

SHALLOW WATER ACOUSTIC REQUIREMENTS FOR REAL-TIME MODEL IMPLEMENTATION

INTRODUCTION

With the end of the Cold War and the rise of tensions in other areas of the world, shallow waters have become new regions of interest and concern for today's military. In this sense, shallow water is used to include littoral water. The variability of the shallow water environments significantly increases the complexity of acoustic system operations. At the same time, operational experience at sea is diminishing due to fewer contacts and reduced operations. Experience previously gained operationally is therefore being replaced by on-board and shore-based training. Realistic training requires a shallow water model that accurately represents acoustic transmission and environment properties of the ocean.

Need for a Shallow Water Model

Effective training to sustain current missions and tactics requires realism in simulation that supports the unique and variable characteristics of shallow water environments. Current systems do not meet this requirement. They do not simulate the variability of the water content, bottom types and profiles, nor the background noise required for a realistic representation of a shallow water environment.

Shallow Water Working Group (SSWG)

The Chief of Naval Operations (CNO) tasked the Naval Air Warfare Center Training System Division (NAVAIRWARCENTRASYSYSDIV) to develop a Navy Shallow Water Ocean Model requirements document that would support the acquisition of a Shallow Water Ocean Model. NAVAIRWARCENTRASYSYSDIV established a Shallow Water Working Group (SWWG) comprised of the Naval Warfare communities (NUWC, NAWC, NSWC), the Office of the Oceanographer of the Navy, the DoD Modeling and Simulation Executive Agent Office, the Office of Naval Research, the Naval Research Laboratory, the Naval Meteorology and Oceanography Command, and the Naval Oceanographic Office. Each organization contributed knowledge in its specific analytical, training, model and data requirements areas of expertise.

Requirements Developed

The SWWG has documented the requirements for a standard Environmental Acoustic Modeling System (EVAMS). This defined the modeling and data requirements for acoustic training systems. The requirements were developed in three phases: (1) an analysis of training system requirements based upon interviews with the fleet [1]; (2) identification of the high-level training requirements [2]; and (3) a description of how the training simulation will use the EVAMS [3]. This paper reports the results of that effort.

TRAINING SYSTEMS REQUIREMENTS ANALYSIS (TSRA)

Interviews with Subject Matter Experts (SMEs) at operational and training commands provided the basis for the TSRA. Interviews conducted at 18 sites, divided among the Submarine, Surface, Air, Mine, and Surveillance Communities, were structured around a questionnaire of more than 130 questions relating to tactics and training. In addition to the on-site interviews, publications such as Naval Warfare Publications (NWP), reports, textbooks, and requirements documents were consulted.

Shallow Water Missions

Shallow water tactical missions of the various warfare communities were examined for impacts imposed by the shallow water environment. In addition, future missions including multi-static exploitation, improved ASW, ASUW, LFAA, twin-line array, Extreme Low Frequency (ELF), and Extended Echo Ranging (EER) were considered. The geographical areas of interest to the fleet, for both realistic training and data collection, are those regions listed in the current Office of Naval Intelligence (ONI) top ten list at any given time.

Fleet personnel experienced in shallow water operations indicate that the most significant characteristic of shallow water is its variability. A combination of environmental characteristics makes each area unique. The variability occurs not only between regions but within the same region, within time ranging from seasons to hours.

Training Levels

There are three levels of training required for shallow water acoustics:

Basic. The Basic level is for students new to the acoustic environment. Demonstrating the effects of different features and conditions of the ocean environment is important for this level. A simple generic shallow water model is sufficient.

Intermediate or Advanced. The Intermediate or Advanced level is for students from the fleet returning to school or on-board training. The training includes contact prosecution, contact analysis and evaluation, team training, maneuvering solutions (fire control), and tactical employment of sensors. Realistic modeling and data are required.

Mission Rehearsal. Mission Rehearsal is the most stringent training requirement. Realistic modeling and site-specific data are required.

Realism Required

Levels of training other than basic require the ocean environments to represent specific geographic areas. All levels of training require simulation of bottom and surface interactions, absorption losses, and vertical and horizontal bending due to sound speed distribution as represented by a Sound Velocity Profile (SVP).

Environmental Factors. The environmental factors (Table 1) that must be modeled were determined from the fleet needs. Environmental changes within the shallow water operating theaters are of great concern. It is critical that the correct effects for the environmental changes be modeled to provide an accurate representation of the real world.

Some of the environmental factors remain constant for a training session, and others must be updated during a session. The requirement to update during a training session imposes time constraints in the implementation.

Frequency and Time. Environmental effects must be modeled for the frequency band of the sensors being simulated. Data must be generated in time to update the operators' displays with correct signal representation.

MODELING AND DATA REQUIREMENTS

Existing models of the ocean used in training are characterized by flat-bottom, single SVP environments. These models do not meet the high degree of realism needed by the fleet to maintain readiness. The current capabilities in both modeling and data must be improved.

Table 1. Environmental Factors

Factor Class	Factor
Ambient Noise Sources	Directional Shipping
	Distant Shipping
	Distributed Biologics
	Geo-acoustic noise
	Oil Rigs
	Surf Noise
Arctic Environment	Weather
	Ice Coverage or Canopy
	Ice Roughness
	Ice Thickness
	Icebergs
Bottom Characteristics	Marginal Ice Zone
	Bathymetry
	Geophysical Description
	Churning
	Clutter
Contact Sources	Roughness
	Sources that are modeled in the training system simulation and are attenuated based upon EVAMS data.
Water Conditions	Biologic Reverberation Contributors
	Churning - Shoreline area only
	Currents
	Diurnal effects
	Eddies
	Fresh Water
	Fronts
	Salinity
	Sea State
	Seasonality
	Surf Conditions
	SVP
	Temperature
	Tidal effects and fluctuation

Model Implementation Requirements

The fleet's acoustic training requirements were consolidated by the SWWG into the following model requirements.

Seamless Transitions. The model must represent the environment in a consistent fashion. The model must provide a seamless transition, with no discontinuities resulting from inconsistent data or models.

Scaleability. The model must provide a method of scaling computational requirements in order to support each specific training device.

In-Situ Data. The integration of *in-situ* data shall allow the virtual environment of the training simulations to be updated to reflect actual environments experienced by "live" tactical systems. Data must be accepted and integrated prior to and during training exercises.

Frequency Spectrum. The model must match or exceed the frequency spectrum of both existing and known future sensors and weapons.

Dynamic Acoustic Sources. The model must provide for multiple dynamic acoustic sources. These sources must be able to maneuver within the changing 3-D environment.

Range Dependence. A range dependent model that incorporates multiple SVPs representative of fronts, eddies, and varying bottom topography and type is required.

Real-Time Simulation-Stimulation. The model must support real-time simulation or stimulation. Each second of scenario time reflected in the presentation to the trainee shall equal one second of actual clock time.

Geographic-Specific Environments. The model shall provide data directly representative of specific geographic areas. It shall also provide synoptic data that accurately reflects the environment.

Tactical Decision Air (TDA) Consistency. The model shall present an environmental acoustic representation that is consistent with TDAs driven by input data consistent with the environment defined in the training scenario.

Environmental Acoustic Consistency. The model shall provide consistent environmental representation across sensors operating within the gaming area.

Acoustic and Nonacoustic Consistency. When nonacoustic products are part of the environmental model, the models shall be consistent with acoustic environmental models.

Variable Resolution. The model shall be able to extract, store, and accept data from variable-resolution data bases.

Modeling Range. The model shall support close-in (near zero range) to long-range (determined by the longest known or planned detectors) modeling. Range resolution may be variable, but the resolution must be fine enough to provide realistic simulation effects for the most sensitive sensors.

Four-Dimensional Environmental Representation. The model must provide 4-D (spatial coordinates plus time) environmental representation, including dynamic changes such as diurnal effects and eddy movements. The acoustic propagation shall be consistent with the 4-D merged, blended environment.

Support for Instructional Displays. The model shall support data generation for debrief and trainer displays as well as scenario generation and control.

Environmental Modeling Requirements

The characteristics for propagation, ambient noise, reverberation, and active reflections shall be modeled to provide an accurate representation for training. The model must render the effects of the environmental phenomena and also provide for updating and displaying the effects for instructor consideration.

Spatial and Temporal Variability. The model must support deterministic spatial and temporal variation (e.g., fronts, eddies, and currents).

Propagation Characteristics. The model shall simulate sound propagation for both active and passive acoustic signals in a range-dependent synthetic ocean. It shall simulate multipath interference that results in Lloyd's mirror, convergence zones, shadow zones, ducts, and duct leakage.

Bottom Characteristics. The fleet indicated that the most important aspect of shallow water is the bottom. For training purposes, bottom effects should include the acoustic wave interaction with the bottom, sub-bottom, the depth of the water column along the acoustic path, the absorption and reflectivity characteristics of the bottom, and any objects that are on the bottom.

Ambient Noise Sources. The training community considers contact-generated acoustics and most man-made sources outside the areas of ambient noise. This does not indicate that these are not ambient sources; only that the training community treats them differently for modeling and implementation. The following is a list of ambient noise sources.

- Biologics (distributed)
- Geo-acoustic Noise
- Ice
- Shipping (Distant and Directional)
- Surf Noise
- Surface Winds
- Weather

Water Conditions. Water conditions are extremely diverse in the shallow water environment. There are several factors added to the water conditions that are important for shallow water training that are not necessary for deep water training. The follow is a list of water condition requirements for effective shallow water training.

- Biologic Reverberation Contributors
- Currents

- Diurnal Effects
- Eddies
- Fresh Water Run-off
- Fronts
- Salinity Profiles
- Sea State
- Seasonality
- Surf Conditions
- Temperature Profiles
- Tidal Effects and Fluctuation
- Turbidity

Arctic Conditions. The following additional environmental conditions should be included when modeling Arctic areas.

- Ice Canopy or Ice Coverage
- Ice Roughness
- Ice Thickness
- Icebergs
- Marginal Ice Zone

The model shall accept the values of the environmental factors (Table 1) from standard databases or from instructor inputs. The model should accept bathymetric data in fixed or variable grid spacing.

Data Requirements

The following data are required:

Representative of Specific Geographic Areas.

The environment for intermediate and advanced training will represent conditions that may be encountered in the defined area during a selected frame time, including seasonal, diurnal, and hourly fluctuations. It will be consistent with the geographic features and conditions of the area. A set of environments may depict the states through which the environment passes during an extended frame time.

Variability of Data. Data representing the geographical area of interest should be temporally indicative of area conditions. If diurnal or hourly variations are experienced in this area, data should accurately reflect the conditions of the environment. The synthetic environment presented to the trainee should be consistent with what would be experienced in the area during similar environmental conditions.

Integrated In Situ-Data. The EVAMS shall be capable of accepting *in-situ* data for use in a training scenario, both prior to and during run-time. The *in-situ* data shall be integrated realistically and seamlessly with environmental databases.

Data Resolution to Support Multiple Training Levels. Data will be required to support the high fidelity operator level training through command level synthetic force representation. This requires a consistent data representation for an area supporting a wide range of force requirements.

TRAINER SYSTEM IMPLEMENTATIONS

Targeted training systems for use of the EVAMS include, but are not limited to, the Joint Simulation System (JSIMS), Battle Force Tactical Trainer (BFTT), Submarine Multi-Mission Team Trainer (SMMTT), Interactive Multi-Sensor Analysis Training (IMAT), Sonar Employee Trainer (SET), and the AN/SQQ-89 On-Board Trainer (OBT).

Training Situations

Underwater acoustic trainers can be used in stand-alone or team trainer configurations. In the stand-alone configuration, the functions that occur outside the acoustic environment (*e.g.*, command and control, fire control tracking, and communications) are accomplished by the instructor. In the team training configuration, the tasks of sub-team and team communications is added to the functions the acoustic operator performs in the stand-alone mode.

In either configuration, the main tasks performed by the acoustic operator are detection, tracking, and classification of a contact. In the detection phase, the operator uses the sensors available to search the ocean environment for a contact of interest. The sensors include the LOFAR (Low Frequency Analysis and Recording) display, audio from headsets or speakers, and other intelligence (*e.g.*, radio transmissions and visual sightings). In the tracking phase, the team determines the exact location of the contact. The acoustic operator assists, using such cues as quality and relative level of the sound, frequency shift (Doppler), and bearing rate.

In the classification phase, the operator identifies the type of contact. This is the most difficult part of the problem and requires use of acoustic cues that may be very subtle (it requires a high-fidelity simulation to provide accurate cues). In addition to initial classification, the operator monitors the contact continuously, identifying contact events such as surfacing, submerging, turning, speeding

up, slowing down, starting and stopping engines, compressors, and pumps, and venting tanks.

Trainer Examples

Examples from the Submarine, Surface, Air, Surveillance, and Mine communities were selected to illustrate the differing priorities the various classes of trainers place upon the model and ocean phenomena requirements.

Submarine Multi-Mission Team Trainer (SMMTT). The SMMTT is a shore-based trainer that includes acoustic, combat control, and visual (periscope) training systems. This trainer requires a high fidelity ocean representation with a 1 second update rate for contacts closer than 1 kyd. and a lower update rate for contacts farther away.

On-Board Trainers. The most recent OBTs are the AN/BSY-2 Acoustic OBT (AOBT) and the AN/BQQ-5E OBT. Systems under development include the New SSN On-Board Team Trainer (NSSN OBTT) and the Acoustic Rapid COTS Insertion (ARCI) OBT. These trainers use precalculated propagation loss tables. EVAM could be used to compute tables for small shallow-water areas for use in these trainers. Also, the NSSN OBTT development team is considering using the SMMTT implementation and would prefer to implement a real-time ocean model instead of using a table driven approach.

Interactive Multi-sensor Analysis Trainer (IMAT) and Basic Operator Training. In general, the update rate, bandwidth, and contact-sensor pair requirements for these trainers are less than those of the team trainers. However, data on propagation paths and the environment are needed to support these trainers.

IMAT is a system that uses 2-D and 3-D visual displays to provide instruction in active and passive analysis, active and passive environments, beamforming, and target motion analysis.

Basic operator training in the past has been limited to knobology. However, the increase in PC capability now allows PC-based training to include a broader range of topics.

AN/SQQ-89 On Board Trainer (OBT). The 89-OBT stimulates tactical equipment to provide

simulated acoustics for use in on-ship training. A high-resolution, coherent model of the environment is needed to simulate the acoustics of the actual signals in the water. The present system uses a deep water ocean model. The principal improvements needed for 89-OBT active simulation are in the areas of transmission loss and bottom reverberation. The principal improvements needed for passive simulation are in the areas of transmission loss and ambient noise.

Tactical Anti-Submarine Warfare Integrated Trainer (TASWIT). TASWIT is a networked multi-warfare tactical team trainer that focuses on the statistics of target detection rather than the generation of individual acoustics. Its purpose is to provide command-level tactical sensor and command and control (C2) simulation for use by ship and ship-air combat teams and by battle group staff supervisory-level personnel. A lower level of acoustic fidelity is allowed, as long as the detection statistics are not affected.

Sonobuoy trainers. The 14B51 LAMPS Mark III Trainer, the 2F146 CV Helo WST, the 2F92B S-3B WST, and the P-3C Update III 2F140 TORT are shore-based air warfare trainers that provide training for sonobuoy sensor utilization. For ocean simulation, air trainers currently use passive, range-independent look-up tables. For active simulation, the 2F146 uses a look-up table for active propagation loss, but the other trainers do not use a propagation loss model.

Dipping Sonar Trainer. The SH-60F CV Helo aircraft and its 2F146 WST use a Dipping Sonar in addition to sonobuoy sensors.

Personal Computer Micro-Digital Acoustic Sensor Simulator (MicroDASS). MicroDASS injects signals from a library of synthesized targets into a live Sound Surveillance System (SOSUS) data stream. MicroDASS is focused upon passive acoustic target generation, with limited user-defined inputs for transmission loss modeling

Table 2. Prioritized Phenomena Requirements.

COMMUNITY	Submarine	Surface		Air		Surveillance	Mine
TRAINER	SMTT, OBT, and Basic Training	89-OBT	TASWIT	SONOBUOY TRAINER	DIPPING SONAR TRAINER	MicroDASS & MRE	CSITE SSQ-94
EFFECT	PRIORITY						
Absorption Losses	Medium	Low	Low	Medium	Medium	Low	Medium
Bottom and Surface Interaction	High	High	High	High	High	High	High
Coherent Propagation Environment	High	High	Low	High	High	High	Medium
Horizontal Bending	Medium	Low	Low	High	High	Medium	Medium
Vertical Bending	High	Low	Low	Medium	Medium	High	High
Phenomena Interdependence	High			High	High	High	High
Near Field Effects				Medium	Medium	Medium	Medium
Reverberation	High	High	Medium	High	High	High	High
Sediment Layer Propagation	High	Low	Low	High	Medium	High	High
Spatial Variability	High	Medium	Medium	Medium	High	Medium	High
Temporal Variability	Medium	Medium	Medium	Medium	Medium	Medium	Medium
Under Ice Environments	Low			Low	Low	Low	N/A
Up Slope and down Slope Effects	High	High	High	High	High	High	High
Variable Ambient Noise Sources	Medium	Low	Low	Medium	Medium	Low	Medium

Mission Readiness Exercise (MRE). MRE stimulates the SURveillance Towed Array System (SURTASS) and Fixed Distributed System (FDS) arrays. MRE uses the MicroDASS engine to generate target data and includes the limited transmission loss modeling capability common to MicroDASS. MRE generates passive signature data for up to 6 (SURTASS) or 30 (FDS) independently targets in real time.

AN/SSQ-94 Combat System Integrated Training Equipment (CSITE). CSITE, now being developed, will provide both team training and operator training in for mine hunting and neutralization operations. CSITE simulates an operational area and provides acoustic signals to stimulate the mine countermeasures sonars.

Requirements Prioritization

The environmental phenomena and the ocean modeling requirements were prioritized for each of the trainer classes described (Tables 2 and 3). Environmental phenomena such as bottom and surface interaction as well as up slope and down

slope effects were rated high in priority. Modeling requirements such as a standardized model, scaleable fidelity, and range dependence were also rated as high priority items.

OTHER ISSUES

There are issues besides the modeling of the ocean and representation of the phenomena. The following issues should be addressed in order to support future applications and remain cost effective.

System Architecture. The EVAMS should be designed with an open architecture. It should not be tied to specific platforms and should allow for hardware upgrades without appreciable impact on software configuration. The EVAMS must support a scaleable software architecture that supports On-Board Training through Shore-Based Training requirements. The system tailoring will be a function of the computational and fidelity requirements of each community. The EVAMS must support real-time training requirements from basic through mission-rehearsal training.

Table 3. Prioritized Model Requirements.

COMMUNITY	Submarine			Surface		Air		Surveillance	Mine
TRAINER	SMTT	OBT	IMAT & BASIC	89-OBT	TASWIT	SONOBUOY TRAINER	DIPPING SONAR TRAINER	MicroDASS & MRE	CSITE SSQ-94
REQUIREMENT	PRIORITY								
Acoustic and non-acoustic consistency	Medium	High	Low	Low	High	High	High	Low	High
Broad Frequency Spectrum	High	High	Medium	High	High	High	High	High	Medium
Close in to long range modeling	High	High	High			High	High	High	Medium
Consistent with TDAs	High	High	Medium	Medium	High	High	High	High	High
Data Generation for debrief and trainer displays	Medium	Medium	High	Low	Low	High	Medium	Medium	Medium
Environmental Acoustic Consistency across sensors	High	High	Medium	High	High	High	Medium	High	High
4-D environmental representation	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	High
Multiple Dynamic (Moving Acoustic Sources)	High	High	High	High	High	High	High	High	High
Range Dependent	High	High	High	High	High	High	High	High	High
Real-Time Simulation or Stimulation	High	High	High	High	Low	High	High	High	High
Scaleable Fidelity	High	High	High	Low	Medium	High	High	Low	High
Seamless Transitions	High	High	High	Low	Medium	High	High	High	High
Specific Geographic Areas	High	High	Medium	Medium	Medium	High	High	Medium	High
Standardized model	High	High	High	High	High	High	High	High	High
Use of Synoptic Data	Medium	Medium	Low			Medium	High	High	Medium
Variable resolution	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium	Medium

The EVAMS must support published DoD standards and initiatives. It should include the High Level Architecture (HLA) requirements and databases to be consistent with the Synthetic Environment Data Representation and Interchange Specification (SEDRIS).

Network Simulations. The EVAMS will be used in both stand-alone and networked applications. Consistency in EVAMS data will allow consistent representations among the networked simulations. The EVA and training communities will need to work together to ensure appropriate implementations and applications are employed.

Tactical Decision Aids and Trainer System Commonality. The EVAMS should provide an environmental representation that is consistent with Tactical Decision Aids (TDAs). This consistency depends upon TDAs being driven by

input data consistent with the environment defined in the training scenario. The consistency should then allow the TDA output to reflect the result the trainee is experiencing or determining from the training system tactical display simulation.

Standard Interfaces. Standard interfaces for the EVAMS should be defined, and an interface document describing inputs and outputs should be maintained. All applications using the EVAMS should be designed to use the published interface.

Time-Saving Algorithms. The EVAMS should incorporate time saving algorithms and adaptable resolution databases wherever practical. For example, it is not necessary to compute the propagation paths and acoustic loss beyond the detection capability of the sensor.

Multiple Path Propagation Implementation. Computation of propagation loss must be limited to a reasonable number of paths. The EVAMS must insure that the path selection does not produce erroneous discontinuities in the calculated value.

Optimized Data. EVAMS databases should be optimized for use by the training community. Fixed grid-point databases should be processed to eliminate redundant data. Data compression should be done in a consistent manner, and the resulting data should be consistent with the fixed-grid databases. The compression of the databases should not affect the EVAMS results.

Verification, Validation, and Configuration Management. Software engineering processes should be used in the implementation of the EVAMS. A configuration process should be in place prior to verification, validation, and accreditation. Particular attention should be paid to the following items

Authoritative Sources. The EVAMS should incorporate validated models and databases from authoritative sources whenever feasible. When using these existing models and databases, implementation should conform with documented, appropriate usage.

Sources of Model and Data. The sources of models and data should be documented.

Use of Models and Data for other than Intended Use. Implementation of models and data obtained from authoritative sources outside of regions certified for use should be documented.

SUMMARY

This paper has presented the requirements for an Environmental Acoustic Modeling System (EVAMS). The first step was to determine the fleet requirements for a shallow-water ocean model for training. Subject Matter Experts (SMEs) at 18 different operational and training commands were interviewed to determine needs. In addition, publications such as Naval Warfare Publications (NWP), requirements documents, and trainer descriptions were reviewed to determine what training was being done and how it was being done.

The result of the training analysis was used to determine the ocean phenomena and modeling requirements for the EVAMS. These requirements define the phenomena such as ocean variability, bottom conditions, reverberation, and noise needed to realistically simulate the shallow water ocean environment

and the modeling constraints such as seamless transitions and consistency.

These requirements were related to existing or proposed training systems across the user communities. The ocean phenomena and modeling requirements were rated by priority for nine different classes of acoustic trainers. This provides information that will be useful in cost-benefit analysis during the development of the EVAMS.

Finally, issues besides modeling of the ocean were discussed. Issues relating to software development, system architecture, standardization, and data sources are beyond the modeling requirements, but important to the viability of the EVAMS.

ACKNOWLEDGMENTS

The authors extend thanks and recognition to the Fleet Activities and the SWWG members.

The personnel from the tactical and training communities participated in extensive interviews and analysis. The time taken to accommodate this data gathering was crucial to assess training requirements. The expertise provided was invaluable.

Fleet Activities

COMSUBDEVRON TWELVE
SUBRON TWO
NAVSUBSCHOOL NEW LONDON
COMSUBPAC/COMSUBLANT
COMSURFWARDEVGRU
TACTRAGRULANT
FLETRACENLANT.
FLEASWTRACENPAC.
COMHSLWINGPAC.
SEACONTROLWINGPAC
COMHSWINGPAC
COMPATWINGPAC
Commander, Undersea Surveillance
Naval Ocean Processing Facility
IUSS (CTF-12)
COMINEWARCOM
NSWC COASTAL SYSTEMS STATION

The SWWG members represented many different communities, and the varying perspectives and insights were essential to the success of the group accomplishments. Many hours of discussion, writing and editing were involved in generating the SWWG documents. This paper is a reflection of the data presented in these documents.

REFERENCES

[1] Naval Air Warfare Center Training Systems Division, *Training Systems Requirements Analysis for Shallow Water Ocean Model (Rev D)*, 24 Sep 1996.

[2] Naval Air Warfare Center Training Systems Division, *Environmental Acoustic Modeling System (EVAMS) Requirements Document, Part I: Training System Requirements*, Dec 1996..

[3] Naval Air Warfare Center Training Systems Division, *Environmental Acoustic Modeling System (EVAMS) Requirements Document, Part II: Training System Implementations*, Dec 1996