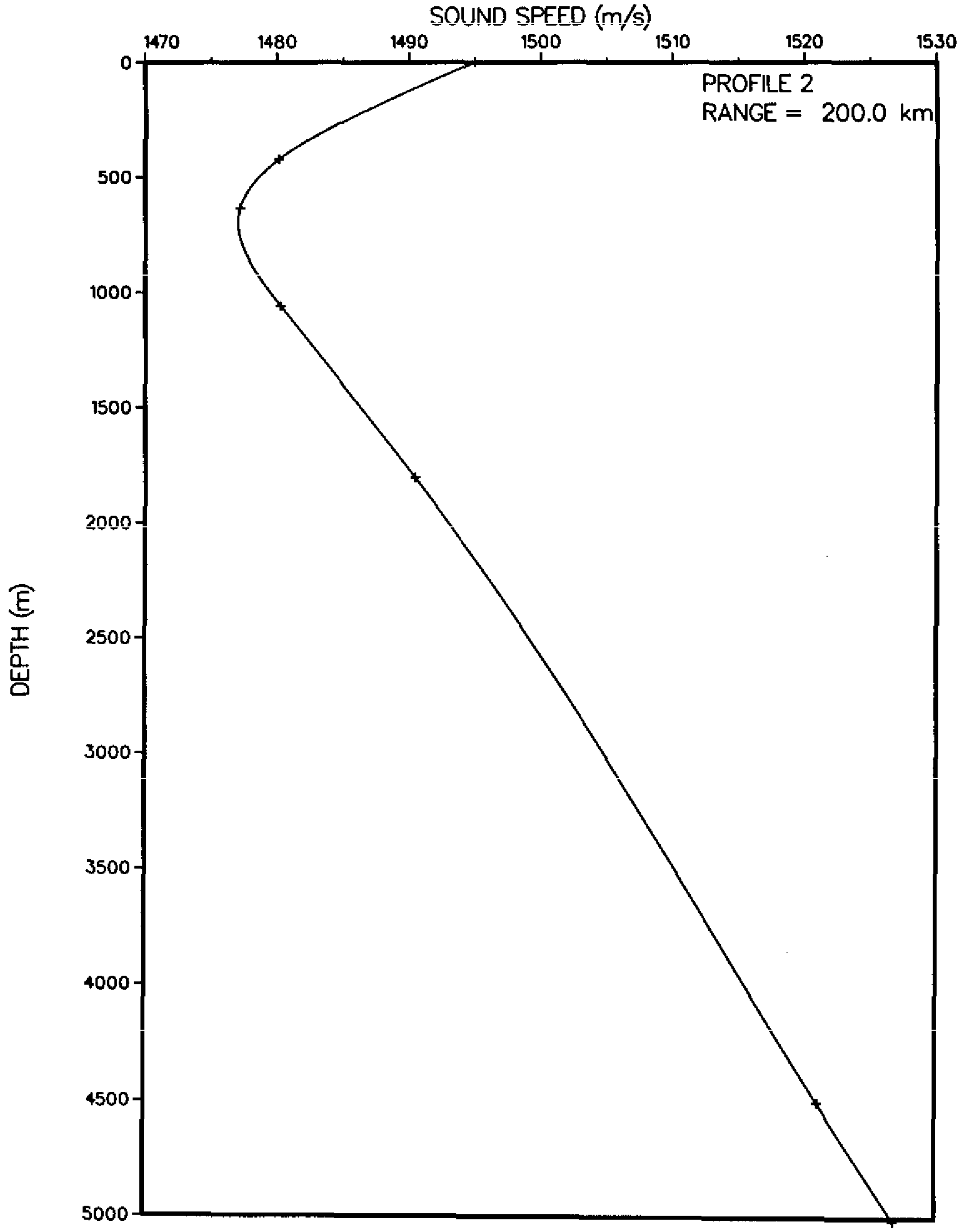

Fig. 19 – Second selected sound speed profile

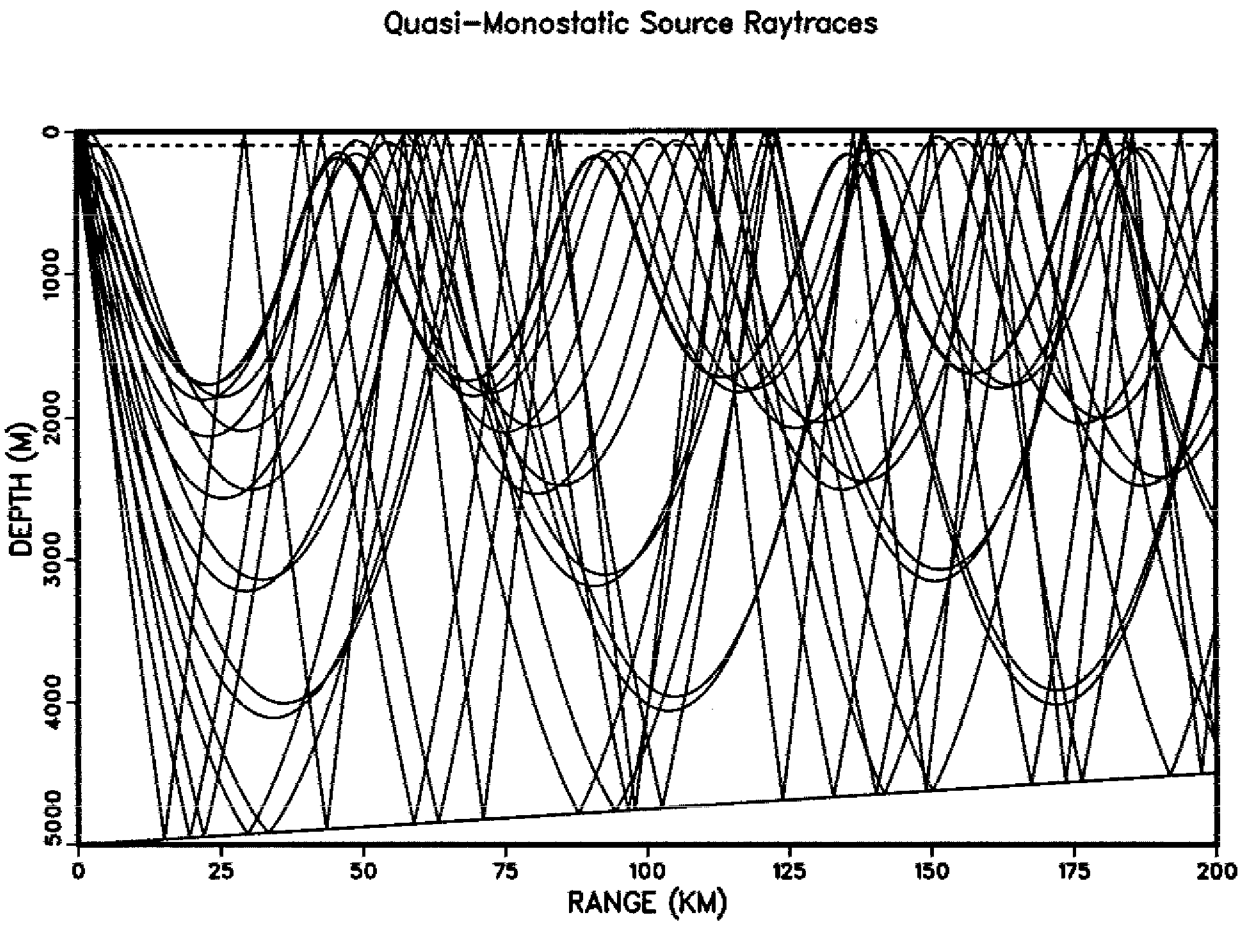

Fig. 20 – Raytraces from source to target

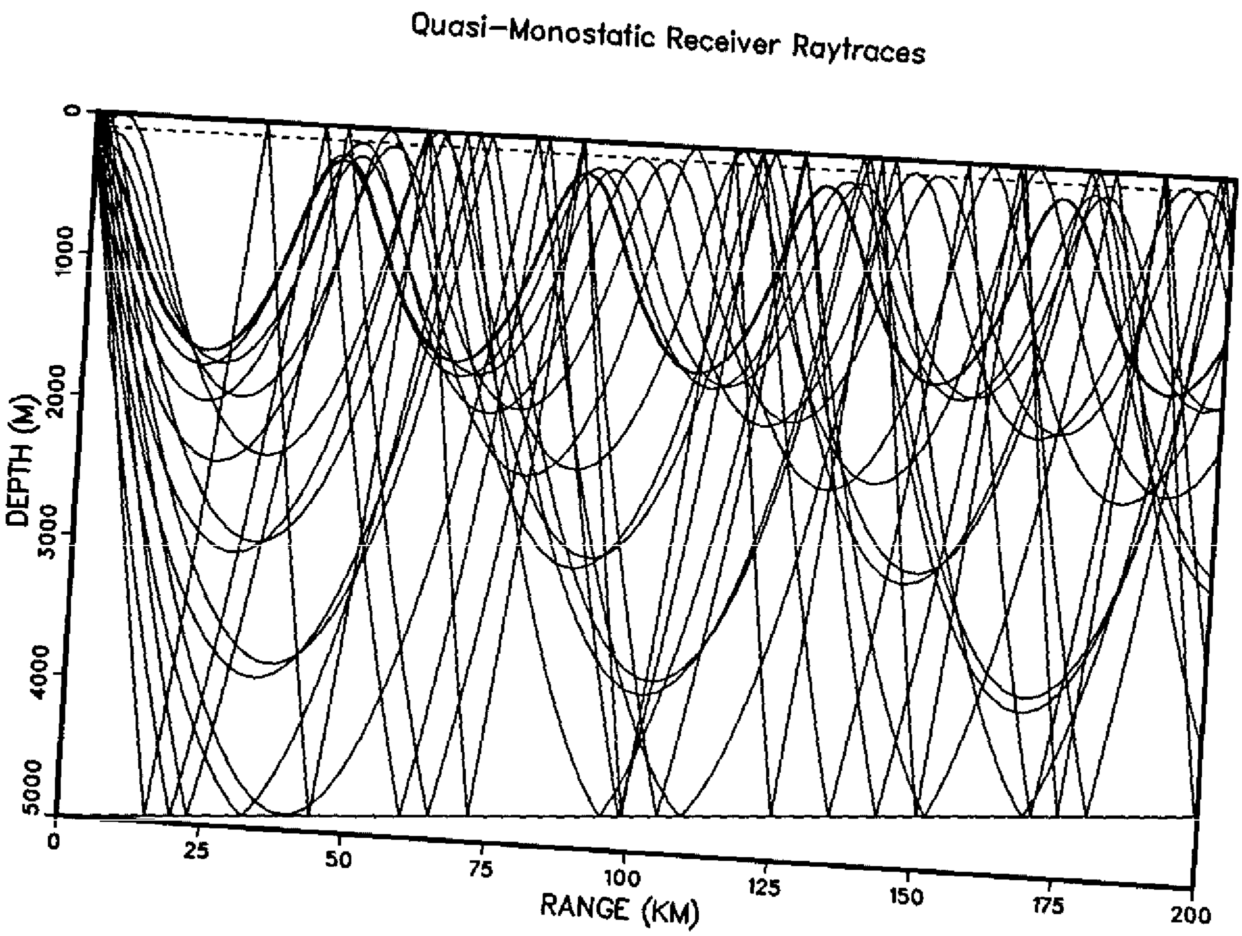

Fig. 21 - Raytraces from receiver to target

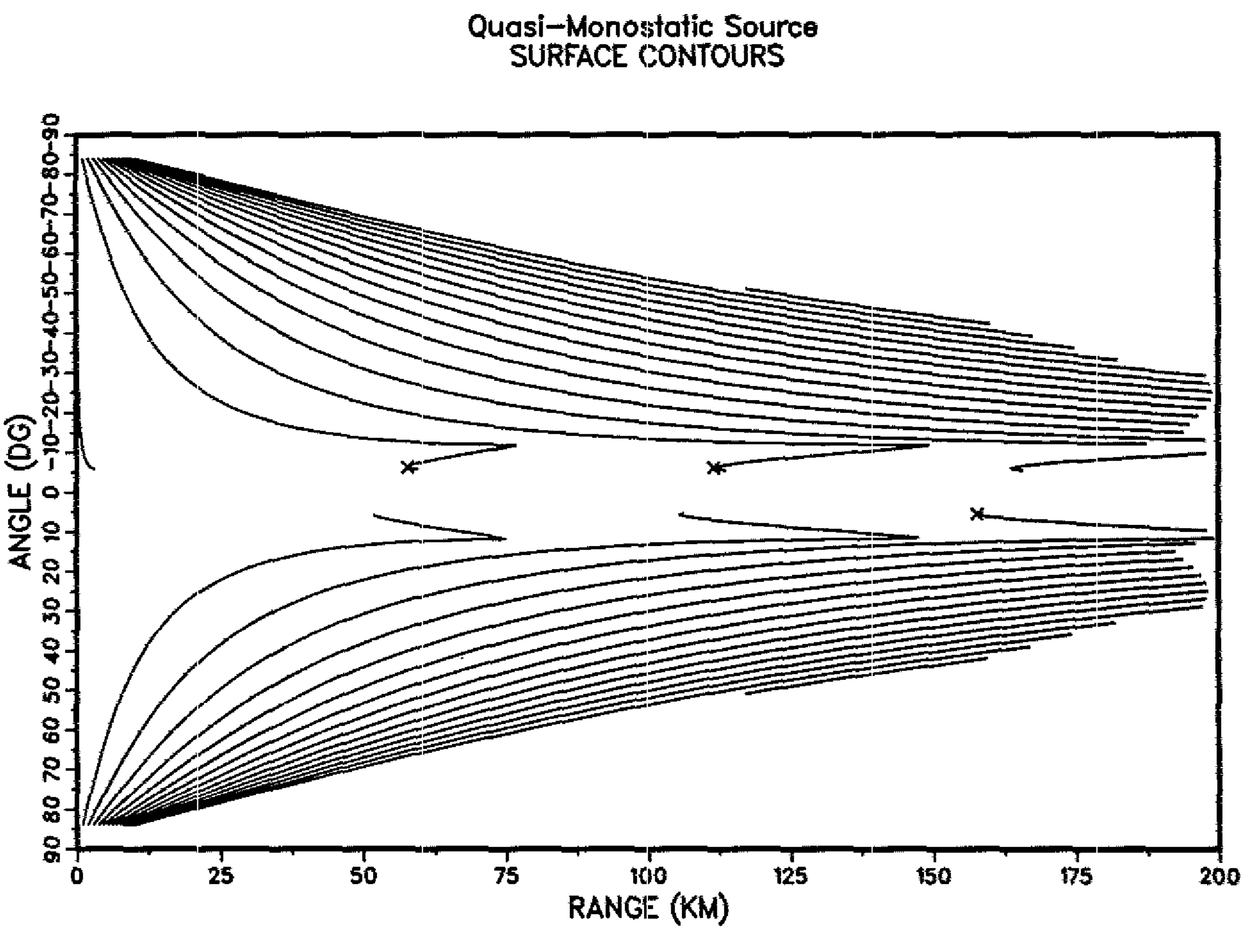

Fig. 22 – Source to surface ordered contours

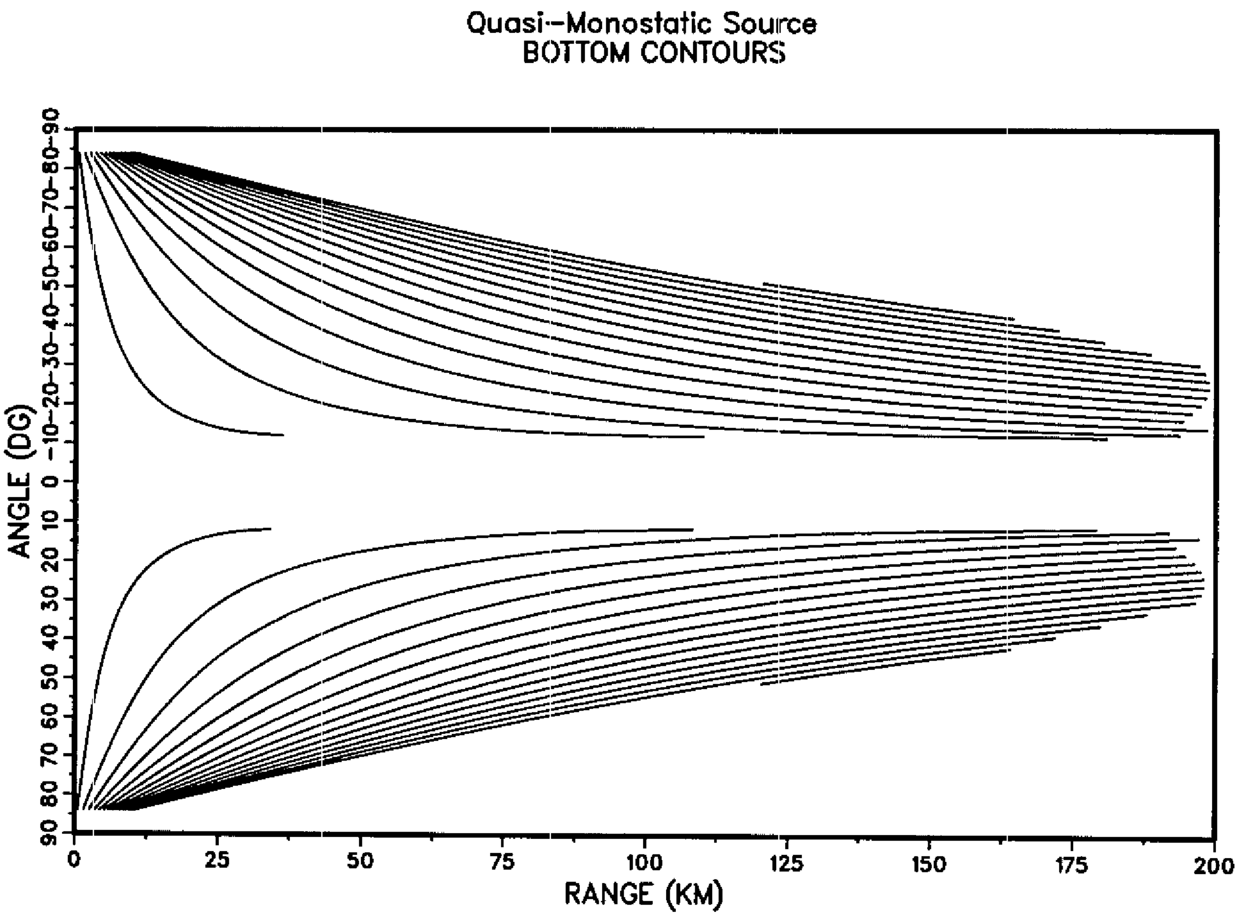

Fig. 23 – Source to bottom ordered contours

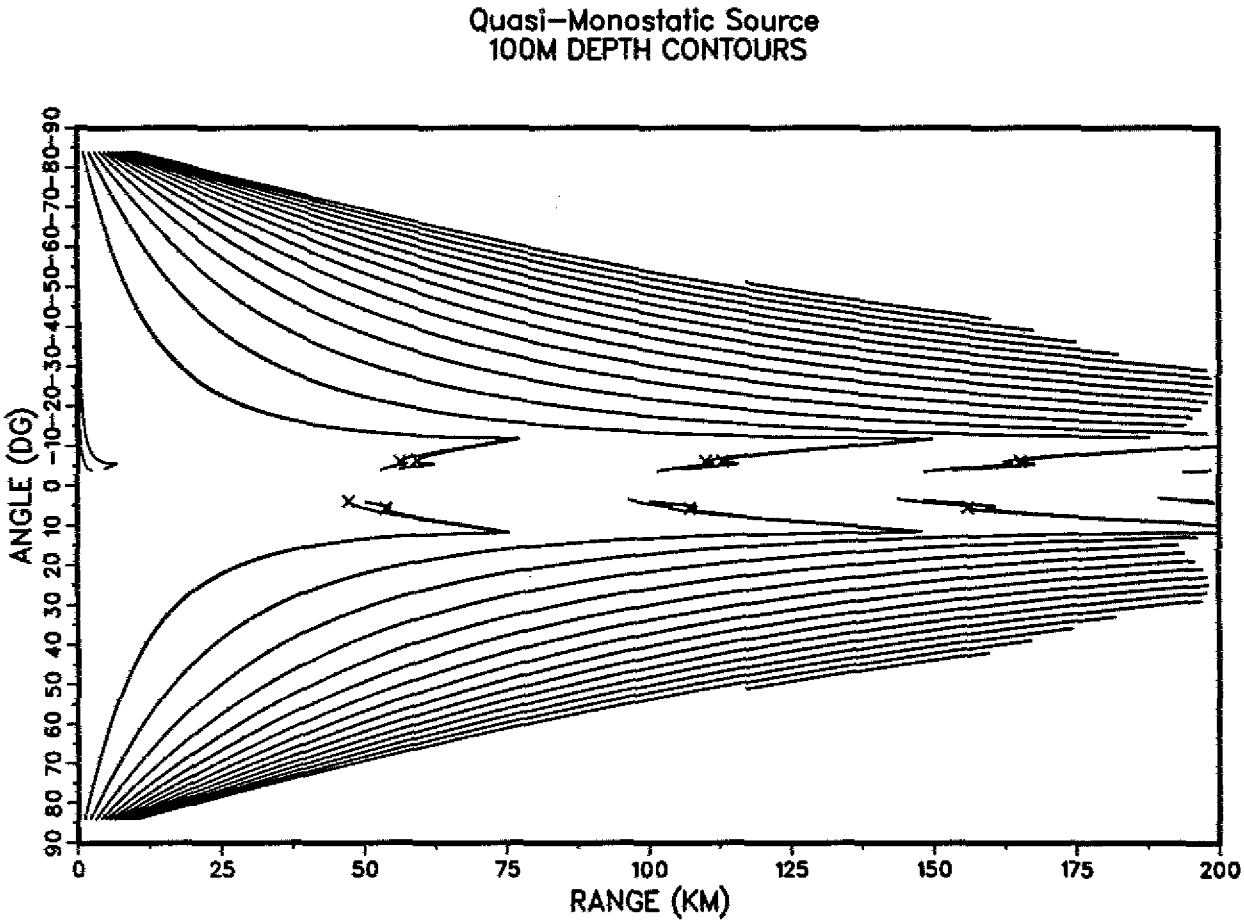

Fig. 24 – Source to target ordered contours

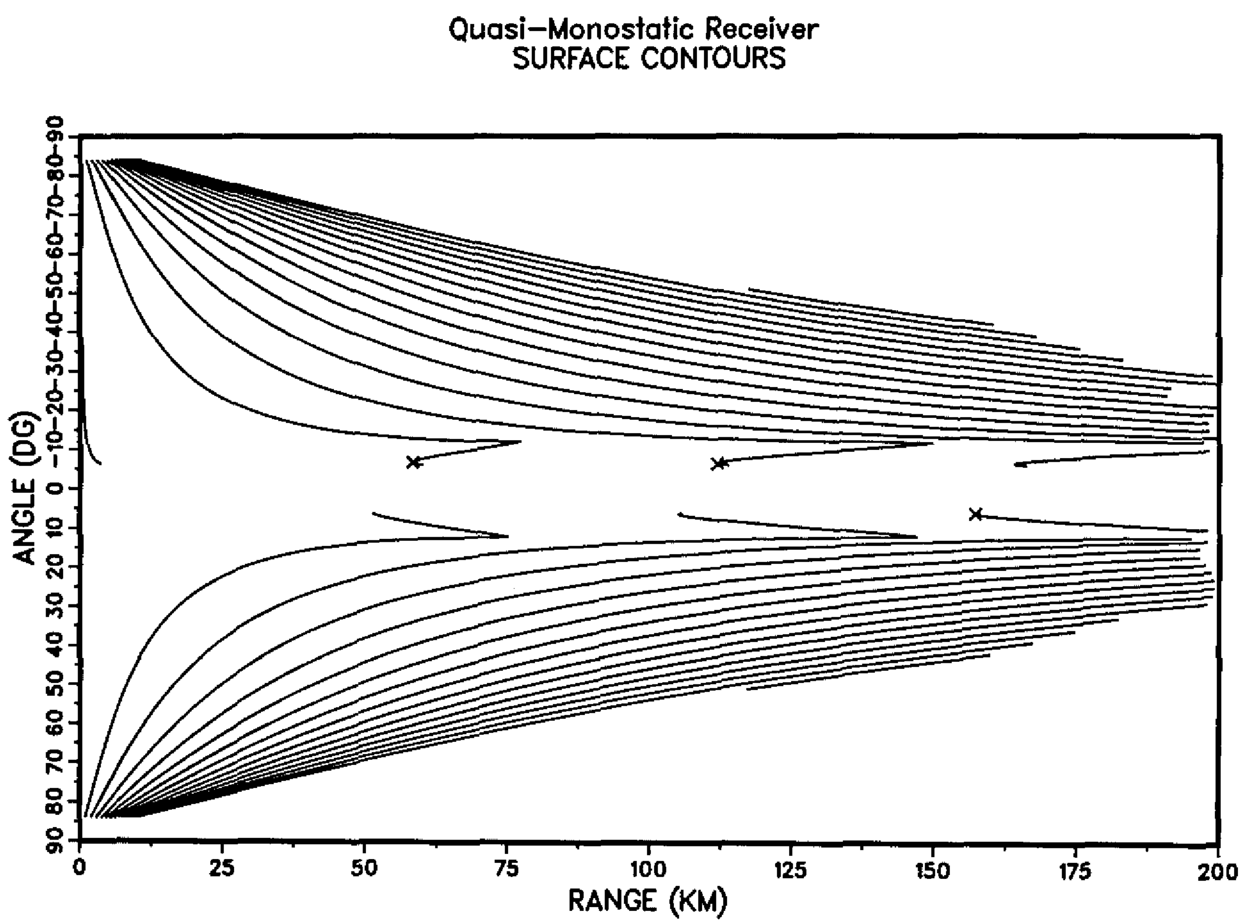

Fig. 25 – Receiver to surface ordered contours

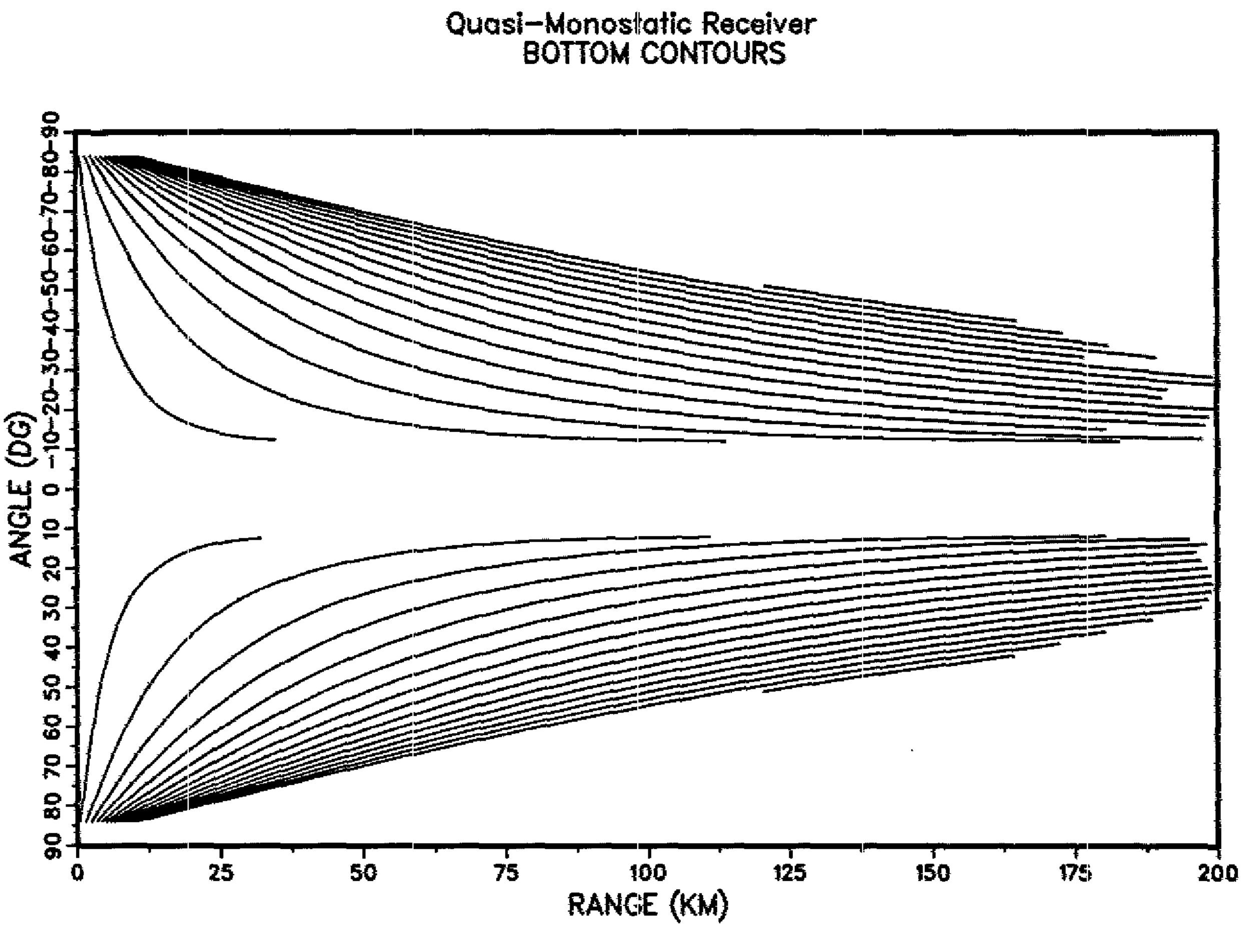

Fig. 26 – Receiver to bottom ordered contours

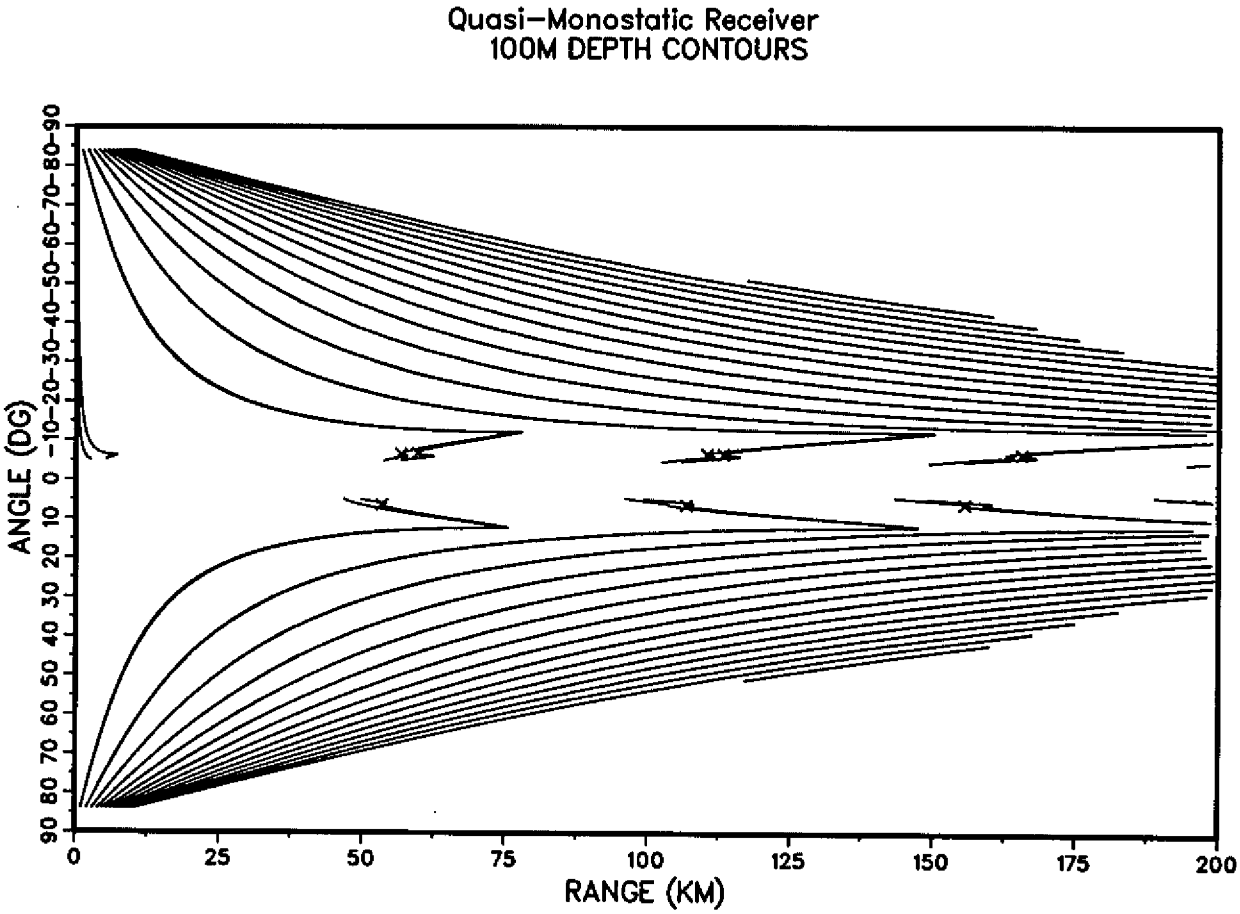

Fig. 27 – Receiver to target ordered contours

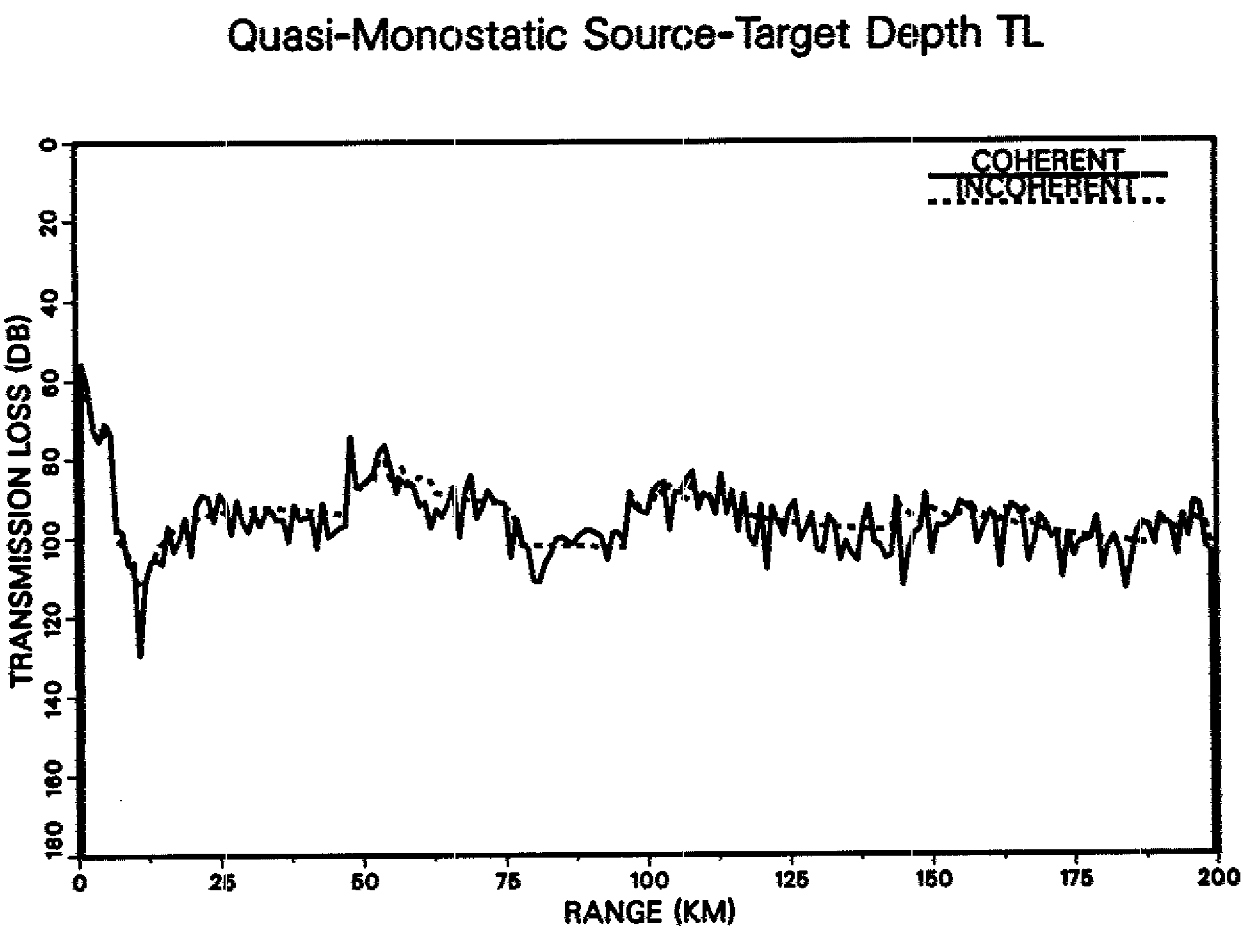

Fig. 28 -- Transmission loss for source to target

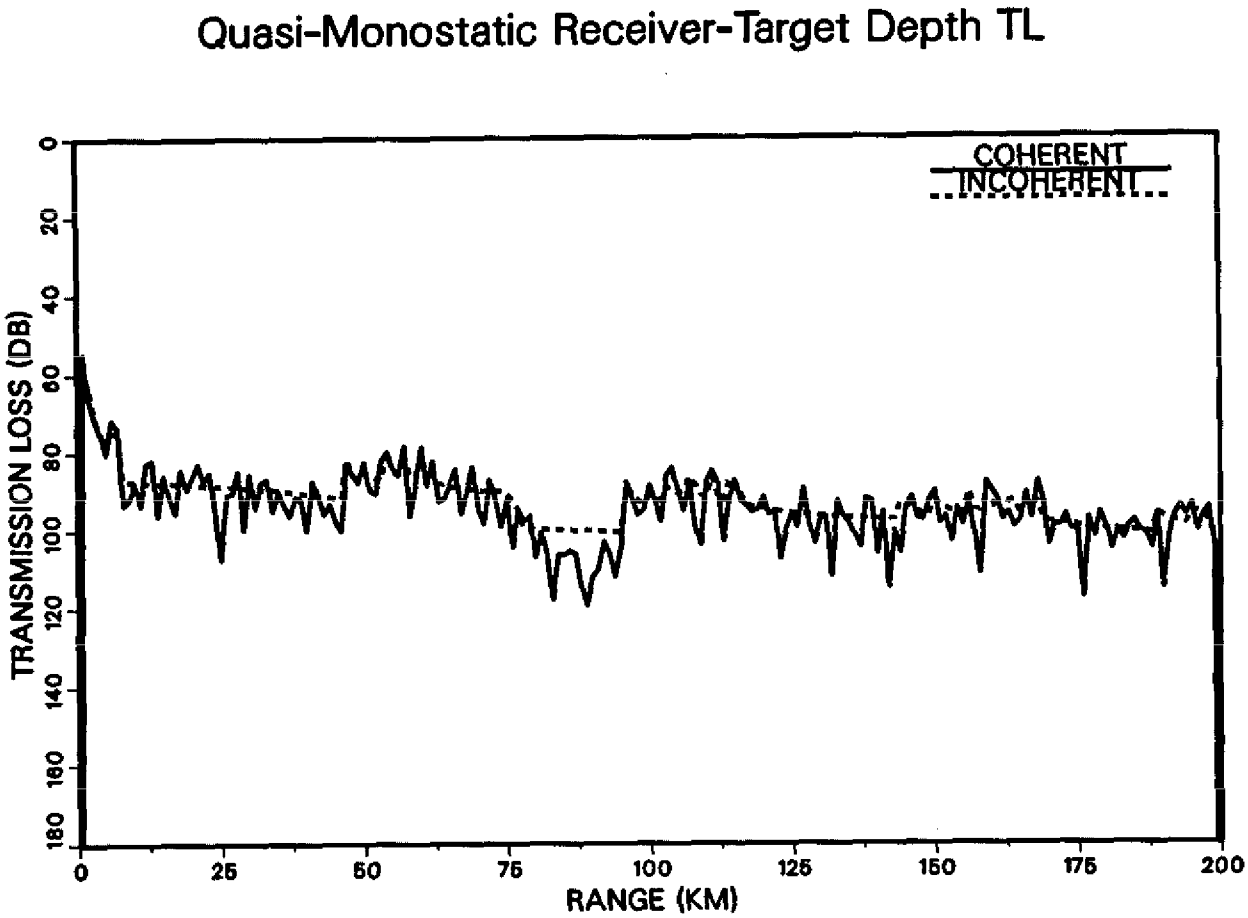

Fig. 29 – Transmission loss for receiver to target

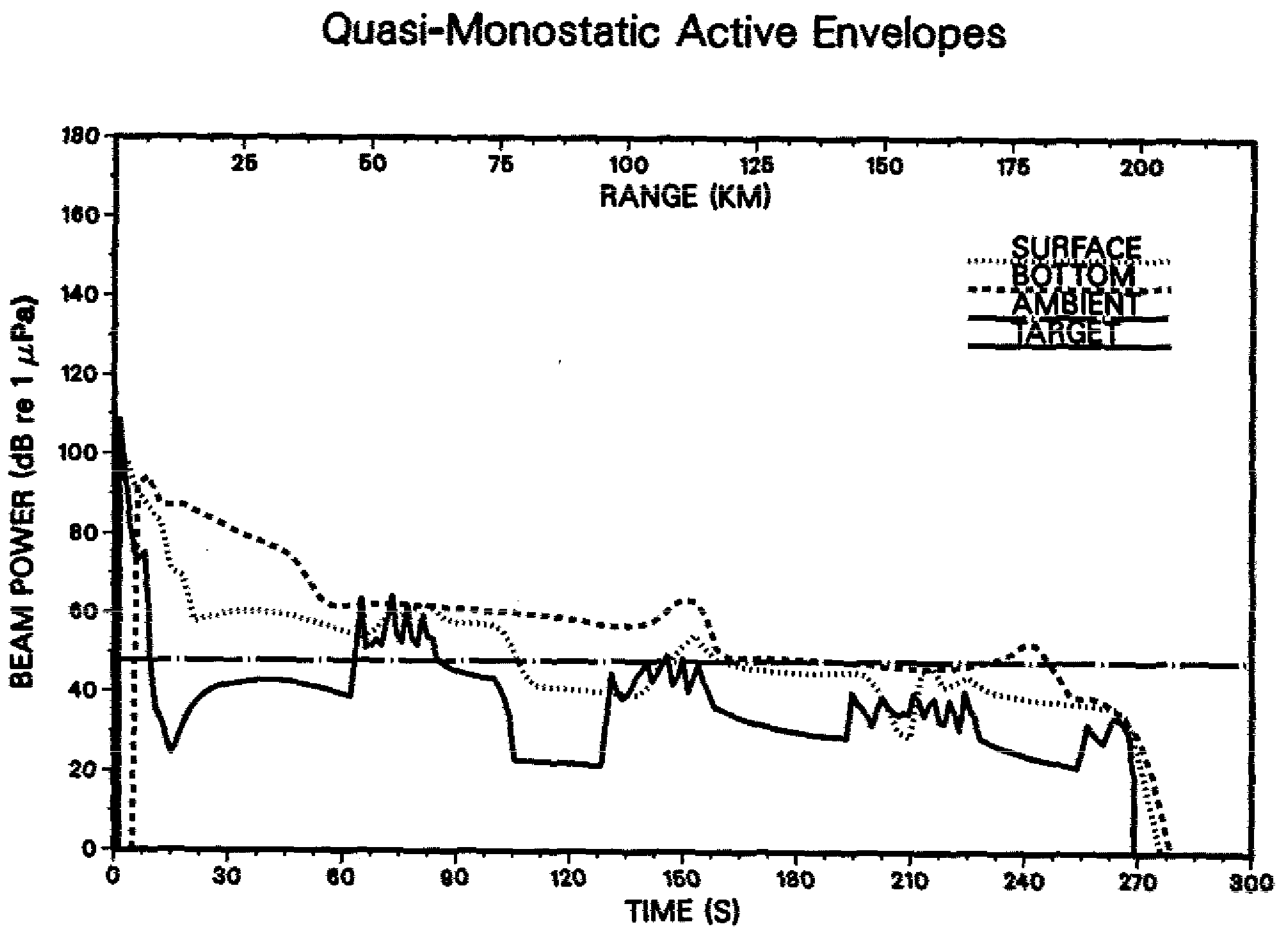

Fig. 30 – Surface and bottom reverberation levels; target echo levels vs the ambient noise

Appendix A

RASP FILENAMING CONVENTIONS

This appendix outlines the RASP filenaming convention imposed by the use of the MENU program, and describes the general content of the output files. It is important to note that the specific output filenames presented here are created automatically by the MENU program.

Three types of files are generated during a complete RASP run. These are:

1. **Print files.** These files provide a log of the important parameters used in the corresponding module. The print files are ASCII formatted and are intended for user access. They have an extension of .PNT.
2. **Data Files.** These files contain data that are passed on to the succeeding module. The data files are binary files and have a .DAT extension.
3. **Plot files.** The plot files are generated by using the DISSPLA graphic package, and their filename may be site specific. Each module produces one DISSPLA device independent metacode file. These are named PLT2.DAT in this document, with the highest version coming from the last run module. To look at these plots on a specific device, such as VT240, the PLT2.DAT file must be postprocessed. (Note: DISSPLA's postprocessor only looks at the highest version of a PLT2.DAT file. Therefore, to look at a previous version the user must either delete or rename all higher versions.) The steps to run this DISSPLA postprocessor are site specific. Check with a user consultant on how their postprocessor works.

For consistency and error reduction and to provide a more recognizable name for each file, a system has been devised for naming conventions that will have long-term value for aiding communications within a user group. The rationale is as follows:

The first two letters of each print and data filename begin with the name of the module that generated the files. That is, if a file was created in PROFIL, then the filename begins with PR. A RAYACT file would begin with RA. RTHETA, REVERB, and ACTENV would be RT, RV, and AE respectively. Typically, two to four zeros then follow, and the last two letters in the filename indicate specific information about the file. Such information includes whether the file refers to the source (S) or receiver (R) and if the data pertain to bottom (B), surface (S), or target (T) reverberation. The modules that generate only one print file, PROFIL and ACTENV, do not need the last two letters, and these spaces are filled with zeros. A typical modification used by experienced users when editing the TOTAL.COM file is to replace the zeros with the bearing measured with respect to north.

Table A1 lists the filenames of the print (.PNT) files and summarizes the contents of each file. Table A2 lists the data (.DAT) filenames, and Table A3 presents the multiple versions of the plotting (PLT2.DAT) files. Inspection of these filenames best show the simplicity of the naming convention. Of course, many other conventions could be devised, but this is the simplest and most straightforward approach. The immediate identification of each filename upon inspection reduces run set up errors and assists in communications within a user group.

Table A1 – Summary of RASP Print File Contents For Sample Execution in Section 5

Program	Print File Contents		Filename(s)
PROFIL	Bottom profile table of range and bottom depth; SVP tables(s) of depth, velocity, gradient, and curvature; information on profile connections made.	one file:	PR0000.PNT
RAYACT	For both source and receiver: range and depth; fan angle specifications table; target depth(s); bottom loss table(s); brief summary of input environment data; ray path limits; iteration parameters; ray launch angles list.	two files:	RA000S.PNT RA000R.PNT
	For both source and receiver: ray statistics (optional).	two files:	RA0STS.PNT RA0STR.PNT
RTHETA	Source and receiver each have a file for surface, bottom, and target. Each contains the input characteristics, vertical beam pattern, launch angles processed, contour information, and ray histories and events listed by ray order and family type.	six files:	RT00SS.PNT RT00SB.PNT RT00ST.PNT RT00RS.PNT RT00RB.PNT RT00RT.PNT
REVERB	For both surface and bottom: source/receiver processing information, backscattering table, signal characteristics, and reverberation level (uncalibrated) vs time.	two files:	RV000S.PNT RV000B.PNT
TLVSR	For both source path and receiver path: input information, coherent and incoherent transmission loss vs range.	two files:	TL00ST.PNT TL00RT.PNT
ACTENV	For both surface and bottom: a. signal and system parameters, b. weighting summary, c. boundary reverberant power vs time. Target echo level vs time.	one file:	AE0000.PNT

Table A2 – Summary of RASP Data File Contents For Sample Execution in Section 5

Program	Data File Name	Comments
PROFIL	PR0000.DAT	environment
RAYACT	RA00SS.DAT	source-to-surface
	RA00SB.DAT	source-to-bottom
	RA00ST.DAT	source-to-target
	RA00RS.DAT	receiver-to-target
	RA00RB.DAT	receiver-to-bottom
	RA00RT.DAT	receiver-to-target
RTHETA	RT00SS.DAT	source-to-surface
	RT00SB.DAT	source-to-bottom
	RT00ST.DAT	source-to-target
	RT00RS.DAT	receiver-to-surface
	RT00RB.DAT	receiver-to-bottom
	RT00RT.DAT	receiver-to-target
REVERB	RV000S.DAT	surface reverberation
	RV000B.DAT	bottom reverberation
TLVSR	TL00ST.DAT	source-to-target
	TL00RT.DAT	receiver-to-target

Table A3 – Summary of RASP Plot File Contents For Sample Execution in Section 5

PROFIL	PLT2.DAT;1	environment
RAYACT	PLT2.DAT;2	source
	PLT2.DAT;3	receiver
RTHETA	PLT2.DAT;4	source-to-surface
	PLT2.DAT;5	source-to-bottom
	PLT2.DAT;6	source-to-target
	PLT2.DAT;7	receiver-to-surface
	PLT2.DAT;8	receiver-to-bottom
	PLT2.DAT;9	receiver-to-target
TLVSR	PLT2.DAT;10	source-to-target
	PLT2.DAT;11	receiver-to-target
ACTENV	PLT2.DAT;12	total reverberation

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Appendix B

DESCRIPTION OF PROGRAM INPUT VARIABLES

This appendix provides a listing of the RASP program input variables, their definitions, and allowed values, as given in the order they appear when each subprogram of the model is run in stand-alone mode. As such, this glossary provides a user-oriented perspective of the available processing paths. These inputs are not actually inputs to the MENU program, but rather are variables within the RASP source code. All inputs below, other than character data, are in free field format.

In the following descriptions, a LINE represents inputs that are always to be provided; an Option represents inputs that are required only if preceeding parameters have certain values. These Option lines are always followed with information specifying the criteria for their inclusion. The references to *Default* indicates the value the program will (should) set the parameter to if a zero is input. The user is advised to treat the *Defaults* as typical values and input them.

B.1 Program PROFIL

PROFIL is a program to process sound speed profiles and bottom bathymetry. It prepares sound speed profiles and bottom bathymetry for use in subsequent programs. This is essentially a program to order environmental data, correct for Earth's curvature, interpolate between data points, calculate first- and second-order derivatives of environmental functions (storing these data on file for later use in program RAYACT), and display the data in various plot formats.

B.1.1 PROFIL *Input Variables:*

LINE 1: TITL(I), I = 1,17 — Format: 18A4

TITL = Title to be used by plotting routines for this program execution. *(Maximum of 68 characters.)*

LINE 2: PRTFIL — Format: A30

PRTFIL = Name for output print file from this execution *(Maximum of 30 characters).*

LINE 3: OUTFIL — Format: A30

OUTFIL = Name for output environmental data file *(Maximum of 30 characters).*

LINE 4: KK — Format: free

KK = Produce composite environment plot?

1 = yes
0 = no

LINE 5: KK — Format: free

KK = Produce a sound speed contours plot?
1 = yes
0 = no

LINE 6: KK — Format: free

KK = Produce plot(s) of selected profile(s)?
1 = yes
0 = no

LINE 7: BINFIL — Format: A30

BINFIL = Name of file containing the bathymetric data *(Maximum of 30 characters)*.
The data should be formatted as sequential pairs of range-depth values. *A maximum of 800 bottom points are allowed.*

LINE 8: IUBR — Format: free

IUBR = Flag for units of input bottom data.
0 for km
1 for nmi

LINE 9: PINFIL — Format: A30

PINFIL = Name of file containing the sound speed profiles *(Maximum of 30 characters)*.
The data should be formatted as sequential pairs of depth-sound-speed values (at each range). Each complete set is to be preceded by the range and number of depth values for that set. *A maximum of 100 profiles, each with a maximum of 50 points, is allowed.*

LINE 10: IUPR — Format: free

IUPR = Flag for units of input ranges of sound speed profile data.
0 for km
1 for nmi

Option A: NS, NINC, NE — Format: free
(Include when plot(s) of selected profile(s) is/are chosen.)

NS = Number of first profile to be plotted.

NINC = Increment of profiles to be plotted.

NE = Number of last profile to be plotted.

Option B: IPU Format: free

(Include when a composite environment plot OR sound speed contours plot has been requested.)

IPU = Flag for unit type of plot range axis.
0 for km.
1 for nmi.

B.1.2 PROFIL *Output:*

- Environmental information on data file OUTFIL to be used as input for program RAYACT.
- Print out on PRTFIL containing: bottom profile table of range and bottom depth; SVP tables(s) of depth, velocity, gradient, and curvature; and information on profile connections made.
- Optional (PLOTS):
  1. Sound speed profiles (linear fit) plus bathymetry.
  2. Environmental sound speed contours plus bathymetry.
  3. Individual sound speed profiles (spline fit).

B.2 Program RAYACT

RAYACT is a ray-tracing program to calculate ray-path encounters with surface, bottom, and target-depth hits associated with selected rays. Bottom loss data are entered at this stage (to reduce computations for rays with high losses). The purpose is to calculate ray paths and relevant parameters, e.g., the travel time, turning points, grazing angles, etc., from the source to the boundaries and targets. For quasi-monostatic or bistatic configurations, this must be run again from the receiver to the boundaries and targets. This information is stored on files for later use in program RTHETA.

B.2.1 RAYACT *Input variables:*

LINE 1: TCARD(I), I = 1,17 Format: 18A4

TCARD = Title to be used by plotting routines for this program execution. *(Maximum of 68 characters.)*

LINE 2: PRTFIL Format: A30

PRTFIL = Name for output print file from this program execution *(Maximum of 30 characters).*

LINE 3: KPRNT Format: free

KPRNT = Print flag indicating how much detailed ray turning point and ray statistics information is to be printed, e.g., KPRNT=10 indicates to print for every 10th ray.

This can be a very large file, and is generally produced only for diagnostic purposes.

Option A: F17FIL Format: A30

(Include when KPRNT > 0 .)

F17FIL = File name for print out of ray statistics
(Maximum of 30 characters).

LINE 4: PROFIL Format: A30

PROFIL = Input data file created by preceding PROFIL run
(Maximum of 30 characters) .
(See OUTFIL in the program PROFIL description.)

LINE 5: SDEPTH Format: free

SDEPTH = Source depth (m). Should be the center of a vertical line array.

LINE 6: TDEPTH(I) Format: free

NOTE: Unusual input structure.

TDEPTH(I) = Target depths (m), (I = 1,2,3).
0 = Indicates no targets will be processed.
> 0 Indicates to calculate for this target depth,
and read in another target depth.

Option B: *Input 0 or another target depth.* Format: free

Option C: *Input 0 or another target depth.* Format: free

A maximum of three target depths can be input.

LINE 7: RINIT, RMAX, NODUC, NBB, TMAX, BLMAX, MAXORD Format: free

RINIT = INITIAL/MIN. RNG TO SOURCE (km).

RMAX = Maximum range for calculations (km).
Default = range used in PROFIL unless $TMAX > 0$ in which case $\max(1., TMAX \times 1.7 + RINIT)$ is used.

NODUC = Use of connecting profile connections.
1 = Do not use. Program will perform horizontal interpolation of sound speed.
0 = Use profile connections for sound speed interpolation. Program will perform range interpolation of sound speed along line connections.

NBB = Maximum number of bottom reflections (< 97) before ray termination.
Default = 96.

TMAX = Maximum travel time after which a ray will be terminated (sec).
Default = $\max(10., (RMAX - RINIT)/1.3)$.

BLMAX = Maximum bottom loss that a ray is allowed to accumulate (dB).
Default = 150 dB.

MAXORD = Maximum number of boundary interactions plus turning points (< 199).
Default = 198.

LINE 8: IPARAM — Format: free

IPARAM = Do you wish to redefine default ray iteration parameters?
1 = yes
0 = no

Option D: DELMIN, DELMAX, HITDEL, VFAEPS, DELSMX — Format: free
(Include when IPARAM > 0 .)

DELMIN = Minimum allowable arc length increment (m).
Default = 20.

DELMAX = Maximum allowable arc length increment (m).
Default = 1000.

HITDEL = Vertical distance from boundary or target depth within which a ray is considered as hitting that boundary or depth (m).
Default = 0.2

VFAEPS = Minimum acceptable velocity field accuracy in interpolated values (m/sec).
Default = 0.2

DELSMX = Maximum allowable change in $\sin(\theta)$ for rays of launch angle θ near 0.0 deg (w.r.t. horizontal).
Default = 0.02

LINE 9: NAFAN — Format: free

NAFAN = Number of launch angle fans to process.
For all fans, maximum resolution = 0.1 deg.

LINE 10: ANGST, ANGINC, ANGEND — Format: free
(Repeat NAFAN times.)

ANGST = Starting launch angle (> -90 deg)
Negative values indicate upwardly launched rays.

ANGINC = Angle increment to be used to generate additional rays (an integral multiple of 0.1 deg).

ANGEND = Final launch angle (< 90 deg).
Positive values indicate downwardly launched rays.

Repeat Line 11 and Option F up to four times.
Note: Unusual Input Structure.

LINE 11: KLF, KFR, ROFTAB(j) Format: free

KLF = Bottom loss table flag.

KLF < 0 then bottom loss values will be input.

KLF = 1,2,3,4,5 according to standard FNWC bottom types (see references).

KFR = *Multipurpose.*

If KLF > 0, then KFR is the frequency (Hz) to be used in the stored tables.

If KLF < 0, then KFR is number of angle and bottom loss pairs to be input. (Maximum = 100)

ROFTAB(j) = Maximum range (km) to which this (j < 5) table of bottom loss values applies.

Option E: GRANG(i,j), DBLOSS(i,j) Format: free

(Include when KLF < 0 .)

GRANG(i,j) = Maximum grazing angle (deg from 0 to 90) corresponding to the ith entry in the jth bottom loss table.

DBLOSS(i,j) = Bottom loss (dB) corresponding to the ith angle of the jth table. $(i = 1, KFR)$

NOTE: A maximum of four tables can be input. If less than four are input, the final Line 11 must be 99,0,0 in order to signal the program that less than four tables have been input.

LINE 12: KPLT Format: free

KPLT = Plot flag for ray paths.

+n = Plot every nth ray processed between −20 and +20 deg.

−n = Plot every nth ray between an input minimum and maximum. See APLMIN and APLMAX.

0 = For no plot.

Option F: APLMIN, APLMAX, DM Format: free

(Include when KPLT is negative.)

APLMIN = Minimum angle (deg > −90) to be plotted.

If KPLT > 0 then APLMIN is automatically set to −20.

APLMAX = Maximum angle (deg < 90) to be plotted.

If KPLT > 0 then APLMAX is automatically set to 20.

DM = Maximum depth (m) of ray paths.

Default = BOTMAX (computed in program PROFIL*).*

LINE 13: IFOUT(1) Format: free

IFOUT(1) = Write surface encounters to output file?

1 = yes, save

0 = no, do not save

Option G: SRFIL — Format: A30

(Include when IFOUT(1) = 1 .)

SRFIL = File name of surface encounters
(Maximum of 30 characters).

LINE 14: IFOUT(2) — Format: free

IFOUT(2) = Write bottom encounters to output file?
1 = yes, save
0 = no, do not save

Option H: BRFIL — Format: A30

(Include when IFOUT(2) = 1 .)

BRFIL = File name of bottom encouters
(Maximum of 30 characters).

Option I: IFOUT(jj) — Format: free

REPEAT THIS LINE (and the next, if **1=YES** *is chosen) for as many target depths* (≤ 3) *that were requested at LINE 7.*

IFOUT(jj) = Flag for saving *jj*th target depth encounter data.
1 = yes, save
0 = no, do not save

Option J: TGFIL(jj) — Format: A30

(Include when IFOUT(jj) = 1 .)

TGFIL(jj) = Name of data file for storing *jj*th target depth encounters
(Maximum of 30 characters).

B.2.2 RAYACT *Output:*

- Ray calculations on data files SRFIL, BRFIL, TGFIL(jj) for input to program RTHETA.
- Print out on PRTFIL containing for source or receiver: range and depth; fan angle specifications table; target depth(s); bottom loss table(s); brief summary of input environment data; ray path limits; iteration parameters; ray launch angles list.
- Optional:
  1. Ray statistics printed on F17FIL.
  2. Plot of ray paths in range, depth.

B.3 Program RTHETA

RTHETA is a program to reformat ray information from RAYACT, to determine the presence of caustics, and subsequently to apply the wave-theoretic correction (if requested). This program also weights the rays according to source and receiver beam patterns, calculates attenuation, and finally computes ray amplitudes and phases. Specifically it forms range/source-angle (order contour) curves corresponding to either surface ($z = 0$) or bottom encounters, or arrivals at predetermined depth. Transmission loss (corrected for vertical beam patterns) is calculated by using both ray-bundle (with caustic correction) and spatial averaging techniques. The $R(\theta, \rho)$ curves, together with one type of transmission loss estimate, are stored on an output file for further processing (by REVERB and/or TLVSR).

B.3.1 RTHETA *Input Variables:*

LINE 1: TITL(I), I = 1,17 — Format: 18A4

TITL = Title to be used by plotting routines for this program execution. *(Maximum of 68 characters.)*

LINE 2: IFPNT — Format: free

IFPNT = Want full RTHETA contour print file?
1 = yes
2 = no

LINE 3: PRTFIL — Format: A30

PRTFIL = Name for output print file from this program execution. *Maximum of 30 characters.*

LINE 4: INFILE — Format: A30

INFILE = Input data file created by preceding RAYACT run. *Maximum of 30 characters.*
See SRFIL, BRFIL, TGFIL(jj) of RAYACT program description.

LINE 5: KPLT — Format: free

KPLT = Produce plot of the order contours?
1 = yes
0 = no

Option A: RNGAX, RMIN, RSTEP, RMAX — Format: free
(Include when KPLT = 1 .)

RNGAX = Length of range axis (inches).

RMIN = Minimum range on plot axis (km).

RSTEP = Range increment on plot axis (km).

RMAX = Maximum range on plot axis (km).

Option B: ANGAX, ANGMN, ASTEP, ANGMX — Format: free
(Include when KPLT=1 .)

ANGAX = Length of launch angle axis (inches).

LINE 2: INFILE Format: A30

INFILE = Name of input data file created by preceding RTHETA run.
(Maximum of 30 characters.)

LINE 3: RGMN, DRG, RGMX Format: free

RGMN = Minimum range (km) for computations.

DRG = Range increment (km).

RGMX = Maximum range (km) for computations.
Default = 10000. if DRG=0.

LINE 4: IFARR Format: free

IFARR = Flag indicating that vertical arrival structure is to be computed (up to 100 angles can be considered).
0 = no
1 = yes

Option A: NAA Format: free
(Include when IFARR > 0 .)

NAA = Maximum number of arrivals to be found.
$1 \leq NAA \leq 48$

LINE 5: PRTFIL Format: A30

PRTFIL = Name of output print file.
(Maximum of 30 characters.)

LINE 6: IFPLT Format: free

IFPLT = Produce plot of transmission loss vs range?
0 = no
1 = yes

Option B: XAXIS, RGMN, DX, RGMX Format: free
(Include when IFPLT > 0 .)

XAXIS = Length of horizontal range axis of plot (inches).
Default = 10.

RGMN = Minimum range of plot (km).
Default = 0.

DX = Range increment for plot labels (km/in).
Default = automatic scaling.

RGMX = maximum range of plot (km).
Default = maximum range of computations.

Option C: YAXIS, TLMIN, DBINC, TLMAX — Format: free

(Include when IFPLT > 0 .)

YAXIS = Length of vertical plot axis (inches < 8.0).
Default = program computes.

TLMIN = Minimum transmission loss (dB) for top of plot.
Default = program computes minimum.

DBINC = Transmission loss label increment (dB/in) for plot.
Default = automatic scaling.

TLMAX = Maximum transmission loss (dB) for bottom of plot.
Default = computes maximum TL.

LINE 7: IFOUT — Format: free

IFOUT = Flag indicating that output will be stored on file.
0 = no
1 = yes

Option D: OUTFIL — Format: A30

(Include when IFOUT > 0 .)

OUTFIL = Name of output data file.
(Maximum of 30 characters.)
For use in subsequent ACTENV program.

B.4.2 TLVSR *Output:*

- Optional:
  1. Transmission loss computations on data file OUTFIL to be used as input for program ACTENV.
  2. Printout on PRTFIL containing: input information, coherent and incoherent transmission loss vs range.
  3. Plot of transmission loss vs range at specified surfaces and target depths.

B.5 Program REVERB

REVERB is a program to calculate reverberation and echo levels as a function of time or launch angle. Surface scattering is computed here. The program estimates monostatic, quasi-monostatic, or range-independent bistatic boundary reverberation as a function of time, and optionally the vertical-angle distribution of received reverberation. The program stores results on output files for further processing (e.g., for the scaling and plotting performed by program ACTENV).

B.5.1 REVERB *Input Variables:*

LINE 1: TITL(I), I = 1,17 — Format: 18A4

TITL = Title to be put in print file for this program execution. *(Maximum of 68 characters.)*

LINE 2: PRTFIL — Format: A30

PRTFIL = Name of output print file from this execution. *(Maximum of 30 characters.)*

LINE 3: KEY — Format: free

KEY = Type of reverberation geometry.

1 = Monostatic – *Source/Receiver arrays should be identical.*

2 = Quasi-monostatic

3 = Bistatic – *Environment should be range-independent.*

LINE 4: MXHITS — Format: free

MXHITS = Maximum allowed number of selected boundary (i.e., surface or bottom) encounters by any ray path emanating from the source (≤ 48).

Default = 48

Option A: MXHITR — Format: free

(Include when KEY $\geq$ 2 .)

MXHITR = Same as MXHITS except relates to the receiver (≤ 48).

Default = 48

LINE 5: NVERT — Format: free

NVERT = Flag which when nonzero indicates that the vertical-angle distribution of received reverberation is to be calculated.

< 0 Angular distribution to be calculated at equally-spaced times (See Option C.2).

> 0 Times for which angular distribution calculated are to be individually specified (See Option C.1).

$= 0$ No vertical distribution is calculated.

Option B: THETA1, DTHETA, THETA2 — Format: free

(Include when NVERT $\neq$ 0.)

THETA1 = Minimum vertical receiving-angle (deg w.r.t. horizontal) for which vertical-angle distribution of reverberation is to be calculated.

Negative angles indicate upward rays.

DTHETA = Incremental angle (degs).

THETA2 = Maximum angle (degs).

Note: Switching source and receiver files converts this to launch angle structure of the reverberation.

OptionC.1: VERTTI(I), I = 1,NVERT — Format: free

(Include when NVERT > 0.)

VERTTI(I) = Time (sec) at which angular distribution of reverberation is to be calculated.

OptionC.2: TVERT1, DTVERT, TVERT2 — Format: free

(Include when NVERT < 0.)

TVERT1 = Initial time (sec) at which angular distribution of reverberation is to be calculated.

DTVERT = Incremental time (sec).

TVERT2 = Final time (sec).

LINE 6: RMINR, DR, RMAXR — Format: free

RMINR = Minimum horizontal range (km from receiver) at which reverberation will be calculated.

DR = Incremental range (km). Size of boundary-scattering elements should be approximately $C \times DUR/2$. See Line 7.

RMAXR = Maximum horizontal range (km from receiver) at which reverberation is calculated.

Option D: RMINS, RMAXS — Format: free

(Include when KEY = 3 = Bistatic Run.)

RMINS = Minimum horizontal range (km from source) at which reverberation is calculated.

Must satisfy $|RMINR - RMINS| = (m + 1/2)DR$
where m is a nonnegative integer, e.g., RMINS = 0, RMINR = DR/2.

RMAXS = Maximum horizontal range (km from source) at which reverberation is calculated.

Option E: SEP — Format: free

(Include when KEY = 3 = Bistatic Run.)

SEP = Source-receiver horizontal-range separation (km).

Must satisfy $SEP = n \times DR$ where n is a positive integer.

LINE 7: DUR — Format: free

DUR = CW pulse duration (sec). If an HFM is to be processed by ACTENV, then set to the inverse of the bandwidth. See IPING in ACTENV input description.

LINE 8: T1, DT, T2 — Format: free

T1 = Initial time (sec) for which reverberation envelope is calculated.

DT = Incremental time (sec). Recommend $DT < DUR/2$. Note that $DT > DUR$ acts as a time averaging window.

T2 = Final time (sec).

LINE 9: INFILE Format: A30

INFILE = Name of input data file created by program RTHETA which corresponds to receiver rays.
(Maximum of 30 characters.)

Note: The file will specify the type of boundary generating the reverberation.

Include lines F – G.2 when processing SURFACE reverberation.

Option F: KSCAT Format: free

KSCAT = flag indicating type of surface backscattering model to be used.
0 = Table of backscattering models to be read in.
1 = Chapman-Harris scattering function used.

OptionG.1: SIG(I) Format: free
(Include when KSCAT = 0 .)

SIG(I) = Boundary backscattering strength (in dB $\leq$ 0) at grazing angle I−1 deg (I = 1,91).

OptionG.2: SSO, SS, WS, WH Format: free
(Include when KSCAT = 1 .)

SSO = Backscattering strength (dB) at 0 deg grazing angle used to interpolate between 0 and 1 deg.
Default = −100 dB.

SS = Sea state. Ignored if WS > 0.

WS = Wind speed (kt).
Default = 15 if SS $\leq$ 0 and WH $\leq$ 0.
Default = 5×SS if SS > 0.
Default = (WH/.0026)**2/5 if SS $\leq$ 0 and WH > 0.

WH = Crest-to-trough wave height (ft).
Ignored if WS > 0 or SS > 0.

Include lines H – J.2 when processing BOTTOM reverberation.

Option H: NSCAT Format: free

NSCAT = Number of bottom backscatter models to be used.

NOTE: Repeat lines I – J.2 NSCAT times.

Option I: KSCAT(I),RANGE(I) Format: free

KSCAT(I) = flag indicating type of bottom backscattering model to be used.

0 = Table of backscattering models to be read in.
1 = Lambert's Law used.
2 = URICK ROCK bottom data used.
3 = URICK SAND bottom data used.
4 = URICK SILT bottom data used.
5 = URICK CLAY bottom data used.

RANGE(I) = Maximum range (km) to which this ($I \leq NSCAT$) bottom backscatter model applies.

Option J.1: SIG(I) Format: free

(Include when KSCAT = 0 .)

SIG(I) = Boundary backscattering strength (in dB ≤ 0) at grazing angle I−1 deg (I = 1,91).

Option J.2: SSO, SS Format: free

(Include when KSCAT = 1 .)

SSO = Backscattering strength (dB) at 0 deg grazing angle used to interpolate between 0 and 1 deg.

Default = −100 dB.

SS = Constant term of Lambert's Law model where scattering strength $= SS + 20\ \log_{10} \sin(\text{average grazing angle})$.

Default = −29 dB = MacKenzie's value.

Option K: INFILE Format: free

(Include when Key = 2 = Quasi-monostatic.)

INFILE = Name of input data file created by program RTHETA which corresponds to source rays.
(Maximum of 30 characters.)

LINE 10: IFOUT Format: free

IFOUT = Write results to output file?

1 = yes, save
0 = no, do not save results.

Option L: OUTFIL Format: A30

(Include when IFOUT > 0 .)

OUTFIL = name of output data file for storing reverberation envelope to be used in program ACTENV.
(Maximum of 30 characters.)

Option M: ANGOUT Format: A30

(Include when IFOUT > 0 and NVERT not equal to 0 .)

ANGOUT = name of output data file for storing vertical-angle distribution of received reverberation.
(Maximum of 30 characters.)

Note: Currently, no program is provided with the EXPORT version of RASP to use this file.

B.5.2 REVERB *Output:*

- Printout on PRTFIL containing: source/receiver processing information, backscattering table, signal characteristics, reverberation level (uncalibrated) vs time, and angular distribution.
- Calculation of reverberation envelope on data file OUTFIL for use by program ACTENV.
- Calculation of angular distribution of received reverberation on data file ANGOUT.

B.6 Program ACTENV

ACTENV is a program that summarizes the performance envelope of the acoustic systems operating charactersitics. Expressing beam power as a function of range or time, ACTENV will scale and plot the surface and bottom reverberation, ocean ambient noise, and target echo envelopes. Different reverberation envelopes can be combined in a weighted average to produce a composite level. Alternatively, envelopes can be time-averaged to more accurately represent system characteristics. Source and receiver array properties, boundary spectral spreading, and processing parameters are some of the more important input requirements.

B.6.1 ACTENV *Inputs:*

LINE 1: TITL(I), I = 1,17 — Format: 18A4

TITL = Title to be used by plotting routines for this program execution.
(Maximum of 68 characters.)

LINE 2: PRTFIL — Format: A30

PRTFIL = Name of output print file.
(Maximum of 30 characters.)

LINE 3: IPING — Format: free

IPING = Ping type

1 = Gated-CW

2 = Impulsive

1 = FM – See DUR in program REVERB.

Option A: DUR — Format: free

(Include when IPING = 1 or IPING = 3 .)

DUR = Ping duration (sec).

Option B: BW Format: free

(Include when IPING = 2 or IPING = 3 .)

BW = Bandwidth (Hz).
For impulsive (IPING=2) this is the analysis bandwidth.
For FM (IPING=3) this is the pulse's bandwidth, assumed to be the analysis bandwidth.

LINE 4: TMIN, TMAX Format: free

TMIN = Minimum time (seconds after transmission) for which envelopes will be calculated.

Default = 0.

TMAX = Maximum time (sec) for which envelopes will be calculated.

Default = 100000.

LINE 5: SLE, ELN, ANL, RDI Format: free

SLE = Source level per element (dB).

– *must be input.*

ELN = Number of source elements. Should correspond with number of elements used to create beam pattern in RTHETA. The total source level is calculated in dB using $SL = SLE + 20\ \log_{10}(ELN)$.

ANL = Omnidirectional ambient noise level (dB/Hz).

RDI = Horizontal receiver directivity index (dB). Sould be zero for omnidirectional and vertical array receivers. For fully-populated, unshaded linear arrays with N elements, $RDI \approx 10 * \log_{10}(N)$.

LINE 6: TAXIS, TMN, DT, TMX Format: free

TAXIS = Length (inches) of time axis of plot (≤ 10).

Default = (TMX− TMN)×.05

TMN = Start time (sec) for plot of envelope.

Default = TMIN (see LINE 4).

DT = Time increments (sec/inch) of plot labels.

Default = automatic scaling.

TMX = End time (sec) for plot of envelope.

Default = TMAX (see LINE 4).

LINE 7: ZAXIS, ZMIN, DZ, ZMAX Format: free

ZAXIS = Length (inches) of envelope axis of plot. (≤ 8)

Default = computed by program.

ZMIN = Minimum power (dB) plotted.

Default = computed by program.

DZ = dB labels per inch on plot.

Default = automatic scaling.

ZMAX = Maximum power (dB) plotted.
Default = computed by program.

LINE 8: NOREV, IFWGT — Format: free

NOREV = Number of surface reverberation envelopes to be read in.
Data files are generated by program REVERB.

IFWGT = Flag indicating that envelopes will have nonuniform weightings.
Default = 0.

FOR SURFACE REVERBERATION, REPEAT LINE(S) C and D NOREV TIMES.

Option C: REVFIL — Format: A30
(Include when NOREV > 0 for surface reverberation files.)

REVFIL = Name of input surface reverberation data file.
(Maximum of 30 characters.)
See file ENVOUT created by previous REVERB run.

Option D: WGTT — Format: free
(Include when IFWGT > 0.)

WGTT = Weight for this surface reverberation envelope.

LINE 9: NOREV, IFWGT — Format: free

NOREV = Number of bottom reverberation envelopes to be read in.
Data files are generated by program REVERB.

IFWGT = Flag indicating that envelopes will have nonuniform weightings.
Default = 0.

FOR BOTTOM REVERBERATION, REPEAT LINE(S) E and F NOREV TIMES.

Option E: REVFIL — Format: A30
(Include when NOREV > 0 for bottom reverberation files.)

REVFIL = Name of input bottom reverberation data file.
(Maximum of 30 characters.)
See file ENVOUT created by previous REVERB run.

Option F: WGTT — Format: free
(Include when IFWGT > 0 .)

WGTT = Weight for this bottom reverberation envelope.

LINE 10: IFECHO — Format: free

IFECHO = Flag indicating that target echo levels are to be computed.
Default = 0.

Option G: TRLFIL — Format: A30

(Include when IFECHO > 0 .)

TRLFIL = File name for transmission loss from target to receiver.
(Maximum of 30 characters.)

Option H: LSTAPE — Format: free

(Include when IFECHO > 0 .)

LSTAPE = Flag indicating that additional file must be read in for transmission loss from source to target.
Default = 0.
Note: Needed for quasi-monostatic or bistatic configuration.

Option I: TSLFIL — Format: A30

(Include when LSTAPE > 0 .)

TSLFIL = File name for transmission loss from source to target.
(Maximum of 30 characters.)

Option J: SEP — Format: free

(Include when IFECHO > 0 .)

SEP = Horizontal range (km) from source to receiver.
Default = 0.

Option K: BRG — Format: free

(Include when IFECHO > 0 .)

BRG = Target bearing (deg) relative to receiver (see Fig. 15.)
Default = 0.

LINE 11: TGTS — Format: free

(Include when IFECHO > 0 .)

TGTS = Target strength (dB/m^2).

B.6.2 ACTENV *Output:*

- Printout on PRTFIL containing: signal and system parameters; weighting summary; surface and bottom boundary reverberant power vs time; and target echo level vs time.
- Plots:
  1. Bottom and surface reverberation envelopes as function of time or range.
  2. Target echo levels as function of time or range.

Appendix C

DESCRIPTION OF RASP DISTRIBUTION TAPE

C.1 INTRODUCTION

The RASP distribution package comprises this document and one 9-track, 1600 BPI magnetic tape containing all RASP and MENU code, sample inputs and outputs, and command files for compiling and linking the code in a VAX/VMS environment. This appendix describes the contents and format of the tape in detail, and provides guidelines for installing RASP on a VAX or MicroVAX system.

The distribution package is intended primarily to support VAX users who have CA-DISSPLA graphics capability; however, the package can be useful to other users as well. The tape is written in ASCII "card image" format to provide a readable image for a wide variety of computer systems. Note that program MENU may be of minimal utility in non-VAX environments. Furthermore, RASP graphics are generated by using the CA-DISSPLA plotting package (Version 10.5 or higher) to create metafiles that are to be plotted at a later time by using the DISSPLA postprocessing facility. To support users who do not have DISSPLA, the tape includes a file (DSPLSTUB.FOR) that contains stubs for all the DISSPLA routines, i.e., at link time, DSPLSTUB will satisfy all external references generated by DISSPLA calls in the RASP code. Users of DSPLSTUB will, of course, be unable to produce graphics; however, the print files created by each RASP program will be available.

C.2 DISTRIBUTION TAPE CONTENTS

The RASP distribution tape includes 13 files: eight contain FORTRAN code representing the EXPORT version of RASP (six stand-alone programs) plus the preprocessor program MENU and the DISSPLA stubs file, one contains sample input data, one contains sample output print files, and three contain VAX command files for compiling and linking the RASP and MENU codes. Table C1 identifies each file in order of occurrence on the tape. Note that the file names are not on the tape; these are the recommended names to be used when creating disk files from the tape.

C.2.1 Sample Data Files

File SAMPLIN.DAT contains four individual input files that were used to generate the seven individual output data files found in file SAMPLOUT.DAT, as well as to produce the sample MENU and RASP executions presented in this document. Individual files have been concatenated into a single file of inputs and a single file of outputs to simplify the reading of the distribution tape. Once these data files have been copied from tape to disk, the individual files (which are clearly delineated with internal comments) can be created by using any ASCII text editor. These files

Table C1 – Inventory of Files on Distribution Tape in Order of Occurrence

Tape File Number	File Name	Description
1	DSPLSTUB.FOR	A series of FORTRAN subroutine stubs and function stubs with the names of the DISSPLA routines that are referenced by RASP code. Subroutines perform an immediate return. Functions assign a function value of 1, then return. This file serves as a substitute for the CA-DISSPLA graphics library to allow RASP executions in the absence of DISSPLA.
2	ACTENV.FOR	FORTRAN code for RASP program ACTENV.
3	MENU.FOR	FORTRAN code for the RASP preprocessor program MENU. MENU produces a VAX command file suitable for running RASP; non-VAX users will not be able to apply outputs from MENU without system-specific editing.
4	PROFIL.FOR	FORTRAN code for RASP program PROFIL.
5	RAYACT.FOR	FORTRAN code for RASP program RAYACT.
6	REVERB.FOR	FORTRAN code for RASP program REVERB.
7	RTHETA.FOR	FORTRAN code for RASP program RTHETA.
8	TLVSR.FOR	FORTRAN code for RASP program TLVSR.
9	SAMPLIN.DAT	Sample input data (see Section C.2.1 below).
10	SAMPLOUT.DAT	Sample output data (see Section C.2.1 below).
11	RASPDISS.COM	VAX command file for compiling and linking each RASP program (plus MENU) by using the DISSPLA object libraries. The contents of this file are site specific; the user will have to modify this file to "point" to the DISSPLA object libraries (if available) on the host VAX. This file is useful to VAX users only.
12	RASPNODP.COM	VAX command file for compiling and linking each RASP program (plus MENU) by using the DISSPLA stubs in file DSPLSTUB.FOR as a substitute for the actual DISSPLA object library files. This file is useful to VAX users only.
13	RASPSHAR.COM	VAX command file for compiling and linking each RASP program (plus MENU) by using DISSPLA as a shareable image. The contents of this file are site specific; the user will have to modify this file to "point" to the DISSPLA shareable image (if available) on the host VAX. This file is useful to VAX users only.

Table C2 – Inventory of Sample Print Files Contained in File SAMPLOUT.DAT

Ordinal	File Name	Description (see Appendix A, Table A1 for more details)
1	SMAE0000.PNT	ACTENV print file.
2	SMPR0000.PNT	PROFIL print file.
3	SMRA000S.PNT	RAYACT print file for source raytraces.
4	SMRA0STS.PNT	RAYACT statistics print file for source raytraces.
5	SMRT00ST.PNT	RTHETA print file for source to target rays.
6	SMRV000S.PNT	REVERB print file for surface reverb.
7	SMTL00ST.PNT	TLVSR print file for source to target transmission loss.

are included on the distribution package tape to assist the user in verifying any new installation of the RASP code.

C.2.2 Sample Input Files

The recommended names for the four files, in order of occurrence within SAMPLIN.DAT, are B0000.PRO, S0000.PRO, MENU-QM.INP, and SMPLTOTL.COM. B0000.PRO and S0000.PRO represent the bottom depth profile and sound speed profiles, respectively, as displayed in Figs. 9(a) and 9(b) of this document. These are inputs to the RASP program PROFIL. File MENU-QM.INP (MENU-Quasi-Monostatic.INPut) contains all user responses for the interactive MENU run appearing in this document. SMPLTOTL.COM (SaMPLe-TOTaL.COMmand) is the output file obtained from running MENU with inputs supplied by MENU-QM.INP. It should be equivalent to the sample TOTAL.COM file presented in this document (except for directory names).

C.2.3 Sample Output Files

File SAMPLOUT.DAT contains a series of seven sample print files generated by running RASP with the input stream contained in SMPLTOTL.COM. As with SAMPLIN.DAT, these files are included to assist the user in verifying any new installation of the RASP code, and they have been concatenated into a single file to simplify the reading of the distribution tape. Individual files within SAMPLOUT.DAT are clearly delineated with internal comments. These seven files do not represent a complete set of print files generated by the sample run, but they are sufficient to provide confidence in the integrity of any new RASP installation by comparing them to newly created corresponding print files at the user's site. The recommended names for the seven files, in order of occurrence within SAMPLOUT.DAT are given in Table C2. File names are formed by placing "SM" (SaMple) before the standard RASP print file names.

C.3 DISTRIBUTION TAPE FORMAT

The distribution tape is formatted as a 9-track, 1600 BPI, unlabeled tape containing one line of ASCII characters per record and one record per block. All lines are padded with blanks to a fixed length of 80 characters. There are no internal line terminators, and no internal file names. Files are delineated by a single EOF, with two consecutive EOFs following the last file. This format was selected because of its generic, system-independent nature. The tape should present minimal problems when it is read on any compatible tape drive.

C.3.1 Creation of the Distribution Tape

This section describes the steps followed to create the RASP distribution tape. Although this information should not affect the user directly, it is included here for documentation purposes and to supplement the discussions on tape format and content.

The distribution tape was generated at NRL on a VAX Model 6310 in a three-step procedure. In step one, file MK_FIXED.FDL (MaKe-FIXED-length.File-Definition-Language) was created (via a text editor) containing input directives for the VMS CONVERT utility. MK_FIXED.FDL instructs CONVERT to output 80-character fixed-length records with no line terminator characters. The contents of MK_FIXED.FDL follow:

```
RECORD
        BLOCK_SPAN                  no
        CARRIAGE_CONTROL            none
        FORMAT                      fixed
        SIZE                        80
```

In step two, CONVERT was used with MK_FIXED.FDL as input to create a new set of files having the desired format for tape-resident files. The new files were given the extension .FIX in reference to their fixed, 80-character record length. The syntax used to create these files on the VAX follows. The "pad" directive tells CONVERT to use blanks (decimal ASCII character number 32) to fill records to 80 characters.

```
$ convert/fdl=mk_fixed/pad=%d32 DSPLSTUB.FOR DSPLSTUB.FIX
$ convert/fdl=mk_fixed/pad=%d32 ACTENV.FOR ACTENV.FIX
$ convert/fdl=mk_fixed/pad=%d32 MENU.FOR MENU.FIX
$ convert/fdl=mk_fixed/pad=%d32 PROFIL.FOR PROFIL.FIX
$ convert/fdl=mk_fixed/pad=%d32 RAYACT.FOR RAYACT.FIX
$ convert/fdl=mk_fixed/pad=%d32 REVERB.FOR REVERB.FIX
$ convert/fdl=mk_fixed/pad=%d32 RTHETA.FOR RTHETA.FIX
$ convert/fdl=mk_fixed/pad=%d32 TLVSR.FOR TLVSR.FIX
$ convert/fdl=mk_fixed/pad=%d32 SAMPLIN.DAT SAMPLIN.FIX
$ convert/fdl=mk_fixed/pad=%d32 SAMPLOUT.DAT SAMPLOUT.FIX
$ convert/fdl=mk_fixed/pad=%d32 RASPDISS.COM RASPDISS.FIX
$ convert/fdl=mk_fixed/pad=%d32 RASPNODP.COM RASPNODP.FIX
$ convert/fdl=mk_fixed/pad=%d32 RASPSHAR.COM RASPSHAR.FIX
```

In step three, a tape was mounted on the VAX and all the .FIX files were copied to it with a single COPY command as follows:

```
$ TUID:==MUA0:
$ mount/for/rec=80/block=80/nohdr/nolab/dens=1600 TUID
$ copy DSPLSTUB.FIX,-
       ACTENV.FIX,MENU.FIX,PROFIL.FIX,RAYACT.FIX,-
       REVERB.FIX,RTHETA.FIX,TLVSR.FIX,-
       SAMPLIN.FIX,SAMPLOUT.FIX,-
       RASPDISS.FIX,RASPNODP.FIX,RASPSHAR.FIX  TUID
```

C.4 INSTALLING RASP ON A VAX

The procedure for installing RASP from the distribution tape is basically the inverse of the procedure used to create the tape. The steps outlined here assume that all files and all executions will be performed in a single directory. Users can establish their own directory structure and move files as desired after these steps are complete. The TOTAL.COM file produced by MENU allows for the data files and executable files to reside in separate directories.

First the user must login to the VAX and move to a directory that will initially contain all the RASP files. Mount the tape and copy all files into that directory with a series of COPY commands as follows:

```
$ TUID:==[tape unit identifier, e.g., "MUA0:"]
$ mount/for/rec=80/block=80/nohdr/nolab/dens=1600 TUID
$ copy TUID DSPLSTUB.FIX
$ copy TUID ACTENV.FIX
$ copy TUID MENU.FIX
$ copy TUID PROFIL.FIX
$ copy TUID RAYACT.FIX
$ copy TUID REVERB.FIX
$ copy TUID RTHETA.FIX
$ copy TUID TLVSR.FIX
$ copy TUID SAMPLIN.FIX
$ copy TUID SAMPLOUT.FIX
$ copy TUID RASPDISS.FIX
$ copy TUID RASPNODP.FIX
$ copy TUID RASPSHAR.FIX
```

All files with the extension .FIX have 80-character fixed-length records. These should be converted to a variable length record format by using the following procedure: Use a text editor to create a file definition language file called RM_FIXED.FDL containing the following syntax:

```
RECORD
        BLOCK_SPAN               yes
        CARRIAGE_CONTROL         carriage_return
        FORMAT                   variable
        SIZE                     0
```

Then, use RM_FIXED.FDL as input to the VAX CONVERT utility to create at new set of variable length record files from the fixed-length record files. The following syntax is recommended:

```
$ convert/fdl=rm_fixed DSPLSTUB.FIX DSPLSTUB.FOR
$ convert/fdl=rm_fixed ACTENV.FIX ACTENV.FOR
$ convert/fdl=rm_fixed MENU.FIX MENU.FOR
$ convert/fdl=rm_fixed PROFIL.FIX PROFIL.FOR
$ convert/fdl=rm_fixed RAYACT.FIX RAYACT.FOR
$ convert/fdl=rm_fixed REVERB.FIX REVERB.FOR
$ convert/fdl=rm_fixed RTHETA.FIX RTHETA.FOR
$ convert/fdl=rm_fixed TLVSR.FIX TLVSR.FOR
$ convert/fdl=rm_fixed SAMPLIN.FIX SAMPLIN.DAT
$ convert/fdl=rm_fixed SAMPLOUT.FIX SAMPLOUT.DAT
$ convert/fdl=rm_fixed RASPDISS.FIX RASPDISS.COM
$ convert/fdl=rm_fixed RASPNODP.FIX RASPNODP.COM
$ convert/fdl=rm_fixed RASPSHAR.FIX RASPSHAR.COM
```

Following this conversion to variable length record files, all .FIX files can be deleted.

C.4.1 Compiling and Linking

Files RASPDISS.COM, RASPSHAR.COM, and RASPNODP.COM assist the user in compiling and linking RASP by (1) using DISSPLA object libraries, (2) using the DISSPLA shareable image, and (3) using no DISSPLA capability, respectively. The following RASP programs use DISSPLA: ACTENV, PROFIL, RAYACT, RTHETA, and TLVSR.

Linking any FORTRAN applications program with DISSPLA is a highly site-specific procedure. In general, any VAX site that has DISSPLA is likely to have established, in-house linking procedures. These procedures depend on how and where DISSPLA was installed on a particular system and, therefore, are not items addressed in the DISSPLA User's Manual. Users who are uncertain about how to link RASP with the DISSPLA libraries should seek specific advice and instructions from the site system manager.

This appendix provides only broad guidelines concerning linking with DISSPLA. The form in which DISSPLA is installed at a specific site must be considered. This installation can consist of conventional object libraries accessed at link time and/or as a shareable image which would be accessed by RASP at run time. Using the shareable image results in much smaller executable files. Files RASPDISS.COM and RASPSHAR.COM may prove helpful in linking to the DISSPLA package at the user's site, although they are very general in nature. At best, these files will require tailoring to accommodate site-specific library names and paths. Both files contain self-documenting comments to guide the user in supplying this information. If the linking procedure is already established at the user's site, these files can be ignored.

For users who do not have DISSPLA on their system, file RASPNODP.COM should provide the appropriate VAX/VMS commands to successfully compile and link all the RASP programs, including MENU. Execute RASPNODP.COM in the directory containing all the FORTRAN files from the distribution tape with the following command:

```
$ @RASPNODP .
```

This will produce seven executable files (with file name extension .EXE) that represent the complete EXPORT version of RASP, including the MENU pre-processor. By using RASPNODP.COM, subroutines and functions in file DSPLSTUB.FOR are supplied to satisfy external references generated by calls to DISSPLA routines. The code in DSPLSTUB.FOR performs no meaningful function other than to allow linking in the absence of the actual DISSPLA package.

C.4.2 Verifying The RASP Installation

After all seven executable files have been created, the code should be test executed to yield some degree of confidence in the new product. Files SAMPLIN.DAT and SAMPLOUT.DAT are provided on the distribution tape to assist the user in testing and verifying output generated by a new RASP installation. Both tape files contain a series of files for this purpose as described in Sections C.2.2 and C.2.3.

Test MENU as follows using file MENU-QM.INP for input (to avoid making extensive keyboard entries):

```
$ RUN MENU/INPUT=MENU-QM.INP/OUTPUT=MENURUN.LOG .
```

The output from this MENU run will be a file named TOTAL.COM. This VAX command file contains all VMS commands and user inputs to drive RASP through a quasi-monostatic scenario, generating all available plots and most of the available print files. This TOTAL.COM file should be identical to file SMPLTOTL.COM found in SAMPLIN.DAT; it should also be equivalent to the TOTAL.COM file documented in this appendix (except for directory names). File MENURUN.LOG will contain the prompts issued by MENU during the run.

The RASP code can be tested by using the TOTAL.COM file created in the preceding step. First, assure that the two environmental input data files, B0000.PRO and S0000.PRO have been extracted from SAMPLIN.DAT and reside in the default directory named on the first line of TOTAL.COM. These two files are inputs to the RASP program PROFIL. Next, start the RASP run with the following command:

```
$ @TOTAL .
```

The typical run time for this scenario is approximately 5 minutes on a VAX Model 6310, depending on the system usage at the time of execution. Following the run, the user should find in the default directory a series of print files (with the extension .PNT), data files (with the extension .DAT) and, if DISSPLA was used, metafiles with the site-specific default metafile name and increasing cycle numbers. The expected print and data file names should match the lists appearing in Tables A1 and A2, respectively, of Appendix A. Metafiles, if created, should parallel the list in Table A3 of Appendix A, but the file name will reflect the local DISSPLA default metafile name.

It is important to be aware that RASP uses the DISSPLA metafile option, which must be available at the user's site. A metafile is a device-independent plot file generated through DISSPLA at run time that is read at a later time by a DISSPLA postprocessor program. This postprocessor program generates the actual plots on any DISSPLA-supported terminal, plotter, or graphic printer device available to the user. The metafile name used by RASP is the site-dependent default name. Many sites provide a system standard DISSPLA postprocessor program that may, e.g., solicit a metafile name and a plot device from the user, then draw the plot. In the absence of such a site standard, the user is required to write a new FORTRAN program for this purpose, following guidelines provided in the DISSPLA User's Manual. It is impractical to include a postprocessor program with the RASP distribution package because these programs are inherently site dependent and are typically very short. Their basic function is to (1) call an appropriate DISSPLA device initialization routine, and (2) call the DISSPLA subroutine DISPOP to generate the plot.

If the user's DISSPLA installation does not include the metafile option, it is possible to modify the code to draw plots in real time as RASP executes. This is a site-specific excercise depending on which graphic device(s) can be used, but essentially, it involves replacing the call to DISSPLA subroutine COMPRS with a call to a device initialization routine. Refer to the DISSPLA User's Manual for specifics.

Following the RASP execution, DISSPLA users with the metafile option can generate plots from the metafiles for comparison to those in this document. This provides a means of verifying on-site results. For users who have no graphics capability, the print files generated by the test execution can be compared to corresponding sample print files supplied within file SAMPLOUT.DAT. Refer to Section C.2.3 for details on sample print file names. Samples are not provided for every print file; however, these files that are provided represent one of every type, i.e., there is one PROFIL print file, one RTHETA print file, etc.

C.5 NON-VAX USER CONSIDERATIONS

The RASP distibution package is intended primarily for VAX users who have DISSPLA, including the DISSPLA metafile option. Non-VAX users can benefit from this package also, but they must assume the responsibility of determining a procedure for reading the tape and establishing RASP executable files based on the computer resources available.

As discussed previously, the tape is very generic in format to facilitate reading on non-VAX systems. This appendix can offer no specific guidance beyond describing the tape's format and contents (see Section C.3).

All RASP code in written in FORTRAN 77. The user should be aware that it does contain VAX extensions to the ANSII standard. It is likely to generate errors when compiled in a non-VAX environment; however, an experienced FORTRAN programmer should be able to revise or replace nonstandard code to achieve compatibility with any local compiler.

As with any complex mathematical algorithm, no guarantee can be offered that non-VAX outputs from RASP will agree with the VAX outputs. It is highly probable that comparisons will reveal discrepancies that are typically attributable to differences in machine precision, round-off errors, and variations between FORTRAN versions and their libraries. For underwater acoustic models in general, experience has shown that differences in calculated transmission loss of 1 dB or less between computer systems represent satisfactory agreement. Occasional spikes in transmission loss curves can create larger differences (typically up to 4 dB) over short range intervals.