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LEVEL II ②

ENVIRONMENTAL ACOUSTIC SUPPORT FOR FLEET OPERATIONS AND NATO

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November 12, 1980

Scientific Officer
Ocean Programs Office
Naval Ocean Research and Development Activity
NORDA Code 500
NSTL Station, Mississippi 39529

Attention: LCDR A. J. Galus

Subject: Contract No. N00014-79-C-0278

Dear LCDR Galus:

This letter and enclosures consititute the final report for contract N00014-79-C-0278. The final report is line item A002 in accordance with the contract. Also, a technical report prepared under this contract is enclosed along with the final report.

The period of performance was from 7 March 1979 through 14 September 1980. The tasks in this contract dealt with the environmental acoustic (EVA) support of the Tactical ASW Environmental Support (TAEAS) Program objectives in the area of SHAREM operations, COMSIXTHFLEET (Mediterranean Sea), and NATO support.

We have enclosed a DD Form 250 for completion of this contract. SAI would appreciate you noting your acceptance of this work in Block 21B, and sending to our contracts office (Attention: Mrs. Denise M. Van Wyck) a copy of the completed form.

If you have any comments or questions please contact us.

Thank you,

W. D. Kirby

W. D. Kirby

cc: Distribution

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ENVIRONMENTAL ACOUSTIC SUPPORT FOR FLEET OPEARATIONS AND NATO

SAI-81-297-WA

November 1980

Prepared by:
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Ocean Acoustics Division

Prepared for:
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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The tasks in this contract dealt with the environmental acoustic (EVA) support of the Tactical ASW Environmental Support (TAEAS) Program objectives in the area of SHAREM operations, COMSIXTHFLEET (Mediterranean Sea), and NATO support.

The technical test and evaluation of the Ship Helicopter Acoustic Range Prediction System (SHARPS) III in conjunction with

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Section 1

INTRODUCTION

This is the final report for Office of Naval Research Contract N00014-79-C-0278, which was under the technical direction of Ocean Programs Office, Naval Ocean Research and Development Activity (NORDA), NSTL Station, Bay St. Louis, Mississippi. The period of performance was from 7 March 1979 through 14 September 1980. The tasks in this ~~contract~~ REPORT dealt with the environmental acoustic (EVA) support of the Tactical ASW Environmental Support (TAEAS) Program. THE objectives OF THIS REPORT ARE in the area of SHAREM operations, COMSIXTHFLEET (Mediterranean Sea), and NATO support.

Section 2
TASK STATEMENTS

This contract had two task statements which were as follows:

Task 1

Assist NORDA "in the technical support of specific fleet operations, such as SHAREM, which are of direct concern to the TAEAS project. This assistance shall be in the planning, execution and evaluation of environmental acoustic support capabilities. Investigation and analsis shall be conducted and technical documentation of these efforts shall be provided."

Task 2

"Provide support to the Tactical ASW Environmental Support (TAEAS) Program." Specifically, "provide support in the following areas: (a) Assist in the planning and description of Environmental Acoustic (EVA) support for the COMSIXTHFLEET in order to improve the ASW capability in the Mediterranean Sea: (b) Participate in the reconstruction and EVA analysis of two specific 6th Fleet operational exercises and report the results in a technical document; (c) Develop acoustic scenarios that are directly oriented to the 6th Fleet primary ASW sensors in order to predict and analyze performance of these sensors in the Mediterranean unique environment; and (d) Support the TAEAS program in the addressal of key NATO issues and problems by providing the technical description of U.S. performance prediction resources available to NATO and by participating in technical exchange and planning conferences."

The performance of these tasks are discussed in the following sections which highlight the effort and key events which occurred during the course of this contract.

Section 3
SHAREM OPERATIONS TASK

The primary objective of this task was to address the technical test and evaluation of the Ship Helicopter Acoustic Range Prediction System (SHARPS) III in conjunction with the Ship ASW Readiness and Effectiveness Measuring (SHAREM) exercises.

A report (Reference 1) was prepared and distributed to other involved contractors and Navy activities. This report and related efforts addressed the technical data collection requirements for the purposes of EVA model evaluation and the actual model evaluation and analysis process with the viewpoint that the overall evaluation process initially will be in three basic phases in conjunction with SHAREM exercises:

- Pre-exercise forecasts
- During exercise forecasts
- Reconstruction Predictions

Alternatives are discussed because of the complexity, time and costs involved.

Science Applications, Inc. participated in a Navy and contractor team effort to develop a data collection plan as well as an overall evaluation approach. These efforts assisted in the generation of an evaluation plan (Reference 2) and a model evaluation data collection plan (Reference 3).

To support specific SHAREM operations pre-exercise model evaluation statements were prepared as shown in Appendix A.

As a result of these efforts it appears that it is not cost-effective to obtain what may be termed a technical model evaluation due to the cost of collecting the necessary data. SHAREM operations have been utilized for the collection of such data (e.g., Reference 4.), but it is not presently possible for the TAEAS program to fund such efforts. It appears more cost-effective for SHAREM operations to provide the "operational" type evaluation of support products which is now within the SHAREM objectives and discussed as an alternative in reference 1.

Section 4

COMSIXTHFLEET AND NATO TASKS

The initial contract was modified to expand the level of effort and subject matter to include support to the Commander Sixth Fleet (COMSIXTHFLEET) and NATO. Specifically, the interest of COMSIXTHFLEET was to gain an improvement in ASW capabilities within the Mediterranean Sea operating area. The TAEAS program became involved in the support of NATO through the NATO subgroup an Military Oceanography (MILOC).

Science Applications, Inc. directly participated in a review group that visited Fleet Oceanography Command Center, Rota Spain to assess specific EVA support problems and issues. This trip was made between 4 and 8 November 1979, and the scope of the vist was primarily defined by Fleet Numerical Oceanography Center (FNOC), Monterey, California. From this visit a number of specific deficiencies in EVA support were indentified that were not necessarily unique to the Mediterranean Sea operating area. Later, SAI performed technical investigations of the disclosed problems. Where and when necessary SAI assisted in corrective action. A sequence of technical memoranda were generated to report to FNOC and NORDA the findings on almost a problem by problem basis. Most of this effort dealt with SHARPS III, and some significant improvements were made to the satisfaction of COMSIXTHFLEET. In some cases the problems were not correctable in the near future, but have been taken into consideration by the TAEAS program for future research.

Briefly, the key technical problems identified and addressed by this effort were:

- VDS tow depth doctrine in the Med.
- Wind and Waveheight sensitivity
- Shallow Water predictions
- Sensitivity of Ray Theory to sound speed profile changes
- Predictions for Isovelocity environments

Science Applications, Inc. was not able to participate in the reconstruction and EVA analysis of two specific COMSIXTHFLEET operational exercises as originally intended. The necessary data were retained by COMSIXTHFLEET and it was understood that NAVOCEANO representatives performed the desired analysis at COMSIXTHFLEET.

NORDA organized a Mediterranean Sea ASW working group that was part of a large Navy effort to improve ASW in the Mediterranean Sea. SAI participated in this group which met periodicaly at NORDA to address specific ASW scenarios that COMSIXTHFLEET felt were critical. This group addressed specifically

- Alboran Basin
- Strait of Sicily
- Ionian Basin
- Levantine Basin

SAI was in particular responsible for employment guidelines for sonobuoy sensors SSQ-41 and SSQ-77. The results of this working group have been incorporated into a much larger documentation effort.

To support the TAEAS programs interest in NATO a series of briefings were prepared for presentation to the MILOC subgroups. Appendix B represents a description of specific U.S. ASW support products that SAI and Planning Systems Inc. (PSI) jointly prepared for NORDA. Similarly SAI and PSI prepared briefing material for NORDA as shown in Appendix C. This material was incorporated into NORDA's presentation to the NATO MILOC group in the fall of 1979. Updates to this material were delivered by SAI to NAVOCEANO for presentation to the MILOC group in the fall of the 1980, and this briefing material is contained in Appendix D.

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1. SHARPS III Test and Evaluation in Conjunction with SHAREM Exercises, W. D. Kirby, SAI-81-292-WA, May 1979.

2. SHARPS III - Model Evaluation Program Plan (U) The Sutron Corp., SCR-352-79-020, Final Report, CONFIDENTIAL, 5 November 1979.

3. SHARPS III - Model Evaluation Data Collection Plan, The Sutron Corp., SCR-352-79-021, 23 October 1979.

4. SHAREM 26 Acoustic Results --, L. A. King, J. B. Chester, NUSC TM No. 791016, 1 February 1979, CONFIDENTIAL.

APPENDIX A
SHARPS III TEST AND EVALUATION IN CONJUNCTION WITH SHAREM 32

SHARPS III TEST AND EVALUATION IN CONJUNCTION WITH SHAREM 32

I. INTRODUCTION

The model evaluation and the related EnVironmental Acoustic (EVA) support to the SHAREM exercises is sponsored by the Tactical ASW Environmental Acoustic Support (TAEAS) project which is managed by the Ocean Programs Office within the Naval Ocean Research and Development Activity (NORDA) Bay St. Louis, Mississippi. The SHAREM exercises are planned and directed by Commander Surface Warfare Development Group,(COMSURFWARDEVGRU), Norfolk, Virginia.

II. BACKGROUND

Historically, the purpose of SHARPS has been to provide routine and special detection range predictions for surface-ship and helicopter active and passive sonar systems. The original SHARPS (I) became operational in February 1969, and it largely utilized empirical data. Then in late 1971, it was replaced by SHARPS II which was basically an adaptataion of an active sonar performance prediction model (FAST NISSM) that was derived by NUC (now NOSC) from the Navy Interim Surfaceship Sonar Model (NISSM II).

At a SHARPS conference held in October 1974, the general deficiencies of the SHARPS II were presented, and it was recommended that some specific and immediate problems within the SHARPS II be corrected. In addition, it was concluded that the Navy should initiate the development of a new SHARPS III which would overcome many of the deficiencies which could not be corrected within SHARPS II. In early 1975, as recommended, the SHARPS II was modified to produce predictions for new sonars and related modes of operation. The output message format was changed as well.

The development of SHARPS III was carried out under the sponsorship of the Tactical ASW Environmental Acoustic Support (TAEAS) project which is managed by the Naval Ocean Research and Development Activity, (NORDA) Bay St. Louis, Mississippi. A number of Navy organizations and contractors directly contributed to the development of SHARPS III.

SHARPS III is operationally installed on the computers at Fleet Numerical Weather Central (FLENUMWEACEN), Monterey, California. It is an efficient computer program whose purpose is to produce, as a single output performance, predictions for a multitude of user selected active and passive tactical sonars using synoptic and/or observed environmental data (see Appendix I). The sonars and related characteristics are easily changed as required by the SHARPS program user. Even the format of the predicted measures of sonar performance are changeable (see Appendix II). These changes are accomplished by way of a user-oriented interface. The acoustical physics involved offer a significant improvement over SHARPS II in terms of accuracy and reliability; and it is not restricted to surfaceship and hull mounted sonar systems.

The acoustical physics within SHARPS III represent a restructured and reduced version of the Naval Interim Surfaceship Sonar Model (NISSM) II, which was originally developed in 1973 by Dr. Henry Weinberg at Naval Underwater Systems Center, New London, Connecticut. The basic reference for accuracy, size, and running time tradeoffs in the development of SHARPS III was the original NISSM II.

After a review of the SHAREM Program Plan for FY 79-83 by the Chief of Naval Operations (OP-095), it was requested that the Commander, Surface Warfare Development Group provide support during the SHAREM exercises for model evaluation. It was emphasized that model evaluation is essential in order for the Navy to have full confidence in and understanding of the limitations of the sonar performance prediction models that are currently in use and under development. It was stated that "...model evaluation efforts were not to interfere with the exercises, but rather should be supportive of them and should provide beneficial communications between the development and user communities."

At present, the SHAREM exercises can provide operational and some desired technical data for preliminary model evaluations.

With proper planning and coordination, it should be possible to gain the desired EVA model evaluation data from SHAREM exercises while at the same time greatly aiding in the Navy's ability to measure ASW readiness and effectiveness. Another key factor is that operational performance prediction systems, such as SHARPS III which directly support the Fleet's ASW mission, should be subject to readiness and effectiveness scrutiny..

III. APPROACH

An initial EVA/model evaluation effort could be done within three basic phases that greatly parallel SHAREM exercises. These basic phases for a SHARPS III evaluation would be:

a. Pre-exercise forecasts: FLENUMWEACEN would generate SHARPS III and other products sometime before an exercise using standard operational procedures and model inputs. Records of model inputs and outputs would be preserved for analysis (e.g., model evaluation).

b. During exercise forecasts: FLENUMWEACEN would generate SHARPS III and other products during an exercise using in situ XBT's and specific system data, if available. This would again use standard operational procedures, but system related model inputs could be tailored for each exercise unit involved. This would require for example, each exercise unit to establish a few days before the exercise (e.g., by sonar grooming) sonar parameters such as source level, self noise, etc. Also, the individual exercise target characteristics (passive and active) should also be considered in these predictions if possible.

c. Post exercise reconstruction: Using all available environmental, system, target and tactical information, selected situations should be reconstructed using SHARPS III and other necessary models. These prediction products should be made available to CONSURFWARDEVGRU in a timely manner for use in SHAREM analysis as well.

Using the results of all three phases, a meaningful evaluation could be made of the SHARPS III prediction process. Such an evaluation could, for example, identify and possible quantify prediction errors attributable to:

- forecasting of oceanographic and acoustic conditions used as model inputs
- sonar system characteristics
- target characteristics
- tactical and operational factors
- model deficiencies

IV. DATA COLLECTION REQUIREMENT

Table I presents a concise tabulation of the data required for the complete evaluation process. The likely or preferred data sources are identified as well. This table reflects the expected situation in present SHAREM exercises, as well as the eventual goal in data collection.

As a minimum, the items in Table 1 marked with an asterik will be required for a SHAREM 32/SHARPS III reconstruction. These items should be recorded on standard logs or narrative logs during detections, events and any recordings of reverberation vs time (SOM-5) and echo levels.

TABLE I

DATA SOURCES AND SPECIFICATION FOR PREDICTION PURPOSES
(Initial/Goal)

		PHASE	
PARAMETER NAME	I PRIOR	II DURING	III RECON.
Environmental			
Geographical Location/Time	E/E	O/O	M/M
Water Depth	A/A	A/M	A/M
Temperature Profile: shallow	A/A	M/M	M/M
: deep	A/A	A/M	A/M
Salinity Profile: shallow	A/A	A/M	A/M
: deep	A/A	A/A	A/A
Sound Speed Profile: shallow	C/C	C/M	M/M
: deep	C/C	C/C	C/C
Wave Height	A/A	O/M	O/M
Sea State	A/A	O/M	O/M
Wind Speed	A/A	M/M	M/M
Bottom Loss	A/A	A/A	A/M
Volume Scat. Strength	A/A	A/A	A/M
Surface Scat. Strength	S/S	S/S	S/S
Bottom Scat. Strength	S/S	S/S	A/M
Sonar System			
Sonar Type & Installation	R/R	R/R	R/R
Mode	S/S	S/R	L/L
Platform Speed	S/S	S/R	L/L
Sonar Depth	S/S	S/R	L/R
Frequency	S/S	S/R	L/L
D/E Angles	S/S	S/R	L/L
Vert. Beamwidths	S/S	S/R	R/R
Horiz. Beamwidth	S/S	S/R	C/C
Pulse Length	S/S	S/R	L/L
Waveform	S/S	S/R	L/L
Source Level	S/S	S/M	M/M
Recognition Dif. Noise	S/S	S/S	S/M
Recognition Dif. Reverb.	S/S	S/S	S/M
Self Noise	S/S	S/R	M/M
Target			
Depth	S/S	S/E	L/L
Speed	S/S	S/S	E/M
Target Strength	S/S	S/R	R/R
Aspect	S/S	S/S	M/M
Bearing	-	-	M/M
Range	-	-	M/M
Radiated Noise Level	S/S	S/S	R/R

O - Observed
M - Measured
R - Reported
A - Archival
S - Standard
E - Estimated
L - Logged
P - Predicted
C - Computed

TABLE I (Continued)

Acoustic			
Ambient Noise	A/A	A/M	M/M
Reverberation Level	P/P	P/P	P/M
Echo Level	P/P	P/P	P/M
Intercepted Signal Levels	P/P	P/P	P/M
Received Signals (Passive)	P/P	P/P	P/M
Operational			
Detection Range	P/P	P/P	M/M

The coding which identifies the likely or desired data sources can be concisely defined as follows:

Observed (O): The parameter is derived from a qualified and experienced observer at the time and place of interest.

Measured (M): The parameters are measured by appropriate and calibrated instrumentation at the time and places of interest.

Reported (R): The parameters have been obtained from previously reported measurements or other creditable sources which are considered applicable to the subject situation.

Archival (A): The parameters are obtained from historical records of measurements, etc., which may or may not have been interpreted and/or selected for use.

Standard (S): The required parameters have been established by official or widely accepted standards and practices.

Estimated (E): The parameters have been established by a rational process that is considered professional.

Logged (L): The parameter is directly obtained from logs or data tape recordings which are obtained at the time and place of interest.

Predicted (P): The parameter is predicted using recognized models, algorithms or processes which utilize the data available.

Computed (C): The parameter is directly computed using a recognized and qualified mathematical model or formula.

Appendix B

STATUS OF ASRAP III/SHARPS III MODELS FOR TACTICAL ASW SONARS

Prepared by
William D. Kirby
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N00014-79-C-0278

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N00014-78-C-0842

TITLE: STATUS OF ASRAP III/SHARPS III MODELS FOR TACTICAL ASW SONARS

PRESENTED BY:

M.G. Lewis
Naval Ocean Research and Development Activity
Department of the Navy
NSTL Station, MS 39529
U.S.A.

STATUS OF ASRAP III/SHARPS III
MODELS FOR TACTICAL ASW SONARS

PRESENTED BY:

M.G. Lewis
Naval Ocean Research and Development Activity
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1. INTRODUCTION

This presentation concerns Environmental Acoustic (EVA) models to support tactical ASW systems, specifically the shorebased Fleet-support products generated by Fleet Numerical Weather Central, Monterey, California (FNWC): SHARPS and ASRAP. The performance predictions use FNWC's analysis of the ocean medium as inputs to acoustic models, which in turn are used to estimate terms in the SONAR equation.

Our discussion concentrates on the EVA components of the two principal models, and describes how they work, their status, and potential or planned improvements. The presentation is limited to work performed under a program managed by the Naval Ocean Research and Development Activity (NORDA). This program has the responsibility to develop, maintain and upgrade EVA models for such Fleet applications as SHARPS and ASRAP.

To better see the make-up of a performance prediction and how the various components inter-relate, consider the Passive and Active Sonar equations. The EVA, system and target parameters can thus be identified.

Figure 1 shows the "conventional" Passive Sonar Equation. To estimate performance, Signal Excess (SE) is calculated in terms of system, target and environmental parameters. SE can then be converted to detection probability via an Operating Characteristic. The grouping of terms shows signals (at array output), noise (at array output) and RDN. Alternative groupings combine ASG and ANG as Array Gain (or Directivity Index). Finally, the Figure-of-Merit (FOM) is the TL when SE=0.

The predicted performance of an active sonar is governed by the active sonar equations (Figure 2), and again the basic measure of performance is Signal Excess (SE). In the most simple case we consider only a noise background which is represented by the noise limited sonar equation which is similar to the passive sonar equation. A more severe background condition is one in which reverberation dominates. When noise and reverberation are about equal in intensity a more delicate situation exists. Here the background represents a power summation of noise and reverberation, and the effective recognition differential may be highly dependent on how the processor responds to this more complex background.

In all of these active sonar equations the key environment dependent terms that must be predicted are (1) echo transmission loss (TL), (2) reverberation level (RL), and (3) if ambient noise limited the ambient noise level (N).

FIGURE 1

PASSIVE SONAR EQUATIONS

$$SE = \{\text{Array Output Signal}\} - \{\text{Array Output Noise}\} - RDN$$

$$= \{SL-TL+ASG\} - \{N+ANG\} - RDN$$

where SL = source level

TL = transmission loss (to omni receiver) (dB)

ASG = array gain for signal (dB)

N = omni background noise (dB)

ANG = array gain for noise (dB)

RDN = recognition differential (dB)
= array output signal-to-noise ratio (SNR) such that detection probability is 0.5

SE = signal excess

Regroup as:

$$SE=SL-TL-N+\underbrace{\left\{ ASG-ANG \right\}}_{\substack{\text{ARRAY GAIN (AG)}\\ \text{OR}\\ \text{DIRECTIVITY INDEX (DI)}}} - RDN$$

Also: $$FOM=\left\{ TL \text{ when } SE=0 \right\} = SL-N+DI-RDN.$$

FIGURE 2

BASIC ACTIVE SONAR EQUATIONS

NOISE LIMITED CONDITION

$$SE = \underbrace{SL - (N - DI) + TS - RDN_n}_{FOM} - TL \text{ (2 way)}$$

REVERBERATION LIMITED CONDITION

$$SE = SL - RL + TS - RDN_R - TL \text{ (2 way)}$$

COMBINED BACKGROUND

$$SE = SL - \underbrace{10 \log \left(10^{\frac{(N-DI)}{10}} + 10^{\frac{RL}{10}} \right)}_{\text{Background}} + TS - RDN_x - TL \text{ (2 way)}$$

where

SE = Signal Excess (dB)
SL = Transmitter Source Level (dB)
N = Effective Isotropic Noise (dB)
DI = Noise Directivity Index (dB)
TS = Target Strength (dB)
RDN = Recognition Differential (dB)
TL = Echo Transmission Loss (dB)
RL = Reverberation Level (dB)
FOM = Figure-of-Merit (dB)

Now consider the Passive Sonar performance model in current use, the Acoustic Sensor Range Prediction System (ASRAP III). The forecast is most often applied to sonobuoy fields. As noted in the sonar equation, TL and N are the EVA parameters needed to estimate SE for an omni receiver. Given these, $P_D(R)$ and related measures of performance can be calculated. Such predictions are used to decide when to deploy, buoy pattern, best frequencies, expected performance, force levels, etc.

The FNWC ASRAP system is fully automated, and efficient. The EVA models of interest here are for TL and ambient noise (AN), to be discussed in some detail later.

The current ASRAP has been in FLEET use for six years and has been subjected to many tests of reliability and accuracy. Deficiencies have been identified, and are mentioned below in the context of R&D efforts to remove them. Finally, note that ASRAP has recently been upgraded to support a new generation of Vertical Line Arrays (VLAs).

The primary application of the SHARPS III model is for tactical ASW sonars (Figure 3). However, it is not restricted to surfaceship and helicopter sonar systems, but it can produce predictions for any similar platform and/or sonar such as for submarines and sonobuoys. The emphasis is upon predicting active sonar detection ranges for various modes of sonar operation out to just beyond the first CZ (convergence zone). The model can produce predictions for broadband passive sonar modes as well. Counter-detection (or interception) ranges for the subject active sonar emissions are also predicted. For variable depth and helicopter sonars the optimum tow and dip depths are

FIGURE 3

SHARPS III
(Ship Helicopter Acoustic Range Prediction System III)

Applications - Tactical ASW Sonars
- Active Detection Ranges
- Broadband Passive Detection Ranges
- Active Counter-Detection Ranges
- Tow and Dip Depth Selections

Features - Automated Prediction System
- Efficient Software
- Flexible Inputs and Outputs
- User Oriented
- Based upon NISSM II

Status -
- Evaluations
- Application to New Systems

are respectively determined as a function of the acoustic environment, and the guidelines for the respective type sonars.

The major feature of SHARPS III is that it is part of an automated and complex naval message and computerized environmental prediction system. The software design of SHARPS III is such that a large number of varying predictions can be generated in an efficient and cost-effective manner. Also, the model is designed to interface with fleet-type users and it does not require an experienced sonar engineer or underwater acoustician to establish a particular prediction.

The Naval Interim Surface Ship Model (NISSM) II was the starting point of the basic acoustic model within SHARPS III. However, to meet the limitations on computer resources a number of the features and detailed treatments of the environment within NISSM II had to be sacrificed.

At the present time we are involved in a serious evaluation of SHARPS III as well as examining the basic accuracy of NISSM II-type active sonar models. These evaluations are essential if we are going to have any measure of confidence in these models. Also, the SHARPS-type models must keep up with the introduction of new sonar systems, and the needs of fleet users.

Now that the frameworks for ASRAP and SHARPS have been outlined, we concentrate on some of the details and history of each model, with emphasis on the status and potential improvements in the EVA components.

2. PASSIVE ASRAP

Consider now the history and status of ASRAP: its inputs, modules for TL and AN, as well as VLA modifications, evaluation and future improvements.

Recall from the Sonar Equation that the EVA parameters needed are TL and AN (for the omni case). This is exactly what ASRAP predicts. Users must provide other inputs to get SE, PD, etc. (viz., SL, RDN, DI). Arrays and array gain (as opposed to DI) are introduced below.

2.1 ASRAP History

Figure 4 outlines the principal technical development phases for ASRAP:

- First ASRAP used very basic ray-trace techniques for TL and measurements for AN. ASRAP II showed improved TL calculations (RP-70), but retained simple duct model, bottom-loss classes, AN tables, etc.

- ASRAP III has much more sophisticated TL (the FACT Model). Other components received only superficial changes. The bottom classes, noise tables, and duct model are essentially those of 1967.

- The only substantive change in the past six years is an adjustment of the bottom classes and the addition of a VLA prediction capability.

FIGURE 4

DEVELOPMENT HISTORY OF THE PASSIVE ACOUSTIC SENSOR RANGE PREDICTION SYSTEM (ASRAP)

ASRAP I 1967
- developed at FNWC
- simple raytrace, direct and BB
- empirical CZ
- Clay Surface Duct Equation

ASRAP II 1970
- developed at FNWC
- version of RP-70 raytrace
- Clay Surface Duct Equation

ASRAP III 1973
- initiated at BTL
- finalized at AESD
- FACT raytrace
- Clay Surface Duct Equation

1978
- vertical line array modification

2.2 ASRAP TL (FACT)

Figure 5 shows the principal features of the TL module of ASRAP, called "FACT." FACT produces TL as a function of range for selected frequencies. An efficient ray trace (usually fewer than 50 rays) and curve-fit in (R,θ) space to get $(\frac{dR}{d\theta})$ give the model exceptional calculation speed.

Noteworthy is the caustic correction routine based on uniform asymptotic theory: it removes the "blow-up" of ray theory at focal points (e.g., CZs). "Semi-coherent" mode means that paths differing only by a surface reflection are added <u>in phase</u> (coherently) to include Lloyd's mirror (or surface-image-interference) effects for low-frequencies and shallow source or receiver. If the interference field is undersampled in range, the prediction reverts to a smooth (RMS) sum of paths.

The program is fast: about 28 seconds on a CDC 6500 computer for 4 frequencies, 2 source depths, 2 receiver depths, and predictions every 1/2 nm to 120 nm. To save time, there are special routines for surface duct, half-channel, and shallow water propagation.

FACT is a ray-trace model (although modified) and is hence subject to some limits in frequency (e.g., predictions below 25 Hz may well involve bottom interactions not appropriate to the model). Also, the density of rays calculated limit FACT's accuracy at very short ranges. As configured for ASRAP, signal arrival angles arfe not available from FACT.

FIGURE 5

ASRAP
TRANSMISSION LOSS MODEL

FACT
(Fast Asymptotic Coherent Transmission)

- Standard (classical) Ray Trace
- Special Caustic Corrections
- Semi-Coherent (image-interference)
- Fast and Efficient
- Special Treatment
  - Surface Duct
  - Half Channel
  - Shallow Water

The sound speed and bathymetry are assumed independent of range, which is reasonable for short-range, deep-water cases, but not always for shallow water or long ranges. The boundaries are treated as smooth and horizontal, with loss functions (per bounce) depending on frequency and grazing angle (at present, surface loss is zero.)

The special routine for surface ducting accounts for surface scatter, low-frequency cut off and leakage, but has questionable accuracy.

FACT has undergone extensive evaluation and is viewed as having accuracy consistent with the ASRAP application, subject to the limits already mentioned and the quality of environmental inputs.

2.3 ASRAP Automation and Environmental Inputs

ASRAP is resident at FNWC and makes daily forecasts for ASRAP ASW Prediction Areas automatically, i.e., it extracts sound-speed profiles and wind/wave data from the FNWC analysis and executes without programmer assistance. FNWC performs a daily analysis of sound speed using BT observations and historical T-S files. Likewise for wind speed. Special requests can be filled in a short time when inputs are user-provided.

Bottom-loss curves for ASRAP are stored in terms of loss per bounce as a function of frequency and grazing angle. The current data are based on an analysis dating to 1973 or earlier, with only superficial improvements since then.

There are 3 low-frequency (f<1000 Hz) loss functions and 9 high frequency functions. Ocean areas are assigned bottom-loss classes determined from loss data and gross geophysical characteristics.

There is at present no noise "prediction model" for ASRAP consistent in detail and sensitivity with the TL model. The present approach assumes two prevailing components: ship-generated and wind-generated. Omni-directional ship noise is stored in a table, whose values are based on early measurements at 100 Hz and extrapolated in frequency according to surface-ship radiated-noise spectral shape. The resulting omni levels are independent of receiver depth and change with season according to a simple formula (+2 dB in winter, -2 dB in summer). To the ship component is added a wind component based on Wenz-like curves and dependent only on frequency and wind speed.

This empirical model has undergone no evaluation in recent years and has many obvious sources for error and uncertainty. The current ASRAP predicts omni levels, and is fully automatic. Just as in the case of sound speed, users can provide input noise levels (from <u>in situ</u> observations) to FNWC for incorporation in ASRAP predictions.

2.4 Sample ASRAP Messages

Figures 6 and 7 show sample ASRAP III forecasts. The first is the standard teletype format, giving TL versus range for various Target/Hydrophone depth combinations. An AN prediction and environmental data accompany the plot. 50 percent detection range can be found directly for a given FOM.

The second example (Figure 7) shows a special abbreviated message format (upper portion of figure), with a sample plotting sheet. This type of forecast is gaining in popularity because of the compactness of the message.

FIGURE 6

Example

Passive ASRAP Message

General
EVA Data

TL
Plot
dB re 1 yrd
vs
nm

```
PASSIVE ASRAP 8 DAY FCST FROM 20 000Z SEP 71
S083  0765  8765  10740 20680 30629 40603 60557 80516 120476
WH 2 GR11.8 73092000, AN  75/ 58/ 54/50   4A DR/DX 1883/ 217
    HZ
 70.X...10...20...30...40...50...60...70...80...90...100..110...
   .
   .
   .
 80.........II.................................................
   .        XC
   .DCCXXXXX              I
   . XXDDDDDDD          II I
 90.................III.............I..........................
   .             XXXCCC           III I
   .          CXXDDDDDDX     IIIII            IIII
   .          D            CXCCCCC        IIII              I
100...................CXDDDDDDD.....IIICC..........IIIIII.....
   .                    D        DCCCCCCCC      IIII         I
   .                             CDDDDDDDDD     CCCCC         III
   .                                       CCCCDDDDDC       CC
110.......................................DDDD.....DCCCCCCC..C..
```

FIGURE 7

PREDESIGNATED HIGH INTEREST TACTICAL AREA
(PHITAR)

SAMPLE MESSAGE

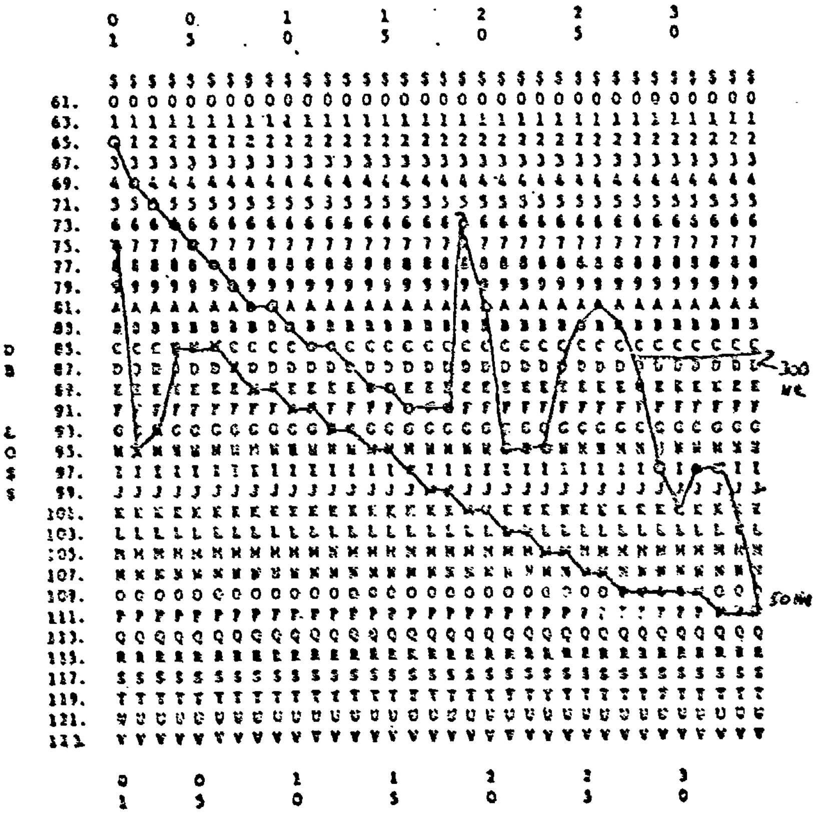
```
P 140053Z JUL 75
FM RUWJACD/FLENUMWEACEN MONTEREY CA
TO RHHAAHA/COMSUBPAC PEARL HARBOR HI
BT
C O N F I D E N T I A L TEST//N03161//
PHITAR FORECAST
A.  USS SHIP 062157Z JUL 75
C114 0957 26963 30952 40941 60927 80933 120946 197961 262975
WH 6, AN/103/88/62/51 75071400,/GRAF,DI(2.),DF(61.),RI(1.),RL(35.)/
50P2035 7BCCC  CDEEF FGGHH IJJKK LLMMN NOOOO OPPPP PQQQQ
150P0637 5ACAA BBCCD DEFFG GHHIJ KLJJL LMMMM NNNOO OOPPP
300P0606 24567 89AAB CCDEE FFF6A HHHOB ABEIK IILPQ OMJ3C
600P1535 24567 7399A ABBCC CDDEE EFFFF GHIII JJKKK LLMMM
1.7P2006 24567 899AB BCDDE EFFGH HHHHI IKLLM MMMOP PPQQR
```

SAMPLE--PHITAR- PLOTTING SHEET

PHITAR FORECAST FOR. 14.JuL.75.(DATE)

AREA.C11.4. FREQ..50.. SOURCE.299.. RCVR.350.
FREQ.300.. SOURCE..CA.. RCVR..CA..
FREQ....... SOURCE....... RCVR.......
FREQ....... SOURCE....... RCVR.......

RANGE (NM)



3. IMPROVEMENTS IN EVA MODELS FOR ASRAP

Given the preceding description of current ASRAP III and history, we focus now on the deficiencies and efforts to eliminate them. Principal problem areas directly related to EVA models are discussed below.

3.1 EVA Model Deficiencies

For TL, bottom loss is out-dated. It is based on a poor understanding of the mechanisms and on sparse data. Rough surface loss/scatter is not accounted for except in the surface-duct equation. The duct model dates to 1967 and is not given much credençe. Likewise, there is little confidence in shallow-water predictions - because of limited understanding of boundary-interaction, a complicated environ ment, and a lack of quality input data. Proper sonar-equation deductions about detection probability require some knowledge of SE fluctuations. Likewise, the sensitivity of ASRAP predictions to environmental inputs should be known.

AN is a very weak component. The empirical model is of questionable accuracy, and only omni broadband levels are given.

Principal Input deficiencies include bottom interaction, the location and properties of ship noise sources, and the reliability of the FNWC sound speed and wind predictions.

Plans to attack some of these problem areas are discussed next.

3.2 VLA Modification to ASRAP

New US and other buoy systems have vertical line arrays (VLA), designed to receive primarily bottom bounce signals (at D/E angles of 15° to 60°+), and to reject noise from distant ships at low frequencies (DE angles of 0° to 15°) and wind noise at higher frequencies (DE angles of 60° to 90°). Figure 8 illustrates some basic VLA response patterns and acoustic arrival structure.

ASRAP has been modified for these applications to include both signal and noise gain (ASG and ANG). The recent modification involves:

- Generate and/or store VLA vertical beam patterns (vs frequencies), i.e., response to plane waves as function of vertical arrival angle.

- Develop noise vertical directionality module which predicts arrival structure of wind component and ship component. Then use omni levels in current ASRAP to get actual noise level versus angle.

- Convolve beam pattern with TL arrival structure to get received signal (SL-TL+ASG).

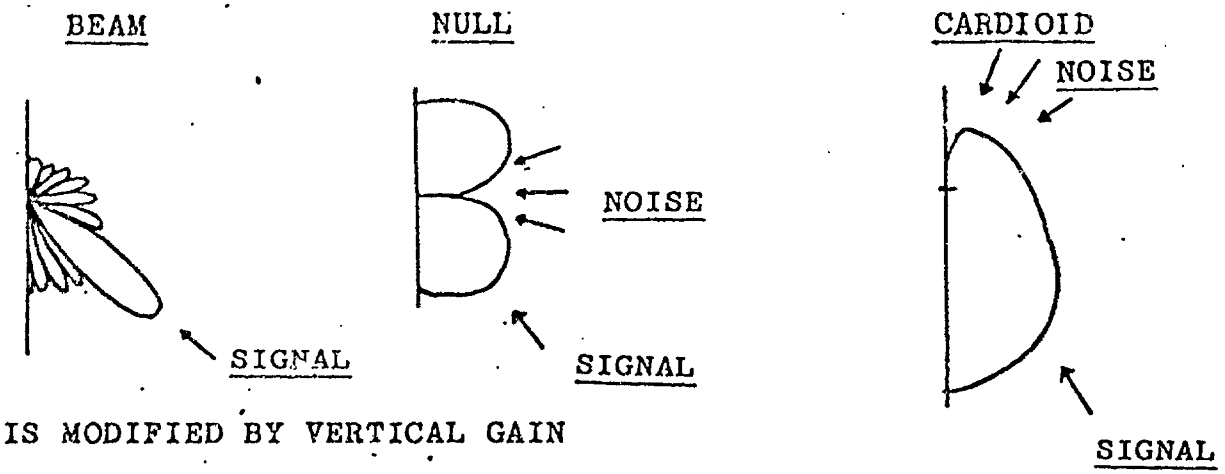
- Convolve noise directionality and beam pattern to get received noise (N+ANG).

- Modify ASRAP output to provide "effective" TL = (TL-ASG+ANG). This is now comparable to "omni" ASRAP prediction of TL and N for omni receiver.

FIGURE 8

ASRAP MODIFICATION FOR VLA

- VLA RESPONSE



  - SIGNAL (TL) IS MODIFIED BY VERTICAL GAIN
  - AT LOW FREQUENCIES, NOISE NEAR THE HORIZONTAL (SHIPPING NOISE) IS REJECTED
  - AT HIGHER FREQUENCIES, NOISE FROM ABOVE (WIND NOISE) IS REJECTED

- ASRAP/VLA MODEL
  - PREDICTS SIGNAL (TL) ARRIVAL AND MODIFIES TL ACCORDING TO ARRIVAL ANGLE AND ARRAY RESPONSE
  - PREDICTS NOISE VERTICAL DIRECTIONALITY AND OMNI LEVEL (ASRAP). NOISE GAIN IS CALCULATED FROM ARRAY RESPONSE TO DIRECTIONAL NOISE FIELD
  - OUTPUT IS A "MODIFIED" TL, INCORPORATING BOTH SIGNAL AND NOISE GAINS

3.3 Improved Surface Duct Treatment for TL

The current routine ("Clay Model") within ASRAP (FACT) for estimating surface-ducted transmission is an early attempt to include wave and rough-surface effects at low frequencies. It is believed to be inaccurate. In particular, the below-layer level was simply given a value 10 dB down from in-layer. Also, leakage losses were not properly dependent on the sound-speed characteristics. A new model is now being implemented in FACT/ASRAP. It provides a better treatment of leakage loss and depth dependence using new techniques for approximating mode depth functions. The new routine has been compared with detailed wave and mode models, as well as with measurements. Results were satisfactory, but additional improvements are needed.

The treatment of rough-surface scatter remains inadequate. Only the specular (coherent) term is treated, and then as "loss per bounce" for a mode's ray equivalent. Work is in progress to account for non-specular terms and shadowing.

3.4 Bottom-Loss Upgrade

Current bottom-reflectivity curves at low frequencies are out-dated, and do not include new understanding of mechanisms - derived from many measurements and much analysis over the past 5 or more years. Geophysical properties are to be incorporated and old curves upgraded. Substantial improvements in ASRAP are expected, especially for systems which rely on bottom-bounce signals.

The new approach accounts for refraction of propagating paths through thick sediment layers, as well as reflection/scatter from water/sediment interfaces and the basement.

3.5 Shallow Water Transmission

Prediction capability for shallow-water sound transmission is inadequate for two reasons:

(a) The current TL model (FACT) applies only to range-independent environments.

(b) Bottom and surface reflectivity, together with complex bathymetry and sound speed, drive TL (which is often viewed as "reverberant"). Description of these environmental parameters is lacking.

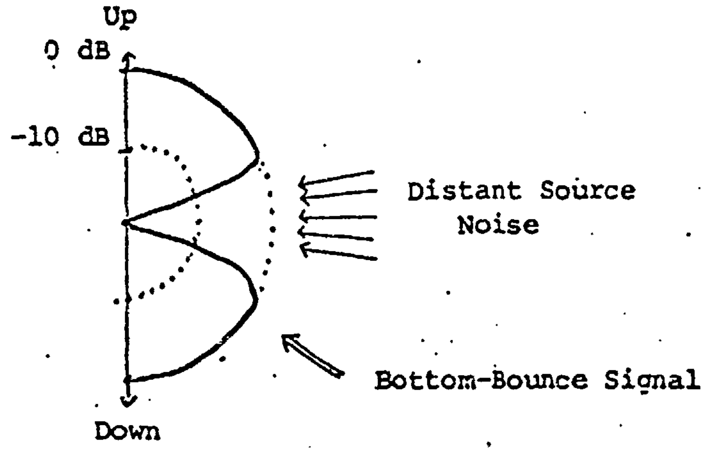
Addressing this problem involves consideration first of a "Predictability Issue": Is there a chance to solve this problem? In other words, because of sensitivity to bottom loss, etc., can we predict TL without measuring it? The approach we have taken to answer the question is to select a high-quality data set, with extensive measurements of the environmental inputs, and see if the TL can be explained and predicted using the best available models and analysis capability. Given satisfactory results, efficient means to obtain inputs for important shallow water areas must be found.

3.6 Ambient-Noise "Notch" Problem

In some cases, a vertical line array's (VLA) response is designed to discriminate against energy which arrives at angles near the horizontal. This has the purpose of reducing distant-shipping noise, while leaving bottom-bounce signal arrivals undisturbed (see Figure 9A).

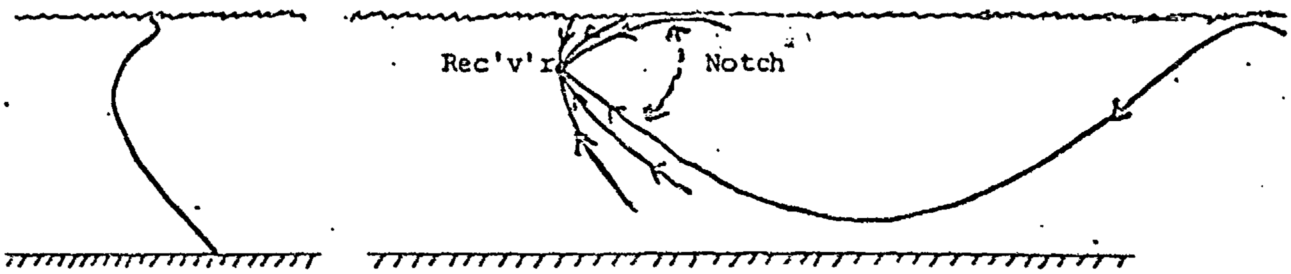
At low frequencies (say, less than 300 Hz), the current noise-directionality model often predicts a "notch" in the vertical structure, near the horizontal. Such a prediction presumes a range-independent environment and does not account for diffraction and scattering. So, for example, an array in the thermocline receives noise energy only from those paths which arrive at angles exceeding the angle of the limiting ray to the surface sources (Figure 9B). Measurements and more realistic models suggest that in many areas this "notch" is actually "filled" (or partially filled) with energy injected into lower-angle paths by any of a number of mechanisms (e.g., slope conversion, shoaling channel axis). A recent modification to the ASRAP model provides an interim treatment, based on data, to estimate the amount of notch filling as a function of ocean area.

As for the effect of all of this on performance predictions, note that the ASRAP/VLA model predicts array gain against noise. The absolute, omni-noise level is given--independent of predicted directionality. Hence, if the model predicts a notch, the gain against noise may be small (since there is little energy to be reduced). If, on the other hand, the notch is filled, then the horizontal null forming VLA system eliminates the noise energy occupying the notch, and thus achieves greater gain (see Figure 10). In this sense, the VLA prediction based on a non-filled notch is pessimistic compared with the new prediction.



Low-Frequency VLA Response

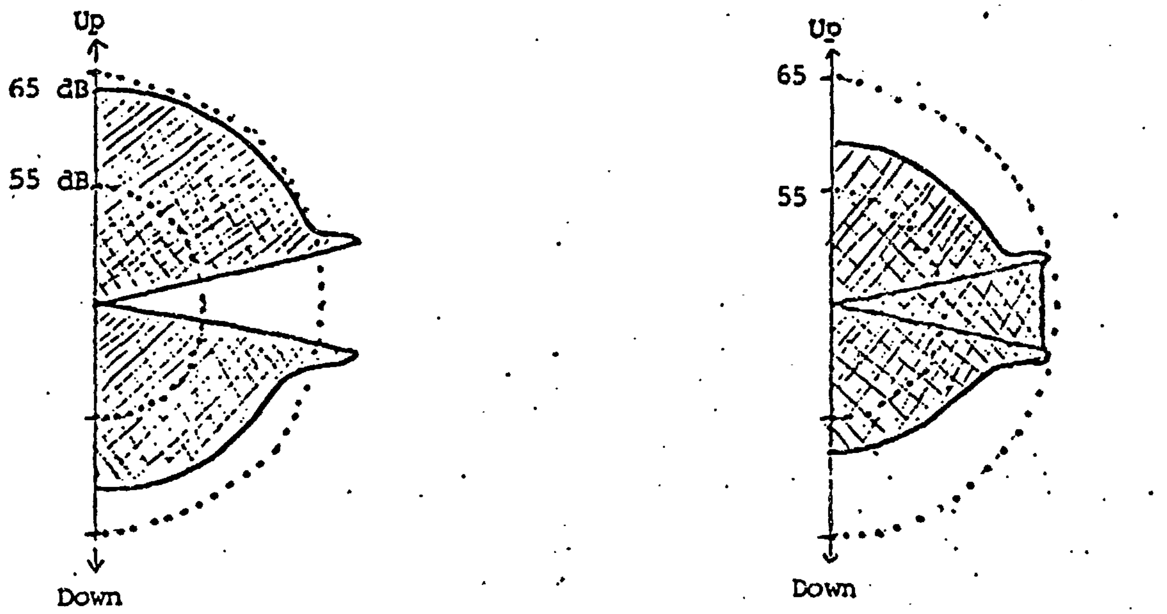
Figure 9A



Sound Speed Profile

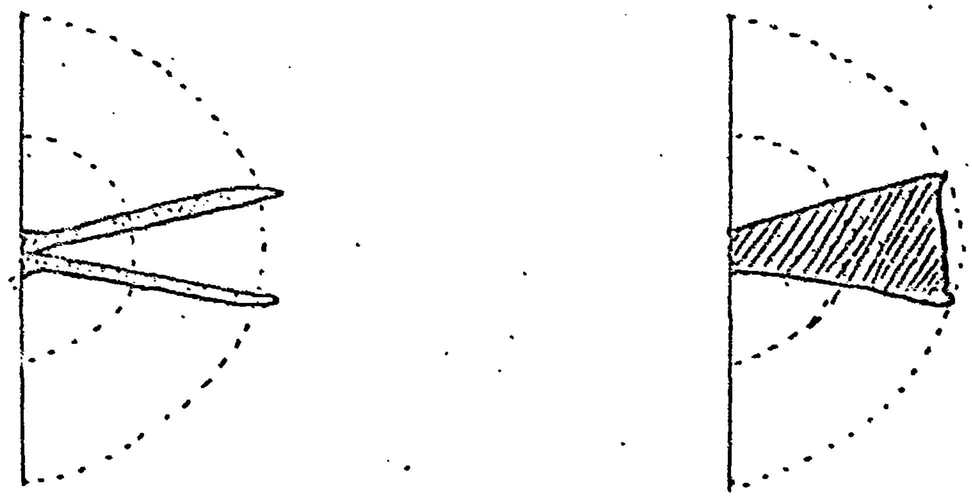
Noise Arrival Angles (Surface Source; Range-Independent Environment)

Figure 9B



Noise Vertical Directionality - Notch Not Filled

Noise Vertical Directionality Notch Filled; Same Omni Level



Noise Rejected When Notch Not Filled

Noise Rejected When Notch Filled

Figure 10

3.7 Improved Ambient-Noise Prediction Model

The modifications of ASRAP (for VLA applications) to account for noise verical directionality and the "notch" problem are viewed as interim improvements--intended to support new sensor systems as they become operational. There is also a long-term effort underway to upgrade the entire ambient-noise modeling capability.

Recall that the current prediction of omnidirectional noise levels is based on an intelligent extrapolation of low-frequency ship-noise measurements and on "Wenz"-type wind-noise curves. It is essentially an empirical model in the form of a lookup table. The vertical directionality is estimated under assumptions of: range-independent environment, simple ship-source distribution and radiation, and geometric-acoustic propagation. The "notch" modification is essentially empirical. For these reasons, the noise module of ASRAP is believed deficient, principally for the shipping component.

A new model has been developed for ship-generated noise, and will be applied in some way to the ASRAP problem. Either the model will be streamlined, or prediction will be made for a limited set of areas and seasons in advance--and stored in tables for use under conditions approximating those of the pre-selected areas and seasons.

The improved noise model employs range-averaged TL for range-dependent environments. It can thus account for the mechanisms most likely affecting the "notch." Input ship-source data has 1° x 1° resolution, with sound speed and bottom-loss available at similar densities. The model is also capable of predicting the azimuthal (and hence 3-D) directionality of the noise field.

Implementation of this improved noise treatment will significantly enhance the ASRAP/VLA predictive capability.

4. SHARPS III

The second fleet support model which we want to discuss is the third generation Ship Helicopter Acoustic Range Prediction System (SHARPS III). This tactical active and passive sonar performance prediction model has its own history and related technical issues. The major features of this model, and the direction of improvements for it are discussed as well.

4.1 SHARPS History

SHARPS III has evolved with its own development history (Figure 11). The SHARPS prediction capability at FNWC was developed originally in 1969 to support the surface ship Navy with active and passive detection range predictions. The first model (SHARPS I) simply represented a computerized table look-up scheme that extracted predictions from empirical and/or precomputed table values published for each sonar. This basically went to the fleet with values which the sonar operator already had aboard in his sonar system manual. In 1971 an on-scene modification instruction was developed for SHARPS I which allowed the fleet user to make some environmental adjustments to the predictions he received.

In an attempt to get a more environment dependent prediction the FAST MOST (or FAST NISSM) model that Watson and McGirr were developing at then NUC was incorporated into SHARPS II in 1972. This model included raytracing for BB (bottom bounce) and CZ (convergence zone) predictions, and

FIGURE 11

SHARPS DEVELOPMENT HISTORY

(Ship Helicopter Acoustic Range Prediction System)

SHARPS I 1969

-- empirically based tables
-- on scene modification 1971

SHARPS II 1972

-- Watson and McGirr Model
  - ray tracing
  - modified AMOS equations

SHARPS II-1/2 1975

-- new output format
-- new sonars

SHARPS III 1977

-- flexibility
-- reduced NISSM II

used the Modified AMOS (Acoustic Meteorological and Oceanographic Survey) equations for direct path, surface ducts and depressed subsurface channels. This was a very fast model on the computer which was totally optimized and tailored to producing the same predictions as before.

SHARPS up to that time produced a very encrypted message type output that hindered the use of the forecasts. In 1975 the message output format was changed into a more readable, plain language-type output. The inner workings of the model were changed to incorporate newer sonars as well. This version is referred to as SHARPS two and a half.

To overcome many of the deficiencies and constraints of SHARPS II in the 1976 time-frame, the development of SHARPS III was initiated. This version adapted NISSM II as the basic acoustic model, which had been developed in 1973 by Dr. Henry Weinberg at NUSC.

4.2 SHARP III Acoustic Model Features

The major environmental acoustic model features of SHARPS III are calculation of propagation loss for echo, reverberation and passive signals and the calculation of reverberation itself (see Figure 12).

With the SHARPS III model being based upon NISSM II a continous gradient raytrace technique is employed which avoids problems with false caustics as found in the more common constant gradient ray techniques. The raytrace technique was initially developed in the CONGRATS (Continuous Gradient Tracing System) model series in 1967. At any

FIGURE 12

SHARPS III

ACOUSTIC MODEL FEATURES

- Propagation
  - Continuous Gradient Raytrace (4 one-way paths)
  - Advanced AMOS Equations
  - Selected Paths for Echo Loss
  - Simple Extended Range Algorithms

- Reverberation
  - Surface
  - Bottom
  - Volume (2 layer)
  - 16 Paths each Component

particular target or scattering point SHARPS III determines up to 4 one-way paths (i.e., eigenrays) as compared to NISSM II originally generating a minimum of 8 and up to a maximum of 32 one-way paths.

For surface duct and subsurface duct propagation paths an advanced version of the Modified AMOS equations are utilized. These are felt to be an improvement over the modified equations used originally in NISSM I and II. To improve the efficiency of the model as well as have a clear identification of the propagation paths used in echo calculations special selections are made in the ray paths used. For reverberation and passive propagation calculations such path selections restrictions are not performed. Also, the range intervals for the echo calculations are specially selected and limited in number to enhance efficiency. For passive and counter-detection predictions which involve extreme ranges (beyond 100 kyds) simple TL explanations algorithms are used. These algorithms are very rough estimators which is commensurate with the extended range predictions being made.

Like NISSM II, SHARPS III calculates surface, bottom and volume reverberation components to gain an estimate of the total reverberation field as a function of time. One difference is that the volume column scattering strength value provided as an input is uniformly partitioned into two layers in the vertical. One layer is within the surface duct, if present, and the other below the layer up to a maximum depth of 1000 meters.

For the reverberation calculations there are up to 4 one-way paths (or 16 two-way paths) determined for each scattering point (i.e., area or volume element). This compares to the minimum of 8 and a maximum of 32 one way paths (or 1024 two-way paths) used in NISSM II.

The SHARPS III model determines the particular active sonar detection range by examining the predicted peak echo to a combined background of reverberation and self-noise. The passive and counter-detection range predictions are based upon the sonar and target input data, and the calculated propagation loss.

Figure 13 summarizes the components or submodels within SHARPS III. In particular it shows which components were removed from NISSM II to construct SHARPS III. Also, some of the treatments are different due to the unique application of SHARPS III compared to NISSM II.

Like most fleet tactical ASW support models, SHARPS III is limited to deep water and range independent environments. The volume reverberation scattering strength value given as an input is a single column strength value which may or may not reflect the actual distribution of scatters in depth. The model's application is primarily for ASW mobile sonars that operate in the medium to high frequency domain of approximately 1 to 15 kHz, and are typically concerned with target detection within the first CZ or less in range. Without modification to the model or inputs the active sonar predictions are for zero doppler or equivalent type targets.

4.3 SHARPS III Automation and Environmental Inputs

Like ASRAP, SHARPS III is part of an automated forecast system at FNWC. The model is used to produce routine and special predictions that can be based upon standard oceanographic synoptic forecasts or based upon the environmental data provided by the prediction requester.

FIGURE 13

SHARPS III MODEL COMPONENTS

ITEM	FUNCTION	TREATMENT/MODEL
1	Depth, Temperature, and Salinity to Sound Speed	Leroy Equation
2	Volumeteric Absorption Coefficient	Hall-Watson Equation
3	Bottom Loss Low Freq. (<1 kHz)	FNWC Bottom Loss Model
4	Bottom Loss High Freq. (≥1 kHz)	NAVOCEANO Bottom Loss Model
5	Surface Loss (Duct)	Marsh and Schulkin
6	Surface Loss (Ray-trace)	Beckmann-Spizzichino/Leibiger
7	Ray-trace Propagation Loss	Continuous Gradient and Eigenrays
8	*Surface Duct Propagation Loss	Advanced AMOS Surface Duct Equations
9	*Subsurface Duct Propagation Loss	Advanced AMOS Subduct Equations
10	Caustic Correction (Smooth)	Ludwig Smooth Caustic Treatment
11	*Boundary Shadow Zone	Removed
12	Reverberation Calculation Method	NISSM II/CONGRATS III
13	Bottom Backscattering Strength	MacKenzie Model
14	Surface Backscattering Strength	Chapman and Harris Model
15	*Surface-Bottom Echo	Removed
16	Target Depth	60 ft and SLD + 200 ft
17	Target Strength	15 dB Default Value for Random Aspect
18	Target Doppler	No Target Dopper Effects and Gains
19	*Sonar Vertical Beampatterns	Sin (x)/x Equation
20	*Signal and Processor Types	Recognition Differential
21	*Detection Probability	Log Normal Distribution with 12 dB Sigma
22	*Detection Range	Specified Signal Excess Achieved
23	*Variable Depth Sonar Tow Depth	AN/SQS-35 Doctrine
24	*Helicopter Sonar Dip Depth	AN/AQS-13A Guidelines

* Represents a substantial difference between NISSM II and SHARPS III

SHARPS III utilizes the same bottom loss model as ASRAP. The volume scattering strength input for reverberation is a column strength value that is current for two frequency domains and a few large ocean areas.

4.4 SHARPS III Sample Message

The standard U.S. Navy SHARPS III forecast contains the predictions for the sonars listed in Figure 14, and the related modes of operation. Figure 15 presents a hypothetical sample of the SHARPS III message output for illustration purposes. Like the ASRAP forecasts the upper few lines give the general environmental acoustic data for the predictions. Active predictions are generated for mostly in layer/and below layer targets, with the ranges given in hundreds of yards. The bottom bounce (BB) predictions (D/E angle and range) are for the inner and outer ranges as well as for the peak signal excess point.

The complete SHARPS III forecast is generated in about 90 to 100 seconds on the CDC 6500 computer, but selected parts of the prediction can be done in far less time.

FIGURE 14

SHARPS III PREDICTIONS

Sonar System	Code	Predictions Produced	
SQS-39	S39	DP	Active
SQS-23 TRAM	S23	ODT	Active
MIP		DP	
LORA		CZ	
SQQ-23	Q23	ODT	Active
		RDT	
		CZ	
		Passive	
SQS-26 Steel Dome	S6S	ODT	Active
		PDT	
		BB/TF	
		CZ	
		Passive	
SQS-26 Rubber Dome	S6R	Same as SQS-26 Steel	
SQS-53	S53	Same as SQS-26 Steel	
SQS-56	S56	ODT	Active
		RDT	
SQS-35 PM-ON	S35	ODT	Active
		RDT	
		Passive	
		Tow Depth	
SQS-35 PM-OFF		Same as PM-ON	
AQS-13	S13	OMNI	
		Passive	
		Dip Depth	

FIGURE 15

SAMPLE SHARPS III FORECAST
(Contains False Information)

```
48 HR SHARPS III FCST FROM 12Z 22 OCT 1979

B125  0484  20483  L38488  41486  43484  48481  58476  80473 100471
POD 50. 4879 4822   4889    4887   4887   4886   4884   4886   4887
WH 01 WS 15 AVG SVL    4887 SLD   382 DP TGT  582 DR/DX  565/ 882
AN 80/69/68 VSC -LO  -54.   HI -45   GR      -.3 BL  6 VAR 20


S39 ----12KTS------18KTS------24KTS-------------CDC/CDM
 ALL    29/17       21/15      18/13              190/569

S23 ----12KTS------18KTS------24KTS-----CZW------CDC/CDM
 MP/L  120/76       43/44      41/43   673-703    932/932
 TR/O   45/45       34/37      33/33              932/932

Q23 ----12KTS------18KTS------24KTS-----CZW------CDC/CDM
 ODT   121/94       80/45      34/39              819/895
 RDT   155/120     141/100     93/71   670-724    932/976
 PSV   QT    21  -  21/11 - 11 NSY 106 - 608/      46 - 46

S56 ----12KTS------18KTS------24KTS-------------CDC/CDM
 ODT    50/50       50/50      44/48             1120/1074
 RDT   50/186       50/148     50/50/            1226/1084

S6S ----12KTS------18KTS------24KTS-----CZW------CDC/CDM
 ODT   132/90       90/32      23/24              982/1026
 PDT   180/144     130/92      42/42   678-699   1031/1099
 BB   MIN-A/R     15/14 MAXSE-A/R  15/17  MAX-A/R     5/25
 PSV  QT    49  -   49/36 - 36 NSY 210  -  641/   49 - 606

S6R ----12KTS------18KTS------24KTS-----CZW------CDC/CDM
 ODT   146/98      100/45      32/31             1015/1057
 PDT   194/164     145/101     44/44   679-700   1120/1139
 BB   MIN-A/R     15/14 MAXSE-A/R  15/17  MAX-A/R     5/66
 PSV  PT    45  -   45/32      NSY 194  -  639/   49 - 600

S53 ----12KTS------18KTS------24KTS-----CZW------CDC/CDM
 ODT   188/218     186/218    178/218            1676/1678
 PDT   198/218     193/218    193/218  179-342  1887/1678
 BB   MIN-A/R       /   MAXSE-A/R    /    MAX-A/R      /
 PSV  QT  609 - 755/615 - 677 NSY 1173 - 1356/1173 - 1355

S35 ----12KTS------18KTS------TD----------------CDC/CDM
 ODT     23/67      23/43      10                 162/498
 RDT     46/75      23/66      10                 199/579
 ODTP    41/75      41/75      10                 182/498
 RDTP    66/78      66/78      10                 199/579

S13      47/35      DD 10      PSV  11 - 10    CDC 322 CDM 390
```

5. IMPROVEMENTS IN EVA MODELS FOR SHARPS

5.1 EVA Model Deficiencies

Probably the most serious deficiency we see today is in basic evaluation of active sonar performance prediction models and the basic EVA components that make up such models. Even in what evaluation work we have done to date, it is clear that we need a medium to high frequency surface duct model or a series of models in which we can take confidence. We must also be able to apply them effectively to any real near-surface sound speed profile structure. The basic surface duct model in the U.S. Navy today (i.e., the AMOS equations) originated in 1954 when computers were a rarity, and little has been done since.

Similar arguments apply to the long standing problems with shallow water. In reverberation we have a number of problems that deal with a basic understanding of the environment as well as being able to effectively implement into numerical models what we know already. Of related importance is having a better data base to work with for volume and bottom backscattering in all of the ocean areas of interest to ASW. Some research into predicting and modeling volume and bottom scattering properties appears possible utilizing indirect information such as biologic patterns and geophysical properties of ocean areas.

For the modern multimode active sonars there are some serious deficiencies in modeling how the environment and a complex sonar system interface and interact.

Almost all active sonar models are designed for the simple single beam, CW pulse, search-light type sonar. Similarly, the more sophisticated sonar systems are more sensitive to the fluctuations and variability that have been to date ill-defined.

NORDA is sponsoring a number of developments which should directly benefit SHARPS III and related performance prediction capabilities. Some of these developments are currently underway while others will be initiated within the near future.

A comparison between SHARPS III and NISSM II echo and reverberation levels has been completed which illustrates the key differences between the two models. For most environments the models agree, and whey they do differ it is most often due to the manner in which the two models operate.

Requests from the fleet have indicated the desirability of having an on-scene modification scheme or instruction which will allow them to make adjustments in the FNWC produced predictions. This would be for observed changes in parameters such as wind speed, wave-height and layer depth. This capability is under development.

For SHARPS III there is a serious need for a more acceptable treatment of shallow water, and half channel environments and for passive and counter/detection predictions. For these predictions a multitude of paths are involved and definitely more than the four currently modeled.

SHARPS III should be modified to generate predictions for active sonobuoys which are not now supported with a completely accurate and realistic model. Active ASRAP predictions are only for noise limited conditions, and it can not effectively predict for the more modern active buoy sensors such as ERAPS.

5.3 Volume Scattering Data Base

NORDA has sponsored and developed a much better volume scattering strength data base for FNWC, and this should become operational in the near future. This development represents a substantial improvement compared to the existing data base. In the area of model evaluations NORDA is undertaking the evaluation of SHARPS III and NISSM II type models using available data and the results of fleet exercises. Just the methodology that should be used in active model evaluations is of concern. How do you gain a measure of confidence in what you predict with a numerical model?

6. SUMMARY

The preceding discussion addressed the status of the ASRAP and SHARPS performance-prediction models, with emphasis on the environmental acoustic components. Note that the current capabiity supports passive sonobuoys (including vertical line arrays) and most active sensors, and provides a means to estimate signal excess or detection ranges against characteristic submarine targets.

The models reside at FNWC, where ocean environmental conditions are predicted and used as inputs to the acoustic transmission and noise modules. These acoustic-model components of ASRAP and SHARPS incorporate in some cases technology current over the past five years, but a number of deficiencies still exist.

Plans to remove deficiencies and improve the overall product apply to three general areas: Model Inputs, EVA Models, and Applications. Figure 16 lists specifics under these categories.

This presentation represents an overview of the status of a special tactical-sensor performance prediction capabiity. The important point to be made is that the forecasts are a valuable asset to ASW forces and that significant improvements are in progress.

FIGURE 16

AREAS OF PLANNED MODEL IMPROVEMENT

INPUTS

- Ocean Models (Thermal, Circulation)
- Boundary Descriptions (Bottom and Surface Properties)
- Ocean Regions (Shallow Water)

EVA MODELS

- Efficiency and Response Time
- Surface Interaction
- Bottom Interaction
- Ducted Propagation
- Reverberation
- Evaluation to Remove Uncertainties

APPLICATIONS

- Advanced Sensors (VLAs, Horizontal Arrays, Deep Sensors)
- In Situ Environmental Data
- On-Scene Modifications to Shore Based Forecasts

APPENDIX C
VIEWGRAPHS AND TEXT
FOR
MILOC

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A. Introduction; ASRAP and SHARPS (5 min.)

VG	
AA-1	Introduction to Acoustic Performance Prediction Models for Fleet Support of Tactical ASW Sensors
AA-2	Passive Sonar Equations
AA-3	Active Sonar Equations
AA-4	Passive ASRAP - applications, features, status
AA-5	SHARPS III - applications, features, status

B. What Passive ASRAP (OMNI) does; its status (5 min.)

VG	
BB-1	Passive ASRAP - outline
BB-2	ASRAP History
BB-3	ASRAP TL Model - FACT
BB-4	Principal Constraints and Limitations for FACT
BB-5	Environmental Inputs and ASRAP Automation
BB-6	ASRAP Noise Prediction
BB-7	ASRAP Teletype Sample Message
BB-8	PHITAR Message Format Sample

C. ARRAP - Related Improvements (7 - 10 min.)

VG

CC-1	Deficiencies in EVA Models for ASRAP
CC-2	ASRAP Modification for VLA's
CC-3	TL: Improved Surface Duct
CC-4	Bottom-Loss Upgrade
CC-5	TL for Shallow Water
CC-6	Noise Notch Problem
CC-7	Improved Noise Prediction

D. What SHARPS does; its status (5 min)

VG

DD-1	SHARPS III Outline
DD-2	SHARPS History
DD-3	SHARPS III Features
DD-4	SHARPS III Model Components
DD-5	SHARPS III Limitations and Constraints
DD-6	EVA Inputs
DD-7	SHARPS Predictions Produced
DD-8	Sample Prediction

E. SHARPS - Related Improvements (5 min.)

<u>VG</u>	
EE-0	Deficiencies in EVA Models for Active
EE-1	SHARPS III Related Improvements

F. Summary (3 min.)

<u>VG</u>

FF-1 EVA Modeling for ASRAP/SHARPS

ACOUSTIC PERFORMANCE-PREDICTION
MODELS FOR FLEET SUPPORT
OF TACTICAL SENSORS

- FNWC (Shorebased) Forecasts
    - SHARPS
    - ASRAP
- EVA Model Components
- NORDA Responsibility
- Status
- Improvements

VG	TITLE	WORDS
AA-1	EVA Models for Fleet Support	Talk is concerned with EVA models to support tactical ASW systems, specifically the shorebased Fleet support products generated by FNWC: SHARPS & ASRAP. The predictions use FNWC's analysis of the ocean medium as inputs acoustic models, which in turn are used to estimate terms in the SONAR equation. This talk concetrates on the EVA components of the two principal models, describes how they work, their status, and potential/planned improvements. I represent NORDA, which has responsibility to maintain/upgrade/ develope EVA models such as SHARPS & ASRAP- this talk is limited to NORDA 530 work.---

PASSIVE SONAR EQUATIONS

$$SE = \{\text{Array Output Signal}\} - \{\text{Array Output Noise}\} - RDN$$

$$= \{SL-TL+ASG\} - \{N+ANG\} - RDN$$

where SL = source level

TL = transmission loss (to omni receiver) (dB)

ASG = array gain for signal (dB)

N = omni background noise (dB)

ANG = array gain for noise (dB)

RDN = recognition differential (dB)
= array output signal-to-noise ratio (SNR) such that detection probability is 0.5

SE = signal excess

Regroup as:

$$SE=SL-TL-N+\underbrace{\left\{ ASG-ANG \right\}}_{\substack{\text{ARRAY GAIN (AG)} \\ \text{OR} \\ \text{DIRECTIVITY INDEX (DI)}}} - RDN$$

Also: $$FOM=\left\{ TL \text{ when } SE=0 \right\} = SL-N+DI-RDN.$$

VG	TITLE	WORDS
AA-2	Passive Sonar Equations	Signal Excess is given in terms of system, target and environmental parameters. This is the "conventional" sonar equation (in dB's). Values are usually <u>Means</u>. In first equation, grouping shows signal (at array output) , noise (at array output) and RDN. Second grouping focuses on array gain or DI. Last one shows FOM.

BASIC ACTIVE SONAR EQUATIONS

NOISE LIMITED CONDITION

$$SE = SL - (N - DI) + TS - RDN_n - TL \text{ (2 way)}$$

FOM

REVERBERATION LIMITED CONDITION

$$SE = SL - RL + TS - RDN_R - TL \text{ (2 way)}$$

COMBINED BACKGROUND

$$SE = SL - 10 \log \; 10^{\frac{(N-DI)}{10}} + 10^{\frac{RL}{10}} \; - RDN_X - TL \text{ (2 way)}$$

Background

where

SE = Signal Excess (dB)
SL = Transmitter Source Level (dB)
N = Effective Isotropic Noise (dB)
DI = Noise Directivity Index (dB)
TS = Target Strength (dB)
RDN = Recognition Differential (dB)
TL = Echo Transmission Loss (dB)
RL = Reverberation Level (dB)
FOM = Figure of Merit (dB)

ASRAP III

(ACOUSTIC SENSOR RANGE PREDICTION SYSTEM)

- Applications
  - Omni Sensors (Sonobuoys)
  - Inputs to Sonar Equation (TL, AN)
  - Tactical Decision Aids
- Features
  - Automated Prediction System
  - Efficient Software
  - Based on FACT Model & Noise Data
- Status
  - New Systems (VLA)
  - Evaluation

VG	TITLE	WORDS
AA-4	ASRAP III	"ASRAP" stands for...., and "III" means 3rd version. The forecast applies mainly to sonobuoys. It is useful at several levels from sonar equations to Decision Aids. As noted in the SONAR equation, we need TL and N passive from EVA models for Passive Sonars. Given these, we can find P_D (R), etc. Such predictions are used to decide when to deploy, buoy pattern, best frequencies, expected performance, force levels, etc. The FNWC ASRAP system is fully automated ..., and quite fast... The EVA models of interest here are for TL (FACT) and AN (now, table lookup based on data). The current ASRAP has been in FLEET use for 6 years and has been subjected to many tests of reliability and quality. There are, however, deficiencies, which are discussed later under heading of future plans. We note that it has recently been upgraded to support new generation of VLA's.

SHARPS III

(Ship Helicopter Acoustic Range Prediction System III)

Applications - Tactical ASW Sonars
- Active Detection Ranges
- Broadband Passive Detection Ranges
- Active Counter-Detection Ranges
- Tow and Dip Depth Selections

Features - Automated Prediction System
- Efficient Software
- Flexible Inputs and Outputs
- User Oriented
- Based upon NISSM II

Status -
- Evaluations
- Application to New Systems

VG	TITLE	WORDS
AA-5	SHARPS III	The primary application of the SHARPS III model is for tactical ASW sonars. However, it is not restricted to surfaceship and helicopter sonar systems but can produce predictions for any like sonar such as for submarines and sonobuoys. The emphasis is upon predicting active sonar detection ranges for various modes of operation out to just beyond the first CZ. Also, the model produces prediction for broadband passive sonar modes as well. The counter-detection (or interception) ranges of the active emissions are also predicted. For Variable Depth and Helicopter Sonars the optimum tow and dip depths are determined as a function of environment. The major feature of SHARPS III is that it is part of an automated and complex navel message and computerized environmental prediction system that the U.S. Navy takes pride in. The software design of SHARPS is such that a large number of varying predictions can be generated in an efficient and cost-effective

VG	TITLE	WORDS
AA-5	(continued)	manner. Also, the model is designed to interface with fleet-type users and does not require an experienced sonar type acoustician to establish a particular prediction. (Naval Interim Surface Ship Model) NISSM II was the starting point of the basic acoustic model. However, to meet the limitations on computer resources a number of the features and in-depth treatments of the environment within NISSM II had to be sacrificed. At the present time we are involved in a serious evaluation of SHARPS III as well as examining the basic accuracy of NISSM II-type active sonar models. These evaluations are essential if we are going to have any measure of confidence in these models. Also, the SHARPS-type models must keep up with the introduction of new sonar systems.

Passive ASRAP

- Basic Components:
  - Environmental Inputs
  - Transmission Loss (FACT Model)
  - Ambient Noise (Data Bank)
- History
- Discussion of Some Details
- Future Improvements (R&D)

VG	TITLE	WORDS
BB-1	Passive ASRAP	Now discuss ASRAP History and how ASRAP works - inputs, modules for TL and AN, as well as VLA modifications, evaluation and future improvements. Recall from sonar Equations that EVA parameters needed are TL and AN (for omni case). This is exactly what ASRAP predicts. User must provide other inputs to get SE, and PD(R) (viz., SL, RDN, DI). Later talk about arrays and array gain (vice DI) in terms of VLAs..

DEVELOPMENT HISTORY
OF THE PASSIVE ACOUSTIC SENSOR RANGE PREDICTION SYSTEM (ASRAP)

ASRAP I 1967
- developed at FNWC
- simple raytrace, direct and BB
- empirical CZ
- Clay Surface Duct Equation

ASRAP II 1970
- developed at FNWC
- version of RP-70 raytrace
- Clay Surface Duct Equation

ASRAP III 1973
- initiated at BTL
- finalized at AESD
- FACT raytrace
- Clay Surface Duct Equation

1978
- vertical line array modification

VG	TITLE	WORDS
BB-2	ASRAP History	Principal technical development phases are shown-to indicate activity: 1st ASRAP was simple - ASRAP II used better TL calculation (RP-70), but retained simpaled duct model, old bottom classes, AN tables, etc. ASRAP III has much more sophisticated TL (FACT Ray trace). Other things only superficially changed. Retain essence of bottom classes, noise tables, duct model form 1967. Only substantive change in past 6 years is adjustment of bottom classes and addition of VLA prediction capability.

ASRAP
TRANSMISSION LOSS MODEL

FACT
(Fast Asymptotic Coherent Transmission)

- Standard (classical) Ray Trace
- Special Caustic Corrections
- Semi-Coherent (image-interference)
- Fast and Efficient
- Special Treatment
  - Surface Duct
  - Half Channel
  - Shallow Water

VG	TITLE	WORDS
BB-3	ASRAP TL Model	FACT produces TL as function of range for selected frequencies. Features are listed. Emphasize clever ray trace (usually fewer than 50 rays) and (curve-fit) in (R,) space to get $(\frac{dR}{d})$. Also, caustic correction is based on uniform asymptotic theory--it removes "blow-up" of ray theory for focusing (caustics). "Semi-coherent" mode means paths that differ only by surface reflection are added in phase (coherently) to include Lloyd's minor (or surface-image-interference) for low-frequencies and shallow source or receiver. Program is fast: About 7 seconds on CDC 6500 for 4 frequencies, 2 source depths, 2 receiver depths with predictions every 1/2 nm to 120 nm. To save time, there are special routines for duct, half-channel, shallow water.

PRINCIPAL CONSTRAINTS AND LIMITATIONS FOR FACT

- Geometric Acoustics (with mods)
- Range-Independent Environment
- Boundary-Interaction
  - -- Bottom
  - -- Surface
- Duct
  - -- Spreading/Cut-Off
  - -- Leakage
  - -- Scatter
  - -- Surface
- In ASRAP, no directionality (Signal Beam-Pattern Corrections)

State of Evaluation

- Undergone extensive testing against data and analytic solutions
- Currently termed U.S. Navy Standard Model (for range-independent environments and low frequencies)

VG	TITLE	WORDS
BB-4	Constraints, For FACT	FACT is a ray-trace (although modified) and is hence subject to some limits in frequency (e.g., predictions below 25 Hz may well involve bottom interactions not appropriate to the model). Also, the density of rays calculated limit FACT's accuracy at very short ranges. The sound speed and bathymetry are assumed independent of range - reasonable for short-range, deep-water cases, but not always for shallow water or long range. The boundaries are treated as smooth and horizontal, with loss functions (per bounce) depending on frequency and grazing angle (at present, surface loss is zero.) A special routine for surface ducting accounts for surface scatter, low-frequency cutoff and leakage, but has questionable accuracy. As configured for ASRAP, signal arrival angles are not available from FACT.

VG	TITLE	WORDS
BB-4	(Continued)	FACT has undergone extensive evaluation and is viewed as having accuracy consistent with the ASRAP application, subject to the limits already mentioned and the quality of environmental inputs.

ENVIRONMENTAL INPUTS AND AUTOMATION FOR ASRAP

- Automation
  - Daily Forecasts for Hundreds of Selected Cases
  - Special Requests
- Sound-Speed Profile
  - FNWC Data Base and Forecasts Periodic Updating/Sources
  - User Input Option
- Wind Speed Wave Height
  - FNWC Data Base and Forecasts
  - Conversion
- Bottom Loss
  - FNWC Data Base
    3 classes for low frequencies
    9 classes for high frequencies
    ASW Prediction Areas
    Loss versus grazing angle

VG	TITLE	WORDS
BB-5	Environmental Inputs and ASRAP Automation	ASRAP is resident at FNWC, Monterey, CA and makes daily forecasts for ASRAP "points" in certain Prediction Areas Automatically, i.e., it extracts sound-speed and wind/wave data from the FNWC analysis and executes without human assistance. Special requests can be filled in short time (12 hrs) when inputs are user-provided. The FNWC performs a daily (every 12 hours) analysis of sound speed using BT observations and historical T-S files. Likewise for wind speed. Finally, bottom loss curves for ASRAP are....

VG	TITLE	WORDS
BB-6	ASRAP Noise	There is at present no noise "prediction" "model" for ASRAP consistent in detail and sensitivity with the TL model. The approach assumes two prevailing components: ship-generated and wind-generated. Omnidirectional ship noise is estimated by table look-up, and is based on old measurements at 100 Hz, extrapolated in frequency according to surface-ship radiated-noise spectral shape. The resulting omni levels are independent of receiver depth and change with season according to a simple formula (+2 dB in winter, -2 dB in summer). To the ship component is added a wind component based on Wenz-like curves, which depend only on frequency and wind speed. This empirical model has undergone no evaluation in recent years and has many obvious sources for error and uncertainty. Standard ASRAP predicts omni levels, and is fully automatic. N.b., just as in the case of sound speed, users can provide input noise levels (from <u>in situ</u> observations) to FNWC for incorporation in ASRAP predictions.

EXAMPLE

MEDITERRANEAN PASSIVE ASRAP MESSAGE

```
PASSIVE ASRAP 8 DAY FCST FROM 3 500Z DEC 74
MM01   0630  10630  20592  26581 57558  98558  131552  151550  197547
WH   1 GR 3.8 74120300,  AN 98/ 81/ 68/ 55    NA DR/DX   106/   643
 850HZ

60.....5....10...15...20...25...30...35...40...45...50...55...6.0
  .
  .
  .X     D
  .     D    I
70..DD...........D.............................................
  .CI     D     D         I
  .  I D   D   D        DX
  . CCXI    D X   D            DD    I
  .   CCC    D     DDD D  D            DD        I
80......IX1.X.........D....DDD.D..D.............DD.............
  .       CC   X         C C  D    DDXDD  D       DI    DD
  .        I  X    C                 C X   DDDDD   DD  D  D
  .          C  IXX     C X                          DD    DD
  .             C  IXII             C   I        X C         D
90...................C.X...IC......C..C..I..........X..........
```

FREQUENCY

RANGE IN NM

FIGURE OF MERIT

VG	TITLE	WORDS
BB-7	ASRAP Teletype Sample	Now we show sample ASRAP prediction

VG	TITLE	WORDS
BB-8	PHITAR	This is sample ASRAP prediction in abbreviated form - becoming popular because of reduced message traffic.

Deficiencies in EVA Models
For ASRAP

- TL: Boundary Interaction
  Ducting
  Shallow Water
  Variation/Fluctuations

- AN: Omni Levels
  Directional Field
  Spatial Details
  Variation/Fluctuations

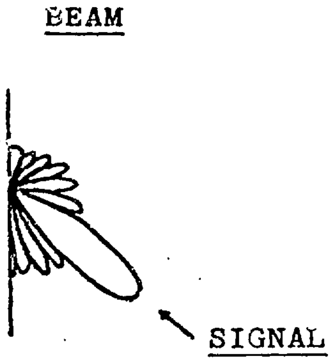
- Inputs: Boundary Properties
  Ship Sources
  Sound Speed/Weather

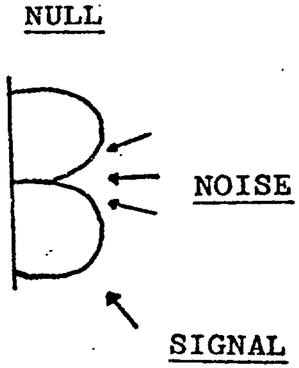
VG	TITLE	WORDS
CC-1	Deficiencies in ...ASRAP	With the preceding description of current ASRAP III and history, we now focus on deficiencies and how we are working to eliminate them. The list shows principal problem areas of direct interest to us - EVA problems. For TL, bottom loss is old and based on poor understanding of mechanisms/sparse data. Rough surface loss/scatter is is not accounted for except in the surface-duct equation. The duct model dates to 1967 and is not given such credence. We have little confidence in shallow-water predictions - because of lack of boundary-interaction understanding, complicated environment, and sparse inputs. Proper sonar equation deductions about PD require some knowledge about SE flux. Likewise, the sensitivity of ASRAP predictions to environmental inputs should be known. AN is in bad shape. Empirical model is of dubious accuracy... Only omni, broadband levels are given.

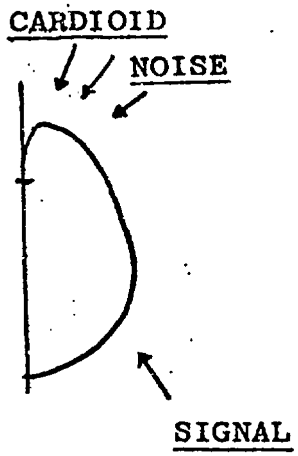
VG	TITLE	WORDS
CC-1	(Continues)	Principal Input deficiencies relate to bottom interaction, the location and properties of ship noise sources, and the reliability of the FNWC sound-speed and wind predictions. We now discuss our program and plans to attack some of these problem areas.

ASRAP MODIFICATION FOR VLA

- **VLA RESPONSE**







  - SIGNAL (TL) IS MODIFIED BY VERTICAL GAIN
  - AT LOW FREQUENCIES, NOISE NEAR THE HORIZONTAL (SHIPPING NOISE) IS REJECTED
  - AT HIGHER FREQUENCIES, NOISE FROM ABOVE (WIND NOISE) IS REJECTED

- **ASRAP/VLA MODEL**
  - PREDICTS SIGNAL (TL) ARRIVAL AND MODIFIES TL ACCORDING TO ARRIVAL ANGLE AND ARRAY RESPONSE
  - PREDICTS NOISE VERTICAL DIRECTIONALITY AND OMNI LEVEL (ASRAP). NOISE GAIN IS CALCULATED FROM ARRAY RESPONSE TO DIRECTIONAL NOISE FIELD
  - OUTPUT IS A "MODIFIED" TL, INCORPORATING BOTH SIGNAL AND NOISE GAINS

VG	TITLE	WORDS
CC-2	VLA Modification to ASRAP	New US and other buoy systems have vertical line arrays (VLA), designed to receive bottom bounce signals (at D/E angles of 15° 60°+) and reject noise from distant ships at low frequencies (DE angles of 0° to 15°) and wind noise at higher frequencies (DE angles of 60° to 90°). ASRAP has been modified for these applications to predict signal and noise gain incorporated in "effect TL." The modification involves the following steps: • Generate store VLA vertical beam patterns (vs frequencies), i.e., response to plane waves as function of vertical arrival angle. • Develop noise vertical directionality module which predicts arrival structure of wind component and ship component. Then use omni levels in current ASRAP to get actual noise level versus angle. • Convolve beam pattern with TL arrival structure to get received signal (SL-TL+ASG).

VG	TITLE	WORDS
CC-2	(Continued)	• Convolve noise directionality and beam pattern to get received noise (N+ANG). • Modify ASRAP output to provide "effective" TL = (TL-ASG+ANG). This is now comparable to "omni" ASRAP prediction of TL and N for omni receiver.

TL: IMPROVED SURFACE DUCT TREATMENT

- Current Duct Model Based on 1967 "Clay" Equation
  - Oversimplified depth dependence
  - Inaccurate leakage losses

- New Routine
  - Based on mode theory, including "virtual modes," to account for leakage and cut-off.
  - Approximate, efficient technique to obtain range-smoothed TL using mode-like depth functions
  - Special WBK treatment allows depth function extension
  - Specular surface scatter treated as "loss per bounce."
  - Evaluation with wave models and data

VG	TITLE	WORDS
CC-3	TL: Improved Surface Duct	Original (Clay) model is early attempt to include wave and rough-surface effects at low frequency in a surface-duct propagation routine. It has the form (in layer): TL(R)=10 log R+leakage+surface loss. This approach was found to be inaccurate: The below-layer level was simply 10 dB down from in-layer. Leakage losses were not properly dependent on the sound-speed characteristics. New model is now being implemented (in FACT/ASRAP). It provides a better treatment of leakage loss and depth dependence using new techniques for approximating mode depth functions. Rough-surface scatter is still not well modeled. Only specular (coherent) term is treated-and then as "loss per bounce" for mode's ray equivalent. Work is in progress to account for non-specular terms and shadowing. The new routine has been compared with detailed wave and mode models, as well as with measurements--with satisfactory results in most cases.

BOTTOM-LOSS UPGRADE

- DEVELOPMENT OF SIMPLIFIED MODEL

  For geophysical Bottom Properties

  For Northern Hemisphere

    Bottom Loss (Angle, Frequency, Location)
    For "Reflection" Models (Fact, ASRAP,..)

  Properties Used Directly in Other Models
    (PE, Normal Modes,...)

- IMPLEMENTATION AT FNWC

  Significant Improvement in Fleet Forecasts

VG	TITLE	WORDS
CC-4	BTM Loss Upgrade	Bottom-reflectivity curves at low frequencies are dated, and do not reflect new understanding of mechanisms - derived from many measurements and much analysis over past 5$^+$years. Geophysical properties are to be incorporated and old curves upgraded. We expect very substantial improvement in ASRAP, especially for systems which rely on bottom-bounce signals (e.g., certain VLA's).
CC-4	Geophysical BTM Models	This is from Waller brief and MGL has explanation for refraction (for thick sediments) and reflection/scatter (thin sediments).

TL FOR SHALLOW WATER

PROBLEM

- TL is often sensitive to range dependencies in environment.
- TL is reverberant, and is strongly dependent on bottom and surface "loss."
- Current ASRAP TL model is input-limited and may have inappropriate physics.

APPROACH

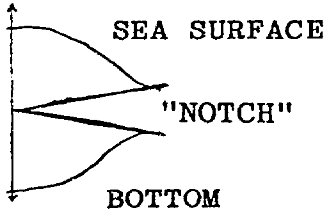
- Address "Predictability Issue": Can we understand/predict TL, AN in shallow water?
- Perform data analysis/model evaluation for high-quality data set.
- Improve inputs/area coverage for ASRAP.

VG	TITLE	WORDS
CC-5	TL for Shallow Water	The Problem is: (a) Current TL model (FACT) is for range-independent environments. (b) Bottom and surface reflectivity, together with complex bathymetry and sound speed drive TL (which is often viewed as "reverberant"). These two things are reasons for not applying ASRAP in shallow water. The approach to the problem is shown. "Predictability Issue" means- is there a chance to solve this problem? (i.e., Because of sensitivity to bottom loss etc., can we predict TL without measuring it?) To begin to answer the question, we use one of best data sets, with measured.environmental inputs - and see if we can explain/ predict the TL, using best available models/analysis capability. Is we find we can do this problem, then we must find efficient way to get inputs for important shallow water areas.

NOISE "NOTCH" PROBLEM

MOST SERIOUS DEFICIENCY IN ASRAP/VLA MODEL IS NOISE PREDICTION

- <u>OMNIDIRECTIONAL LEVELS</u>
  - NOW BASED ON HISTORICAL DATA
  - LONG-TERM IMPROVEMENT IS PLANNED
- <u>VERTICAL DIRECTIONALITY</u>
  - CALCULATION BASED ON SIMPLIFIED AND TRANSMISSION MODELS
  - RESULT IS "NOTCH" NEAR HORIZONTAL, WHERE IS PREDICTED TO BE VERY LOW IN LEVEL



  - BUT, EXPERIMENTS AND MORE PRECISE TRANSMISSION MODELS SUGGEST THAT IN SOME OCEAN REGIONS THE NOTCH IS SUBSTANTIALLY FILLED. DIFFERENCE IN PREDICTED VLA GAIN CAN BE 5 dB OR MORE.
  - INTERIM IMPROVEMENT IS IN DEVELOPMENT (UNDER TAEAS), AND WILL BE IMPLEMENTED DURING FY 79.

VG	TITLE	WORDS
CC-6	Ambient Noise Notch Problem	In some cases, a vertical line array's (VLA) response is designed to discriminate against energy which arrives at angles near the horizontal. This has the purpose of reducing distant-shipping noise, while leaving bottom-bounce signal arrivals undisturbed. At low frequencies (say, less than 300 Hz), the current noise-directionality model often predicts a "notch" in the vertical structure, near the horizontal. Such a prediction presumes a range-independent environment and does not account for diffraction and scattering, so that an array in the thermocline receives energy only from those paths which arrive at angles exceeding the angle of the limiting ray to the surface sources. Measurements and more realistic models suggest that in many areas this "notch" is actually "filled" (or partially filled) with energy injected into lower-angle paths by any of a number of mechanisms

VG	TITLE	WORDS
CC-6	Continued	(e.g., slope conversion, shoaling channel axis). A recent modification to the ASRAP model provides an interim treatment, based on data, to estimate the amount of notch filling as a function of ocean area. As for the effect of all of this on performance predictions, note that the ASRAP/VLA model predicts *array gain against noise*. The absolute, omni-noise level is *given*--independent of predicted directionality. Hence, if the model predicts a notch, the gain against noise may be small (since there is little energy to be reduced). If, on the other hand, the notch is filled, then the VLA system eliminates the noise energy occupying the notch, and thus achieves greater gain (see Figure 10). In this sense, the VLA prediction based on a non-filled notch is *pessimistic* compared with the new prediction.

IMPROVED
NOISE PREDICTION MODEL

- Current Prediction Based on Intelligent Extrapolation of Low-Frequency Ship-Noise Measurements and "Wenz" Curves

- New Model Predicts Ship Noise Using:
  - Ship density fields (1° resolution)
  - Range-averaged TL for range-dependent environment

- Eventual Capability for Depth Dependence and 3-D Directionality
  - Size/Time Constraints for ASRAP and Inherent Sensitivities Suggest Seasonal Predictions or Special Requests.

VG	TITLE	WORDS
CC-7	Improved Ambient-Noise Prediction Model	The modifications of ASRAP (for VLA applicaitons) to account for noise verical directionality and the "notch" problem are viewed as interim improvements--intended to support new sensor systems as they become operational. There is also a long-term effort underway to upgrade the entire ambient-noise modeling capability. Recall that the current prediction of omnidirectional noise levels is based on an intelligent extrapolation of low-frequency ship-noise measurements and on "Wenz"-type wind-noise curves. It is essentially an empirical model in the form of a lookup table. The vertical directionality is estimated under assumptions of: range-independent environment, simple ship-source distribution and radiation, and geometric-acoustic propagation. The "notch" modification is essentially empirical. For these reasons, the noise module of ASRAP is believed difficient, principally for the shipping component.

VG	TITLE	WORDS
CC-7	Continued	A new model has been developed for ship-generated noise, and will be applied in some way to the ASRAP problem. It is currently operational at FNWC, but the computer size/time constraints for ASRAP precludes its direct application to each ASRAP request. Either the model will be streamlined, or prediction will be made for a limited set of areas and seasons in advance--and stored in tables for use under conditions approximating those of the pre-selected areas and seasons. The improved noise model employs range-averaged TL for range-dependent environments. It can thus account for the mechanisms most likely affecting the "notch." Input ship-source data has 1° x 1° resolution, with sound speed and bottom-loss available at similar densities. The model is also capable of predicting the azimuthal (and hence 3-D) directionality of the noise field. Implementation of this improved noise treatment will significantly enhance the ASRAP/VLA predictive capability.

SHARPS III
(Ship Helicopter Acoustic Range Prediction System)

- HISTORY
- BASIC FEATURES
  - Propagation
  - Reverberation
  - Components
- LIMITATIONS
- ENVIRONMENTAL INPUTS
- CURRENT FORECAST
- RELATED IMPROVEMENTS

VG	TITLE	WORDS
DD-1	SHARPS III	We will now discuss the history of SHARPS and how the development of the currently operational SHARPS III came about. This will lead us to were we are today and what areas still need improvements. Some of the basic features and physics of the model will be reviewed as well.

SHARPS DEVELOPMENT HISTORY

(Ship Helicopter Acoustic Range Prediction System)

SHARPS I 1969

- -- empirically based tables
- -- on scene modification 1971

SHARPS II 1972

- -- Watson and McGirr Model
  - - ray tracing
  - - modified AMOS equations

SHARPS II-1/2 1975

- -- new output format
- -- new sonars

SHARPS III 1977

- -- flexibility
- -- reduced NISSM II

VG	TITLE	WORDS
DD-2	SHARPS Development History	The second model which I want to discuss is SHARPS III which is one that has evolved with its own development history. The SHARPS prediction capability at FNWC was developed originally in 1969 to support the surface-ship Navy with active and passive detection range predictions. The first model (SHARPS I) simply represented a computerized table look-up scheme that extracted predictions from empirical and/or precomputed table values published for each sonar. This basically went to the fleet with values which the sonar operator already had aboard in his sonar system manual. In 1971 an on-scene modification instruction was developed which allowed the fleet user to make same environmental adjustments to the predictions be received.

VG	TITLE	WORDS
DD-2	(Continued)	In an attempt to get a more environment dependent prediction the FAST MOST (or FAST NISSM) model that Watson and McGirr were developing at then NUC was incorporated in SHARPS II in 1972. This model included raytracing for BB (bottom bounce) and CZ (convergence zone) predictions, and used the Modified AMOS (Acoustic Meteorological and Oceanographic Survey) equations for direct path, surface ducts and depressed subsurface channels. This was a very fast model on the computer which was totally optimizd and tailored to producing the same predictions as before. SHARPS up to that time produced a very encrypted message type output that hindered the use of the forecasts. In 1975 the message output format was changed into a more readable, plain language-type output. The inner workings of the model were changed to incorporate newer sonars as well. This version at times is referred to as SHARPS two and a half.

VG	TITLE	WORDS
DD-2	(Continued)	To overcome many of the deficiencies and constraints of SHARPS II in the 1976 timeframe, the development of SHARPS III was started. This version adapted NISSM II (Naval Interim Surfaceship Sonar Model II)as the basic acoustic model, which had been developed in 1973 by Dr. Henry Weinberg at NUSC. This model will be discussed next in more detail .

SHARPS III
ACOUSTIC MODEL FEATURES

- Propagation
  - Continuous Gradient Raytrace (4 one-way paths)
  - Advanced AMOS Equations
  - Selected Paths for Echo Loss
  - Simple Extended Range Algorithms
- Reverberation
  - Surface
  - Bottom
  - Volume (2 layer)
  - 16 Paths each Component

VG	TITLE	WORDS
DD-3	SHARP III Acoustic Model Features	Now I would like to discus the environmental acoustic model features of SHARPS III. The major features are the calculation of propagation loss for echo, reverberation and passive signals and the calculation of reverberation itself. With the SHARPS III model being based upon NISSM II a continous gradient raytrace technique is employed which avoids problems with false caustics as found in the more common constant gradient ray techniques. The raytrace technique was initially developed in the CONGRATS model in 1967. At any particular target or scattering point SHARPS III determines up to 4 one way paths as compared to NISSM II originally generating a minimum of 8 and up to a maximum of 32 one way paths. For surface duct and subsurface duct propagation paths on advanced version of the AMOS equations are utilized. These are felt to be an improvement over the modified equations used in NISSM I and II. To improve the efficiency of the model as well as have clear identification of the propagation paths in echo calculations

VG	TITLE	WORDS
DD-3	Continued	special selections are made in the paths used. For reverberation and passive propagation paths no such path selection are performed. Also, the range intervals for the echo calculations are specially selected to enhance efficiency. For passive and counter-detection predictions which involve extreme ranges (beyond 100 kyds) simple TL algorithms are used. These algorithms are very rough estimators which is commensurate with the extend range predictions being made.
		Like NISSM II, SHARPS III calculates surface, bottom and volume reverberation components to gain an estimate of the total reverberation field as a function of time. One difference is that the volume column scattering strength value is uniformly partioned into two layers in the vertical. One within a possible duct and the other below the layer up to a maximum depth of 1000 meters.

VG	TITLE	WORDS
DD-3	Continued	For the reverberation calculations there are up to 4 one-way paths (or 16 two-way paths) determined for each scattering point (i.e., area or volume). This compares to the maximum of 32 one way paths (or the 1024 two-way paths) used in NISSM II. The SHARPS III model determines the particular active sonar detection range by examining the predicted peak echo to a combined background of reverberation and noise. The passive and counter-detection range predictions are based upon the sonar and target input data, and calculated propagation loss.

SHARPS III MODEL COMPONENTS

ITEM	FUNCTION	TREATMENT/MODEL
1	Depth, Temperature, and Salinity to Sound Speed	Leroy Equation
2	Volumeteric Absorption Coefficient	Hall-Watson Equation
3	Bottom Loss Low Freq. (<1 kHz)	FNWC Bottom Loss Model
4	Bottom Loss High Freq. (≥1 kHz)	NAVOCEANO Bottom Loss Model
5	Surface Loss (Duct)	Marsh and Schulkin
6	Surface Loss (Ray-trace)	Beckmann-Spizzichino/Leibiger
7	Ray-trace Propagation Loss	Continuous Gradient and Eigenrays
8	*Surface Duct Propagation Loss	Advanced AMOS Surface Duct Equations
9	*Subsurface Duct Propagation Loss	Advanced AMOS Subduct Equations
10	Caustic Correction (Smooth)	Ludwig Smooth Caustic Treatment
11	*Boundary Shadow Zone	Removed
12	Reverberation Calculation Method	NISSM II/CONGRATS III
13	Bottom Backscattering Strength	MacKenzie Model
14	Surface Backscattering Strength	Chapman and Harris Model
15	*Surface-Bottom Echo	Removed
16	Target Depth	60 ft and SLD + 200 ft
17	Target Strength	15 dB Default Value for Random Aspect
18	Target Doppler	No Target Dopper Effects and Gains
19	*Sonar Vertical Beampatterns	Sin (x)/x Equation
20	*Signal and Processor Types	Recognition Differential
21	*Detection Probability	Log Normal Distribution with 12 dB Sigma
22	*Detection Range	Specified Signal Excess Achieved
23	*Variable Depth Sonar Tow Depth	AN/SQS-35 Doctrine
24	*Helicopter Sonar Dip Depth	AN/AQS-13A Guidelines

* Represents a substantial difference between NISSM II and SHARPS III

VG	TITLE	WORDS
DD-4	SHARPS III Model Components	This viewgraph summarizes the components or submodels within SHARPS III. In particular it shows which components were removed form NISSM II to construct SHARPS III. Also, some of the treatments are different due to the unique application of SHARPS III compared to NISSM II. This table contains far too much detail, and time does not permit us to address each entry.

CONTRAINTS AND LIMITATIONS FOR SHARPS III

- Deep Water
- Range-Independent Environment
- Volume Column Scattering Strength
- Medium to High Frequency Sonars
- First CZ or Less in Range
- Zero Doppler Target

VG	TITLE	WORDS
DD-5	Constraints and Limitations for SHARPS III	Like most fleet tactical ASW Support models SHARPS III is limited to deep water and range independent environments. The volume reverberation scattering strength value given as an input is a single column strength value which may or may not reflect the actual distribution of scatters in depth. Most ASW mobile sonars operate in the medium to high frequency domain of approximately 1 to 15 kHz. These sonars are typically concerned with target detection within the first CZ or less in range. The active sonar predictions are for zero doppler or equivalent type targets.

ENVIRONMENTAL INPUTS
AND AUTOMATION FOR
SHARPS III

- AUTOMATION
  - Daily Forecasts
  - Special Requests
    - Environmental Conditions
    - System/Target Variations
- SOUND-SPEED PROFILE
  - FNWC Data Base and Forecasts
    - Periodic Updating/Sources
  - User Input Option
- WIND SPEED/WAVE HEIGHT
  - FNWC Data Base and Forecasts
  - Conversion
- BOTTOM LOSS
  - FNWC Data Base
    3 Classes for Low Frequencies
    9 Classes for High Frequenies
    ASW Prediction Areas
    Loss Versus Grazing Angle
- VOLUME SCATTERING STRENGTH
  - FNWC Data Base
  - Column Strengh Values
  - High Frequencies Value
  - Low Frequencies Value
  - ASW Prediction Area

VG	TITLE	WORDS
DD-6	Environmental Inputs and Automatic for SHARPS III	Like the ASRAP predictions, SHARPS III is part of an automated forecast system at FNWC. The model is used to produce routine and special predictions that can be based upon standard oceanographic synoptic forecasts or based upon the environmental data provided by the prediction requester. SHARPS III utilizes the same bottom loss model as ASRAP, but more operational use is made of the high frequency bottom loss functions. The volume scattering strength input for reverberation is a column strength value that is current for two frequency domains and a few large ocean areas. This area is a subject in which improvements are being made.

SHARPS III PREDICTIONS

Sonar System	Code	Predictions Produced	
SQS-39	S39	DP	Active
SQS-23 TRAM MIP LORA	S23	ODT DP CZ	Active
SQQ-23	Q23	ODT RDT CZ Passive	Active
SQS-26 Steel Dome	S6S	ODT PDT BB/TF CZ Passive	Active
SQS-26 Rubber Dome	S6R	Same as SQS-26 Steel	
SQS-53	S53	Same as SQS-26 Steel	
SQS-56	S56	ODT RDT	Active
SQS-35 PM-ON	S35	ODT RDT Passive Tow Depth	Active
SQS-35 PM-OFF		Same as PM-ON	
AQS-13	S13	OMNI Passive Dip Depth	

VG	TITLE	WORDS
DD-7	SHARPS III Predictions	The standard U.S. Navy SHARPS III forecast contains the predictions for the listed sonars, and related modes of operation.

SAMPLE SHARPS III FORECAST
(Contains False Information)

```
48 HR SHARPS III FCST FROM 12Z 22 OCT 1979

B125  0484  20483  L38488  41486  43484  48481  58476  80473 100471
POD 50. 4879 4822   4889    4887    4887    4886    4884    4886    4887
WH 01 WS 15 AVG SVL    4887 SLD    382 DP TGT  582 DR/DX  565/ 882
AN 80/69/68 VSC -LO  -54.    HI -45    GR      -.3 BL  6 VAR 20


S39 ----12KTS-------18KTS-------24KTS---------------CDC/CDM
 ALL     29/17         21/15         18/13                  190/569

S23 ----12KTS-------18KTS-------24KTS------CZW-------CDC/CDM
 MP/L  120/76         43/44         41/43    673-703     932/932
 TR/O    45/45         34/37         33/33                  932/932

Q23 ----12KTS-------18KTS-------24KTS------CZW-------CDC/CDM
 ODT    121/94         80/45         34/39                  819/895
 RDT    155/120      141/100        93/71    670-724     932/976
 PSV    QT    21   -   21/11 - 11 NSY 106 - 608/       46 - 46

S56 ----12KTS-------18KTS-------24KTS---------------CDC/CDM
 ODT      50/50         50/50         44/48                 1120/1074
 RDT    50/186         50/148       50/50/                 1226/1084

S6S ----12KTS-------18KTS-------24KTS------CZW-------CDC/CDM
 ODT    1[illegible]/90         90/32         23/24                  982/1026
 PDT    180/144       130/92         42/42    678-699    1031/1099
 BB     MIN-A/R      15/14 MAXSE-A/R  15/17  MAX-A/R       5/25
 PSV    QT    49   -     49/36 - 36 NSY 210   -   641/    49 - 606

S6R ----12KTS-------18KTS-------24KTS------CZW-------CDC/CDM
 ODT    146/98        100/45         32/31                 1015/1057
 PDT    194/164       145/101        44/44    679-700    1120/1139
 BB     MIN-A/R      15/14 MAXSE-A/R  15/17  MAX-A/R       5/66
 PSV    PT     45   -     45/32         NSY 194   -   639/    49 - 600

S53 ----12KTS-------18KTS-------24KTS------CZW-------CDC/CDM
 ODT    188/218       186/218      178/218                 1676/1678
 PDT    198/218       193/218      193/218    179-342  1887/1678
 BB     MIN-A/R          /    MAXSE-A/R      /      MAX-A/R        /
 PSV    QT  609 - 755/615 - 677 NSY 1173 - 1356/1173 - 1355

S35 ----12KTS-------18KTS-------TD-------------------CDC/CDM
 ODT      23/67         23/43        10                     162/498
 RDT      46/75         23/66        10                     199/579
 ODTP     41/75         41/75        10                     182/498
 RDTP     66/78         66/78        10                     199/579

S13       47/35          DD 10         PSV  11 - 10      CDC 322 CDM 390
```

VG	TITLE	WORDS
DD-8	Sample SHARPS III FORECAST	

DEFICIENCIES IN EVA
PREDICTIVE CAPABILITY FOR ACTIVE

- Basic Evaluation
- Surface Ducts
- Shallow Water
- Reverberation
- Volume Backscatter Data Base
- Bottom Backscatter Data BAse
- ENV.-System Interactions
- Fluctuations/Variability

VG	TITLE	WORDS
EE-0	Deficiencies in EVA Predictive Capability for Active	Probably the most major deficiency we see today is in basic evaluation of active sonar performance prediction models and the basic EVA components that make up such models. Even in whatevaluation work we have done to date, it is clear that we need a medium to high frequency surface duct model or a series of models in which can take confidence. We mut also be able to apply them effectively to any real near surface profile structure. The basic surface duct model in the U.S. Navy today (i.e., the AMOS equations) originatged in 1954 when computers were a rarity. Similar arguments apply to the long standing problems with shallow water. In reverberation we have a number of problems that deal with a basic understanding of environment as well as being able to effectively implement into numerical models what we already know. Of related importance is having a better data base to work with for volume and bottom backscattering in all of the ocean areas of interest to ASW. Some research into predicting and modeling volume and bottom

VG	TITLE	WORDS
EE-0	Continued	scattering properties appears possible utilizing indirect information such a biologic patterns and geophysical properties. For the more modern multimode active sonars we are finding some serious deficiencies in modeling how the environment and a complex sonar system interface and interact. Almost all current active sonar models are designed for the simple single beam, CW pulse, search-light type sonar. Similarly, the more sophisticated sonar systems are more sensitive to the fluctuations and variability that have been to date ill-defined.

SHARPS III
RELATED IMPROVEMENTS

- COMPARISON TESTS WITH NISSM II
- ONSCENE MODIFICATION
- BETTER TREATMENT
  - Shallow Water
  - Half Channel
  - Passive/Counter Detection
- ADAPTATION TO ACTIVE SONOBUOYS
- VOLUME SCATTERING STRENGTH DATA
- EVALUATIONS USING FLEET DATA
- EVALUATION OF NISSM II

VG	TITLE	WORDS
EE-1	SHARP III Improvements	NORDA is sponsoring a number of developments which should directly benefit SHARPS III and related performance prediction capabilities. Some of these developments are currently underway while others will be initiated within the near future. A comparison between SHARPS III and NISSM II has been completed which illustrates the key differences between the two models. A report on this is going to press at this time. Requests from the fleet have indicated the desirability of having an on-scene modification scheme or instruction which will allow them to make adjustments in the FNWC produced predictions based upon observed changes in parameters such as wind speed, waveheight and layer depth. This capability is under development. For SHARPS III there is a serious need for a more acceptable treatment of shallow water, and half channel environments and for passive and counter/detection predictions. A multitude of paths are involved and definitely more than the four currently modeled.

VG	TITLE	WORDS
EE-1	Continued	SHARPS III should be modified to generate predictions for active sonobuoys which are not now supported with an accurate and realistic model. Active ASRAP predicts for noise limited conditions, and it can not effectively predict for the more modern active buoys sensors. NORDA has sponsored and developed a much better volume scattering strength data base for FNWC, and this should become operational when the necessary software changes have been made. This development represents a substantial improvement. In the area of model evaluations NORDA is undertaking the evaluation of SHARPS and NISSM II type models using available data and the results of fleet exercises. Just the methodology that should be used in active model evaluations is of concern. How do you gain a measure of confidence in what you predict with a numerical model?

EVA MODELING FOR ASRAP/SHARPS

- CURRENT CAPABILITY
  - Active and Passive Sonars
  - Ocean Environment
  - Acoustic Models

- FUTURE PLANS
  - Improved ocean Model
  - Upgrade Boundary Descriptions
  - Extension to New ocean Regions
  - More Accurate Acoustic Models
  - Definitive Evaluations of EVA Models
  - Better Execution/Response Times

  - Wider Range of Sonars
  - On-Scene Modifications
  - In Situ Data

VG	TITLE	WORDS
FF-I	Summary VG	In brief time-overview of SHARPS/ ASRAP from EVA model point of view. Current capability supports buoys and most active sensors. The ocean environment is predicted (sound speed/ wind) from FNWC analysis. The acoustic models are based on best technology in past 4-5 years. There are deficiencies. Plans to remove deficiencies and improve product include: - Better inputs: Ocean thermal/circulation; Bottom/Surface properties; Shallow Water, etc. - Better EVA Models: Improved efficiency/ response; Surface Loss/BTM Loss/ Duct/Reverb/etc.; Evaluation to remove uncertainties - More Applications: Support new sensors (ERAPS, VLA's, Horizontal Arrays); Support APP for In Situ; Provide on-scene mods to shore-based (historical) predictions

APPENDIX D
VIEWGRAPHS AND TEXT FOR UPDATING MILOC BRIEFING

Prepared by
William D. Kirby

September 1981

VG #1

WORDS

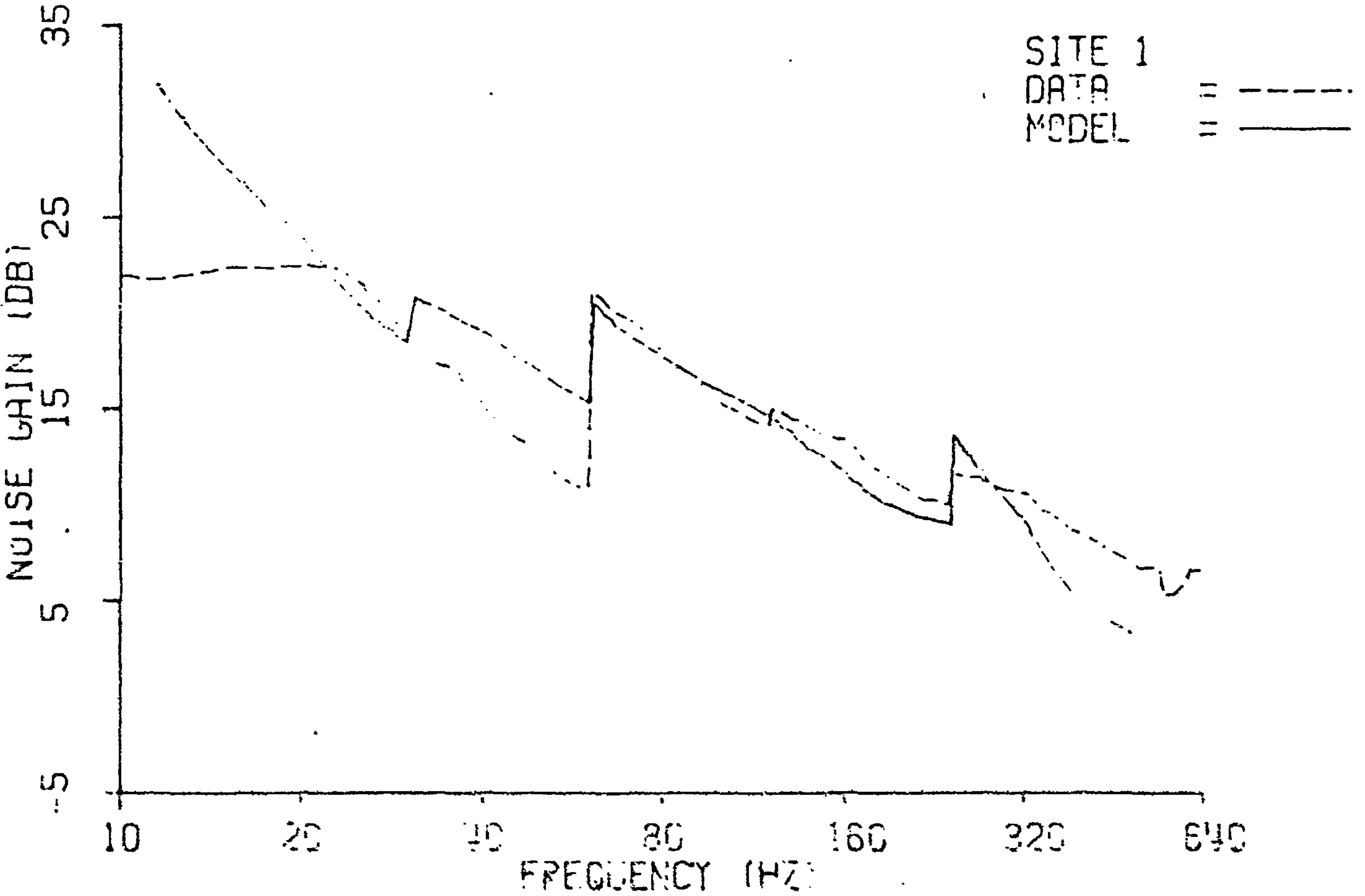
VLA/ASRAP
Noise Gain Evaluation

The Vertical Line Array (VLA) version of ASRAP has been operating at FNOC on a test basis for about a year in conjunction with Vertical Line Array DIFAR (VLAD) sonobuoy tests. In addition the VLA/ASRAP model has been subjected to a rigorous technical evaluation utilizing processed data from the experimental data collection system known as Test Steerable Vertical Line Array (TSVLA) which allows the formation of any type vertical beam desired.

This VG shows an example comparison between a VLA/ASRAP prediction of noise gain verses a corresponding measurement. A simple horizontal null type sensor was being examined in this case at low frequencies. It should be

VG #1	WORDS
VLA/ASRAP Noise Gain Evaluation (Continued)	noted that the data on prediction start to show a marked disagreement below about 20 Hz. Ray theory may not be valid at these low frequencies, as well as the equipment was not particularly designed to operate here. (If anyone asks-the step changes shown are caused by abrupt changes in the beamforming parameters as a function of frequency. Also, the large gain values seen relate to noise only. With a null sensor the target signal is degraded which means the total signal-to-noise ratio gain is much less than the noise gain displayed here.) This plot output is not a standard ASRAP product, but was used for evaluation purposes only.

#1


SITE 1
DATA =
MODEL =
NOISE GAIN (DB)
35
25
15
5
-5
10
20
40
80
160
320
640
FREQUENCY (HZ)

VG #2

VLA/ASRAP
Vertical Noise

WORDS

This VG shows a prediction verses data for the case where a conventional vertical beam has been steered to a number of positions in the vertical. In other words we are evaluating the ASRAP physics ability to predict the vertical arrival structure of ambient noise. The general fit is good but a couple of deficiencies can be seen.

The differences at the steep angles are likely caused by our knowledge of bottom loss, and possibly the ratio between wind and distant shipping noise components.

Also, please note the small dip in the prediction at the horizontal (i.e., 0.0 degrees). This is caused by the noise notch problem which was discussed previously. The data shows that there is a lot of noise in the notch even at 400 Hz.

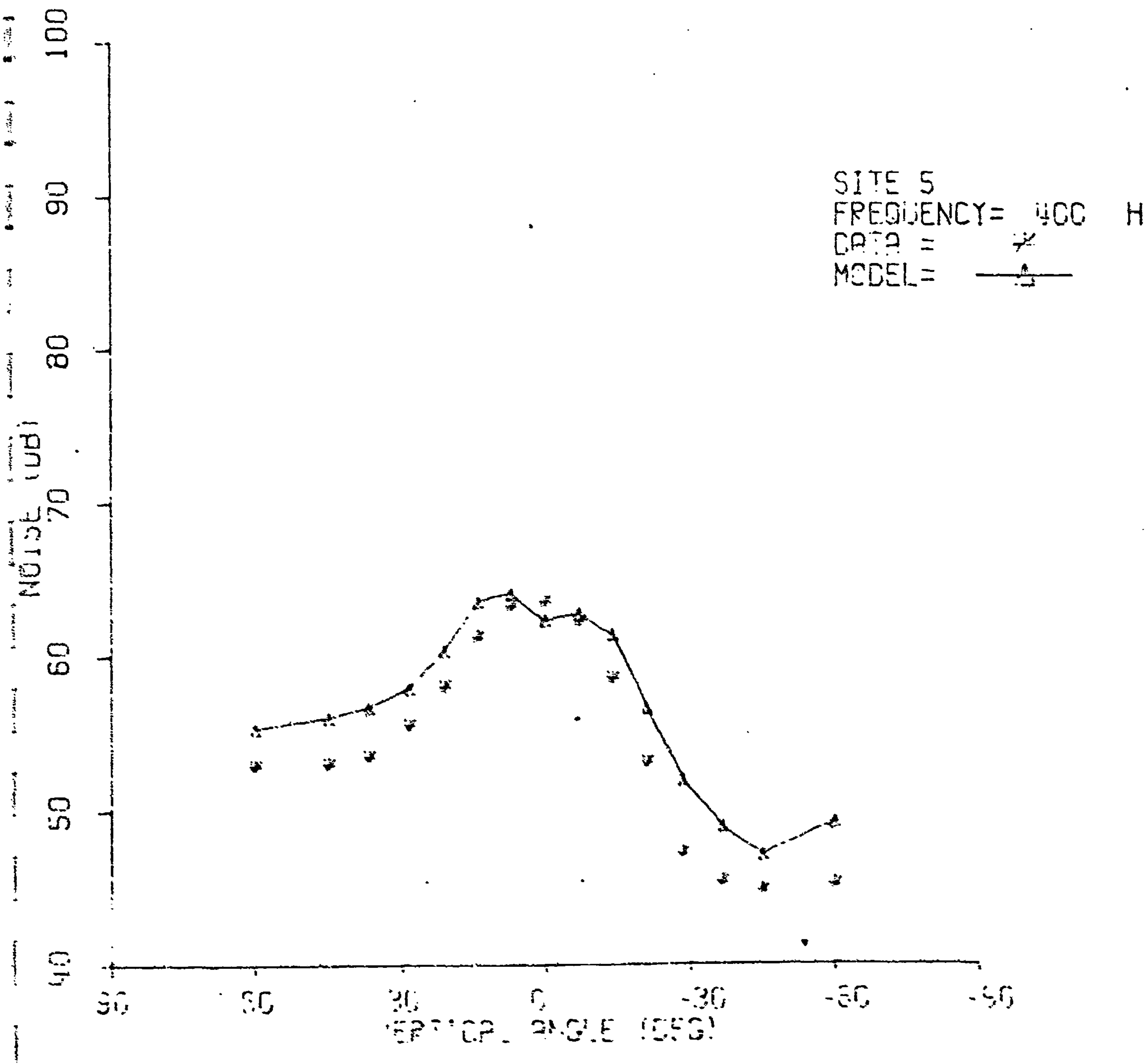
VG #2

VLA/ASRAP
Vertical Noise
(Continued)

WORDS

(This VG also shows the basic deep water ambient noise arrival structure. Most of the ambient noise arrives at a receiver at the low horizontal angles).

#2


SITE 5
FREQUENCY= 400 H
DATA =
MODEL=
NOISE (DB)
100
90
80
70
60
50
40
90
60
30
0
-30
-60
-90
VERTICAL ANGLE (DEG)

VG #4

WORDS

ACTIVE MODEL IMPROVEMENTS

In the last year a few improvements in basic active modeling have been accomplished.

For shallow water and half channel environments a ray-averaging technique has been developed for incorporation in NISSM II, which has not been economical before. In these tough environmental cases an order of magnitude improvement in running time has been achieved.

As a result of some active modeling deficiencies observed during SQS-56 tests a technique for treating RDT and other time dependent transmitter characteristics has been developed. We can now take into account the degradation caused by sidelobes and cross-beam interference.

VG #4	WORDS
ACTIVE MODEL IMPROVEMENTS (Continued)	For the treatment of non-rectangular envelope CW signals and time-compression signals and waveforms, algorithms have been developed and implemented in NISSM II. The efficiency of the Fast Fourier Transform (FFT) has been exploited to perform the necessary convolutions. The FFT implementation has resulted in no increase in NISSM II execution time.

ACTIVE MODEL IMPROVEMENTS

- RAY AVERAGING
- REVERBERATION FOR COMPLEX SYSTEM MODES
- NON-RECTANGULAR ENVELOPE AND LFM PROCESSING

VG #5

WORDS

This VG illustrates an example prediction from a modified NISSM II for the echo arrival structure in time for equal peak level and duration rectangular and cosine squared envelope signals. It should be noted that multipath effects have resulted in the peak echo being a couple of dB less than that from the rectangular envelope signal. The modified NISSM II can use any used specified signal envelope.

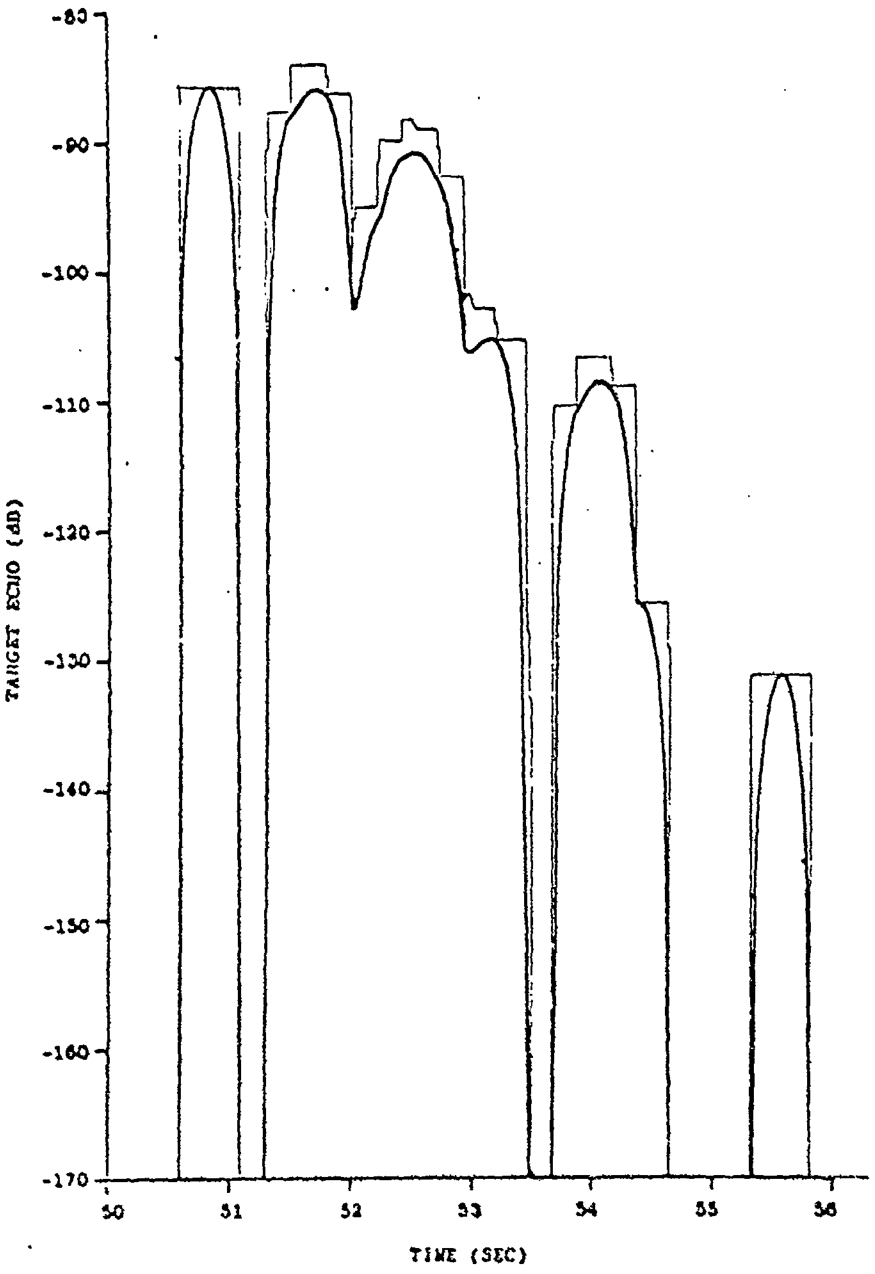


Figure 3-4

Target Echo Functions for Rectangular and Cosine-Squared Pulse Taken at Range 40.7 kyd

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Subj: DECLASSIFICATION OF LONG RANGE ACOUSTIC PROPAGATION PROJECT (LRAPP) DOCUMENTS

Ref: (a) SECNAVINST 5510.36

Encl: (1) List of DECLASSIFIED LRAPP Documents

1. In accordance with reference (a), a declassification review has been conducted on a number of classified LRAPP documents.

2. The LRAPP documents listed in enclosure (1) have been downgraded to UNCLASSIFIED and have been approved for public release. These documents should be remarked as follows:

> Classification changed to UNCLASSIFIED by authority of the Chief of Naval Operations (N772) letter N772A/6U875630, 20 January 2006.
>
> DISTRIBUTION STATEMENT A: Approved for Public Release; Distribution is unlimited.

3. Questions may be directed to the undersigned on (703) 696-4619, DSN 426-4619.

BRIAN LINK
By direction

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Declassified LRAPP Documents

Report Number	Personal Author	Title	Publication Source (Originator)	Pub. Date	Current Availability	Class.
Unavailable	Unavailable	SELF-TENSIONING ACOUSTICAL HORIZONTAL LINE ARRAY (SPRAY) DATA ANALYSIS. FINAL REPORT OF BEARING STAKE TESTS JANUARY THRU MARCH 1977. VOLUME IVB. DATA POINTS 10, 11 AND 12 RAW DATA	Sanders Associates, Inc.	790109	ADC017579	U
ARLTR7924	Mitchell, S. K., et al.	ANALYSIS OF ACOUSTIC BOTTOM INTERACTION IN BEARING STAKE (U)	University of Texas, Applied Research Laboratories	790223	ADE001369; NS; ND	U
TIU1886502F	Eichenberger, D.	REPORT FOR CHURCH STROKE II OCEANOGRAPHIC SERVICES	Texas Instruments, Inc.	790326	ADB036751; ND	U
Unavailable	Unavailable	FINAL REPORT, 1 NOVEMBER 1976-31 DECEMBER 1978	Xonics, Inc.	790430	ADB037987	U
Unavailable	Mitchell, T. M.	PREMOBILIZATION OF R/V INDIAN SEAL	Texas Instruments, Inc.	790531	ADB039703	U
Unavailable	Hays, E. E.	ACODAC AMBIENT NOISE PROGRAM	Woods Hole Oceanographic Institution	790601	ADB040404	U
LRAPPR79029	Unavailable	INTRODUCTION TO THE LRAPP ENVIRONMENTAL-ACOUSTIC DATA BANK (U)	Naval Ocean R&D Activity	790601	ADB041066; NS	U
USRD NO. 4807	Unavailable	MEASUREMENTS ON AQUADYNE MODEL AQ-1 ELEMENTS FOR THE UPGRADED LAMBDA ARRAY	Naval Research Laboratory	790802	ND	U
Unavailable	Ellis, G. E.	SUMMARY OF ENVIRONMENTAL ACOUSTIC DATA ANALYSIS	University of Texas, Applied Research Laboratories	790814	ADA073876	U
BR U0048-9C2	Unavailable	TAP III FINAL REPORT (U)	Bunker-Ramo Corp. Electronic Systems Division	790901	ND	U
ORITR1245	Moses, E. J.	OPTIONS, REQUIREMENTS, AND RECOMMENDATIONS FOR AN LRAPP ACOUSTIC ARRAY PERFORMANCE MODEL (U)	ORI, Inc.	790917	NS; ND	U
Uavailable	Colborn, J. G., et al.	EVALUATION OF STANDARD OCEAN CANDIDATES	Pacific-Sierra Research Corp,	800301	ADA087304	U
Unavailable	Kirby, W. D.	ENVIRONMENTAL ACOUSTIC SUPPORT FOR FLEET OPERATIONS AND NATO	Science Applications, Inc.	801112	ADB052623	U
Unavailable	Unavailable	SUMMARY OF ENVIRONMENTAL ACOUSTIC MEASUREMENTS, MODELING AND ANALYSIS	University of Texas, Applied Research Laboratories	801215	ADB053770	U
Unavailable	Renner, W. W., et al.	SURFACE DUCT, ROUGH SURFACE SCATTERING, AND CUSPED CAUSTIC IMPROVEMENTS FOR FACT	Science Applications, Inc.	810301	ADA126250	U
Unavailable	Wilson, J. H.	WIND-GENERATED NOISE MODELING	Science Applications, Inc.	810401	ADA190143	U
Unavailable	Goit, E. H.	TOWED ARRAY PERFORMANCE PREDICTION SYSTEM - VERSION 1.2	Science Applications, Inc.	810701	ADB059397	U
3	Unavailable	FINAL REPORT	University of Texas, Applied Research Laboratories	810721	ND	U