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MEASURES OF EFFECTIVENESS HANDBOOK

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MEASURES OF EFFECTIVENESS HANDBOOK

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13. ABSTRACT

This document presents a summary of measures of effectiveness (MOE's) used by OPTEVFOR in Development Assists, Operational Assists, Operational Appraisals, Technical Evaluations, Operational Evaluations, Concurrent Evaluations, Fleet Research Investigations and Fleet Operational Investigations. For each OPTEVFOR report reviewed, the platform, system or subsystem considered is briefly described together with corresponding MOE data requirements.

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PREFACE

This handbook provides COMOPTEVFOR with a reference source of measures of effectiveness (MOE's) used in Naval warfare and previous OPTEVFOR projects. In particular, this reference handbook provides assistance to Project Officers and Analysts in the preparation of a TEMP, Evaluation Plan or Test Plan, and as an aid:

(1) in the selection of measures of effectiveness
(2) in the corresponding selection of test objectives
(3) in the identification of data requirements
(4) in the conduct of project operations
(5) in the determination of data analysis techniques to be used.

The information presented in this handbook is based on a comprehensive review of OPTEVFOR reports. Specifically, a summary is presented of MOE's used in Development Assists, Operational Assists, Operational Appraisals, Technical Evaluations, Operational Evaluations, Concurrent Evaluations, Fleet Research Investigations and Fleet Operational Investigations. For each report the platform, system or subsystem considered is briefly described together with the specific test, evaluation, or appraisal objectives, the MOE's selected, and the corresponding MOE data requirements.

The scope of the handbook is limited to effectiveness measures only. Materiel reliability and human factor measures are not included. Even in the effectiveness measure area the coverage is not complete – it was not intended to be. It is expected that continuous update will be performed.

This handbook is FOR GUIDANCE ONLY and is not intended to be the only source of information to be used by Project Officers or Analysts in the selection of measures of effectiveness.

1.0 INTRODUCTION

COMOPTEVFOR personnel become involved in the preparation of project plans for a broad range of projects. In Operational Assists for which the purpose is to gather operational data in a "quick look" effort to aid in deciding whether a particular course of development is worthy of pursuit, the project plan is prepared jointly by COMOPTEVFOR and the Developing Agency, but the execution and reporting of the results is accomplished by COMOPTEVFOR. In Operational Appraisals relating to systems, equipment or components in fleet use which have not undergone operational evaluation and/or been recommended for service use, COMOPTEVFOR is responsible for the planning and prosecution of the project. In Operational Evaluations for which the purpose is to determine the ability of the system or equipment to meet operational performance requirements, COMOPTEVFOR prepares the project plan, arranges for Fleet support, prosecutes the project, and analyzes and reports the results. COMOPTEVFOR has similar project responsibilities for the operational phase of Concurrent Evaluations.

In the preparation of these project plans the overall project objectives must be defined and then the specific objectives, including success criteria, must be identified. An integral part of the project plan for an evaluation will be the definition of the missions or operational roles of the platforms, systems, subsystems and equipments involved. The success criteria form the basis for determining whether or not the missions or operational roles are successful as reflected in whether or not the specific objectives are met. To quantify this determination requires the use of numerical scores or statistical estimates. This is the role played by the measure of effectiveness. It provides the quantification of how well the specific objectives are met such as how successful a platform is in accomplishing its mission or how successful a system, subsystem or piece of equipment is in performing its operational role as part of the mission.

The selection of MOE's is an important step in this preparation for an evaluation. This is because MOE's enable the Project Officer or Analyst to assess whether or not, or how well, the specific test objectives (chosen to test or verify that desired operational or performance goals are met) are satisfied. This handbook is designed to aid the Project Officer or

Analyst in this selection process. It is not intended to be an all-inclusive, or exhaustive, compendium of MOE's such that the Project Officer or Analyst needs only turn to the right page and then select his MOE. With the present changes in the test and evaluation process, previously used MOE's may no longer be appropriate and, even though suggestive of the types of measures which could be used, are in many cases incomplete by today's standards. Not only is the situation dynamic, but it can be generally stated that "every project is different". Consequently, this handbook is not a cookbook, but serves more for stimulation and guidance in general approaches to be followed. The selection of MOE's and the corresponding details must be tailored to the specific project.

Figure 1.1 provides an illustration of the use of this handbook by a Project Officer or Analyst. Once the project objectives, the specific objectives for test and evaluation, the platforms involved and the level of evaluation are defined, the Project Officer or Analyst is at the MOE selection stage. There may be more than one MOE which could be used and, furthermore, for each objective or set of objectives there may be a different MOE which is applicable. The Project Officer or Analyst is thus faced with having to make this selection. It is at this MOE selection stage where a Measures of Effectiveness Handbook can be of the greatest value. The reason for this is that such a handbook would contain a summary of MOE's by area(s) of applicability, criteria (based on test objective(s)) for selection when more than one choice of a MOE exists, formulations of each MOE, an identification of data requirements for computation, and a reference to previous usage of the MOE. Thus, such a document would provide ready access to information needed by the Project Officer and can also serve as a reference source for Analysts in the design of test plans and the evaluation of systems.

Figures 1.2 and 1.3 provide illustrations in ASW of typical MOE's which could be used in platform level and system level evaluations, respectively. As can be seen, at the platform level there may be more than one mission for the platform, for a given mission there may be more than one success criterion, and for a given success criterion there may be more than one MOE. Similarly, for a specified system operational role within a platform mission there may be

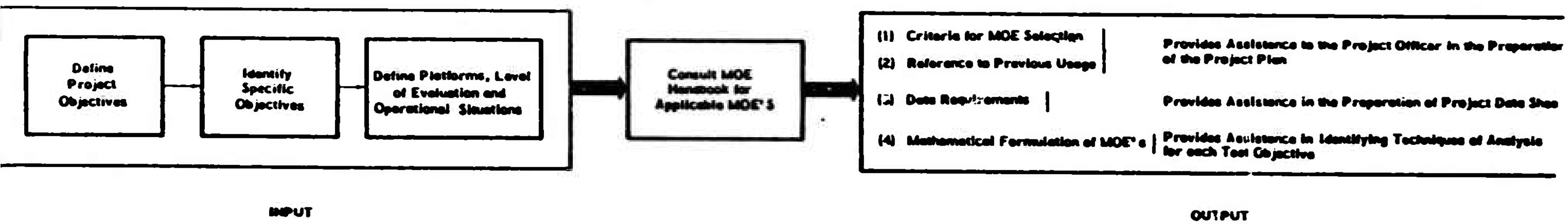


FIGURE 1.1 ILLUSTRATIVE USE OF THE MOE HANDBOOK IN THE PREPARATION OF OPERATIONAL EVALUATION/APPRAISAL PLANS

FIGURE 1.2 Platform Level Illustrative MOE Summary

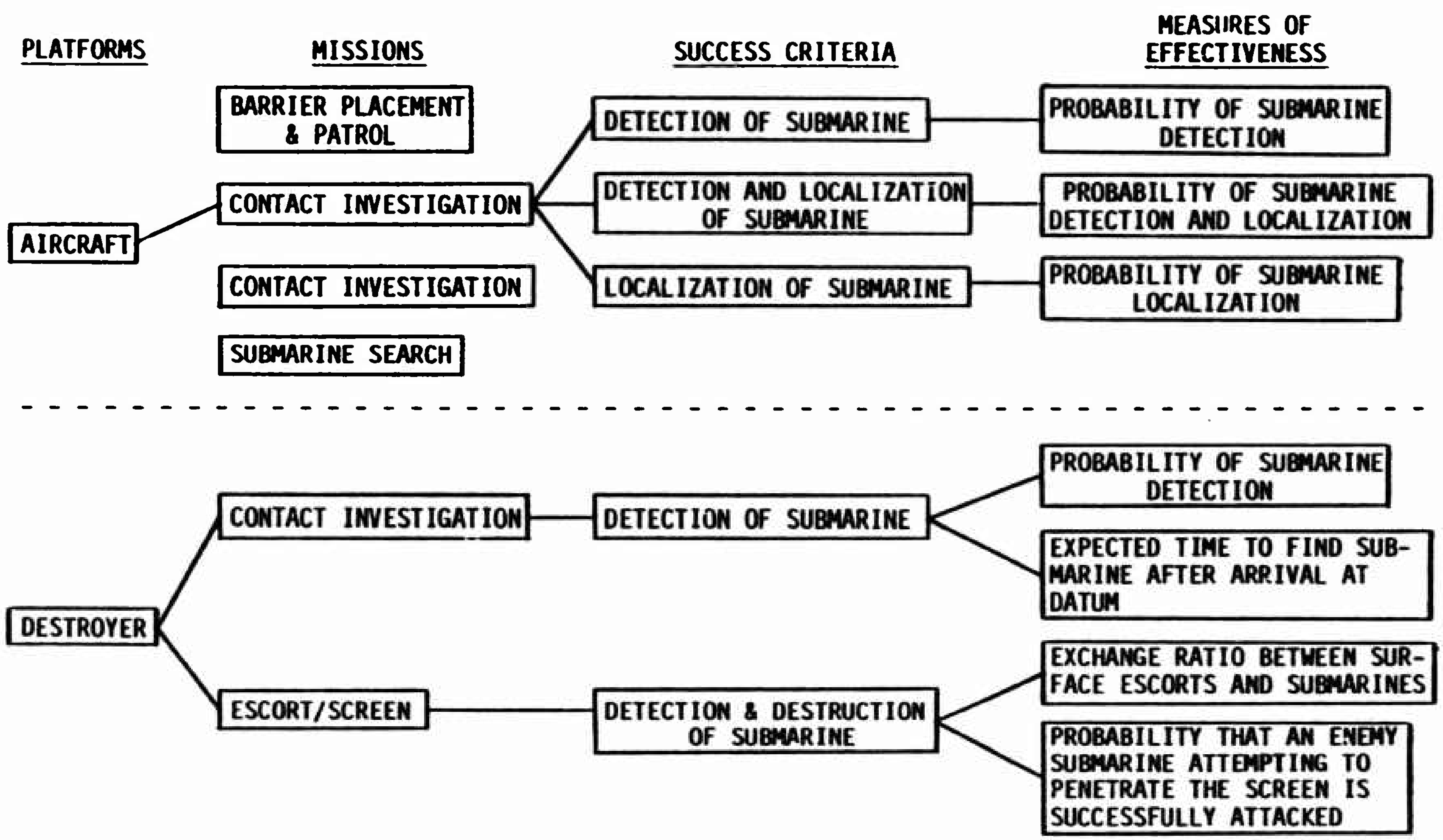
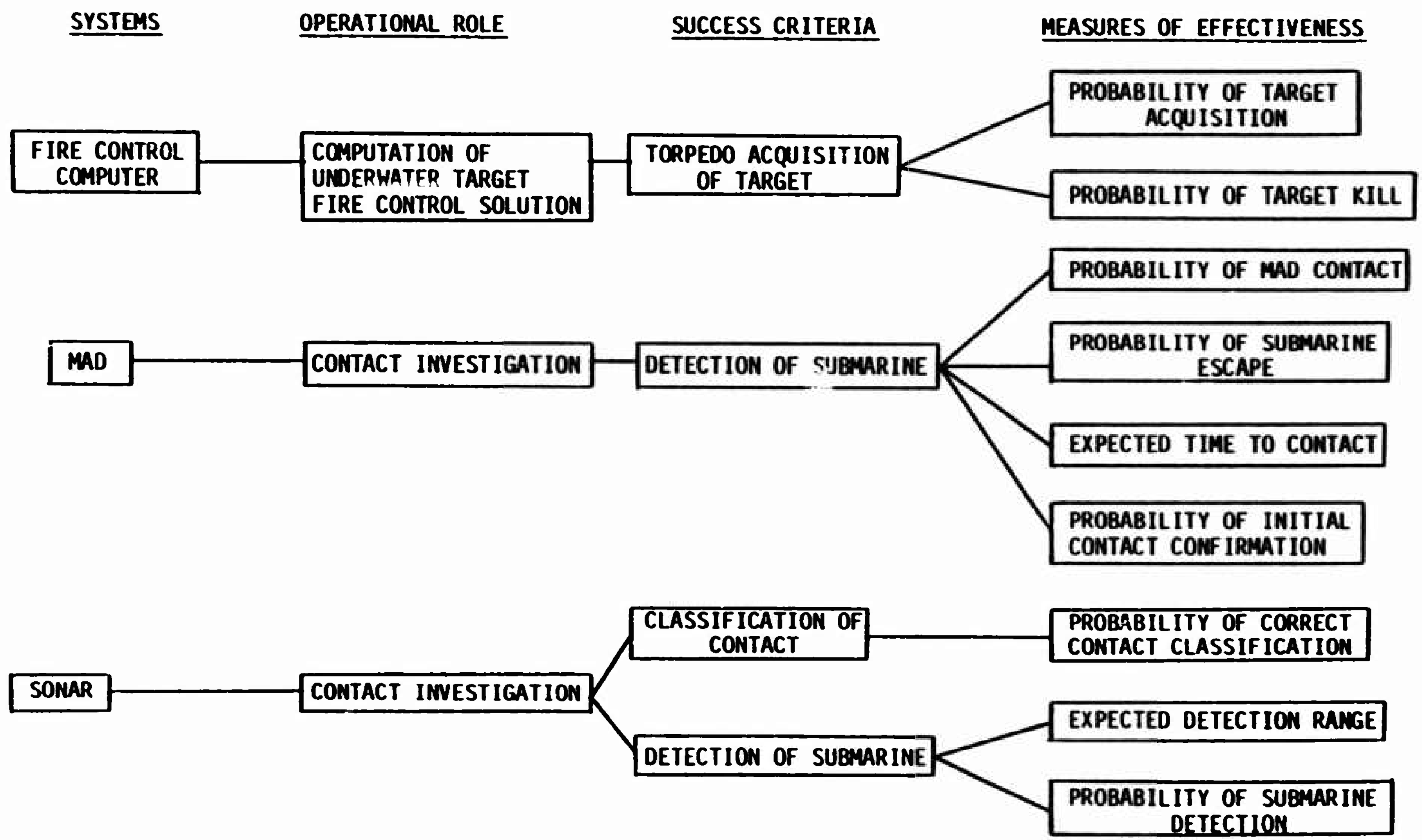


FIGURE 1.3 System Level Illustrative MOE Summary



more than one success criterion, and for a given success criterion there may also be more than one MOE. Each choice of the MOE could be expected to lead to a special set of data requirements. The project plan would thus have to include these data requirements and the project data sheets would have to be structured according to these requirements. The analysis required to compute these MOE's would be dependent upon the complexity of the MOE formulation and could even require the use of a digital computer for not only data processing and reduction but perhaps to perform mathematical simulations of portions of the test which could not be conducted at sea.

It is important to recognize that in the selection of an MOE one must consider the tasks that the platform, system, subsystem or equipment under evaluation has to perform. Measures of effectiveness can also be regarded as measures of how well these tasks are done. For example, in evaluating the detection performance of a sensor, the MOE may be the probability of detection as a function of target range, or in evaluating the kill performance of a missile warhead the MOE may be the probability of target kill given detonation. In many cases more than one task (say, subtask) comprise a broader task such as to achieve overall target kill it must be detected, recognized as a valid target, acquired, tracked, fired at with a weapon and killed. An MOE for each of these subtasks is commonly referred to as a "function MOE" since it provides a measure of how well the individual subtask (or function necessary to accomplish the broader task) is accomplished. Therefore, an MOE for the broader task could be expected to be a function of these subtask or function MOE's. This illustrates the type of hierarchy which generally exists among MOE's.

As the MOE hierarchy evolves from the top level to the lower levels (such as from force level to platform level to system level to subsystem or equipment level), the nature or form of the MOE changes. At the lower levels, the MOE's become less "effectiveness oriented" and more "performance oriented". For example, median detection range, circular error probable, mean miss distance, etc. are typical performance oriented MOE's, whereas expected number of target kills per sortie, probability of target detection, classification, localization and kill, and the exchange ratio given by the ratio of enemy kills to friendly kills are typical effectiveness oriented MOE's at the platform or force levels. It is important to emphasize that the selection of MOE's and data requirements is not a bottom-up procedure but rather a top-down procedure; that is, a Project Officer or Analyst should not first look up MOE's to see what he can calculate and then let this drive the tests that are to be run. He should focus his MOE selection effort at least one evaluation level higher than that called for in the test or evaluation, and select an effectiveness oriented MOE before determining the performance oriented MOE's which it depends upon.

In the following sections are presented discussions of how MOE's are used in OPTEVFOR projects and analyses, guidance in the selection of these MOE's, the hierarchy that exists between MOE's at various levels of evaluation, MOE data formulations, and how to use the MOE data base provided in Appendix B of this handbook. This data base is intended to be illustrative of the types of MOE's that have been used in the past and are thus potential candidates for use now or in the future, however the Project Officer or Analyst should be aware of the caveat, namely, what was used in the past (be it right or wrong) is not necessarily what should be used now or in the future. The Project Officer or Analyst should use this data base as a starting point not as an ending point in the selection of the MOE's most appropriate for his particular test or evaluation. As new MOE's are created and formulated, they can be readily added to the data base, thus providing an up to date MOE reference source.

2.0 GUIDELINES AND CRITERIA FOR MOE SELECTION

The importance of choosing the right MOE is illustrated by a classic example offered by Morse and Kimball.[1] During World War II, British merchant ships in the Mediterranean were provided with anti-aircraft guns to protect them against German dive bombers. After several months of operation, an effectiveness evaluation was made which showed that the enemy aircraft was shot down in only about four percent of the

[1] Philip M. Morse and George E. Kimball, Methods of Operations Research, John Wiley and Sons, New York, 1951

attacks. On this basis, it was tentatively decided to remove the guns, which were relatively expensive and needed elsewhere. It was then pointed out that the wrong MOE had been used in the evaluation. The real objective was to protect the merchant vessels, not necessarily to destroy enemy aircraft, which could be done more efficiently in other ways. If the guns caused the aircraft to stay at high altitude or forced them to maneuver evasively, thus degrading the bombing accuracy, they would have served their purpose. When the MOE was framed in terms of the proper objective, it was found that only ten percent of the protected ships had been sunk when attacked, compared with twenty-five percent for the unprotected ships. Based on these facts, the guns were left on the ships.

A similar type of situation occurred more recently in the Viet Nam War when the SHRIKE antiradiation missile was introduced. This missile was designed to home-on and to destroy radars. When it was first used, the missile was very successful in destroying radars; however, the enemy soon learned that by shutting off or intermittently using their radars they could defeat the missile. Consequently, choosing the missile MOE as the probability of radar kill, we have a case where the initially observed values of this MOE were high, but decreased with time and continued use of the missile. The problem here is one of choosing the wrong MOE. In reality, the purpose of the missile was to increase the survivability of penetrating strike aircraft by suppressing enemy radar transmissions or causing the enemy radars to cease radiating; hence no surface-to-air missiles could be fired. This objective can be accomplished in several ways, namely:

(1) the missile can physically destroy the radar as it is designed to do;
(2) the missile can be fired at the radar target, and if the radar operator is aware that the missile has been launched at him, he may shut the radar off the air rather than risk being destroyed;
(3) the mission can be accomplished if the pilot turns the aircraft carrying the antiradiation missile toward the target, preparing for or feigning a missile launch, and then the radar operator, anticipating a missile attack, shuts down.

Consequently, the mission objective can be accomplished without firing any missiles at all. In the case of strike warfare where the antiradiation missile is employed to protect penetrating aircraft, a candidate measure of effectiveness would be the probability that either no surface-to-air missiles are fired or, given that at least one SAM is fired, all aircraft survive.

In addition to showing that a completely wrong decision can be forced by an injudicious choice of criterion, the above examples serve to illustrate an important principle of criteria selection: the criteria must reflect the user's objectives at the appropriate level of generality. A further observation regarding these two examples is that depending on whether or not your choice is the offensive or defensive role, the corresponding MOE's are different.

Basic guidance in the selection of an MOE and success criteria for the evaluation of a platform, system, subsystem or piece of equipment can generally be found by referring to the principal documents in the RDT&E Planning and Acquisition Process — specifically, GOR's, TSOR's, PTA's, SOR's and TDP's for on-going programs, and CPPG's, CPAM's, STO's, OR's, TLR's and TLS's for new and future programs.

General Operational Requirements (GOR's) forecast operational capability requirements, Tentative Specific Operational Requirements (TSOR's) identify specific operational needs and the required capabilities to satisfy those needs, Proposed Technical Approaches (PTA's) specify alternative approaches to attain the stated needs, Specific Operational Requirements (SOR's) formally state the need for development of new or improved capabilities, and Technical Development Plans (TDP's) document the actions, procedures and resources required to achieve the capability stated in the SOR's. For example, GOR-11 Air Strike Warfare states that in assessing capability to perform the Defense Suppression Mission one must recognize that the objective is to help minimize overall strike force attrition by using escorts to protect against surface and airborne defenses; hence, in this case, the success criterion is based on the requirement that the defenses do not fire, or are relatively ineffective in their fire, during the attack by the primary strike force and thus suppression is successful if the enemy defensive systems are unable to effectively impede the primary mission.

The corresponding SOR's and TDP's then address the specific types of weapon systems and development plans, respectively, in order to meet forecasted operational capability requirements for the performance of this mission against future anticipated threats.

In the case of many new and all future programs, potential sources of information on missions, operational roles, success and performance criteria, and test objectives are of various types. The CNO Planning Programming Guidance (CPPG) document describes Navy roles and missions, and furnishes broad Navy planning guidance. CNO Program Analysis Memoranda (CPAM) treat mission and support areas in terms of cost and capabilities, and furnish the basis for consideration of broad program alternatives. Science and Technology Objectives (STO's), as part of the Research and Development Plan, describe in broad terms the Navy role and objectives anticipated in the particular warfare area in the 10-20 year future time frame, and describe the threat that the Navy anticipates encountering together with the needed capabilities to neutralize or overcome this threat in this time frame. Operational Requirements (OR's) have the purpose of establishing the parameters for the concept or system envisioned and contain the following: a brief concise statement of opposition forces, time frame and the expected parameters of the threat or threat system; performance criteria; performance goals for the intended mission; statement of an achievable level of performance below which the development will not be acceptable; description of the natural and opposition environment; statement of where, how and under what environmental conditions the capability will be employed. The Top Level Requirements (TLR) document is basically a ship acquisition document which establishes a requirements-capability baseline and describes the combat tasks and functions the ship is intended to perform in the defined mission areas. The Top Level Specifications (TLS) document translates the TLR document into a physical ship description.

Once the overall project and specific objectives have been defined, the types of platforms, systems, subsystems and equipments to be evaluated or appraised must be identified, the level of evaluation (such as platform, system or subsystem) defined, and the operational situations for evaluation or appraisal described. For example, the warfare area of interest might be

Airborne ASW and the operational situation that of contact investigation at the system level using a helicopter platform equipped with dipping sonar and torpedoes. At this point in the project plan preparation process, a decision must be made as to what measures of effectiveness should be employed. In this example, some of the choices are: (1) detection sweep width (in nm.) at a prescribed probability of detection, (2) probability of classification given detection, (3) probability of localization given classification and detection, and (4) probability of target kill given localization. The Project Officer is thus confronted with having to make a choice from amongst one or more possibilities, each of which may appear to be equally as good as any other. If the specific objective is assessment of detection capability, then (1) is most appropriate, whereas for the specific objectives of classification, localization and kill measures (2), (3) and (4) are the most appropriate, respectively. A further consideration is that each MOE would typically have its own special data requirements and data formulation.

Tables 2.1 — 2.3 provide a further illustration of the fact that for a given specific objective there generally exists more than one choice of an MOE, each with its own special data requirements and formulation, for the case of communications systems, ECM systems, and radar systems, respectively.

Generally, the choice of an MOE to be used in the evaluation of any platform, system, subsystem or piece of equipment must meet basic requirements such as:

(1) It must directly relate to how well the specific objective is met.

(2) It should be relevant to the mission or operational role of interest.

(3) It should be precisely defined and expressed in terms meaningful to the decision maker in order to prevent decision makers and others from misunderstanding the implications of the MOE.

(4) It must be capable of exact quantitative definition in terms of inputs that are measurable. If the inputs are not measureable, the MOE cannot be evaluated.

TABLE 2.1 COMMUNICATIONS SYSTEM, SUBSYSTEM AND EQUIPMENT MOE'S

SPECIFIC OBJECTIVE	MOE	DATA FORMULATION
Determine data transmission and reception capability	(1) Data rate achieved	Words per minute
	(2) Mean character error rate	Average number of character errors per 1000 character message
	(3) Gross error rate	Percent of messages that have more than 10 character errors per 1000 character message
	(4) Bit error rate	Number of bits missed per second for a given data rate
	(5) Percent messages received	$\frac{\text{Number of messages received}}{\text{Number of messages transmitted}} \times 100$
	(6) Percent messages received that were displayed accurately	$\frac{\left(\text{Number of accurately displayed messages}\right)}{\left(\text{Number of messages received}\right)} \times 100$
Determine voice transmission and reception capability	(1) Mean error rate	Number of words missed per 25-word message
	(2) Probability that a rhyme word transmitted is correctly interpreted	$1 - \frac{\left(\text{Average number of words wrong per N-word message}\right)}{N}$
	(3) Percent sentence intelligibility	(See NELC Report: "Speech Intelligibility in Naval Aircraft Radios")

TABLE 2.2 ECM SYSTEM, SUBSYSTEM AND EQUIPMENT MOE'S

SPECIFIC OBJECTIVE	MOE	DATA FORMULATION
Determine trackbreak capability against radars	(1) Average maximum lock-on range for given trackbreak mode	$\frac{1}{N}\sum_{i=1}^{N}(i^{th}$ maximum lock-on range)
	(2) Average maximum trackbreak range for given trackbreak mode	$\frac{1}{N}\sum_{i=1}^{N}(i^{th}$ maximum trackbreak range)
	(3) Average crossover range (i.e., minimum effective range) for given trackbreak mode	$\frac{1}{N}\sum_{i=1}^{N}(i^{th}$ crossover range)
	(4) Average number of trackbreaks per radar run for given trackbreak mode	$\frac{\text{Number of trackbreaks}}{\text{Number of radar runs}}$
	(5) Average time to lock-on	$\frac{1}{N}\sum_{i=1}^{N}(i^{th}$ time to lock-on)
	(6) Average time to break lock	$\frac{1}{N}\sum_{i=1}^{N}(i^{th}$ time to break lock)
	(7) Average burnthrough range	$\frac{1}{N}\sum_{i=1}^{N}(i^{th}$ burnthrough range)
Determine false target, decoy and deception capability	(1) Average triggering range by attack radar	$\frac{1}{N}\sum_{i=1}^{N}(i^{th}$ triggering range)
	(2) Average maximum effective range in target decoy mode	$\frac{1}{N}\sum_{i=1}^{N}(i^{th}$ maximum effective range)

TABLE 2.2 (Continued)

SPECIFIC OBJECTIVE	MOE	DATA FORMULATION
	(3) Average minimum effective range in target decoy mode	$\frac{1}{N}\sum_{i=1}^{N}(i^{\underline{th}}$ minimum effective range)
	(4) Average maximum effective range in trackbreak mode	$\frac{1}{N}\sum_{i=1}^{N}(i^{\underline{th}}$ maximum effective range)
	(5) Average minimum effective range in trackbreak mode	$\frac{1}{N}\sum_{i=1}^{N}(i^{\underline{th}}$ minimum effective range)
	(6) Probability of successful deception for given mode of operation	$\frac{\text{Number of successful deceptions}}{\text{Number of deception attempts}}$
	(7) Probability of successful blanking	$\frac{\left(\text{Number of times radar signals were blanked}\right)}{\left(\text{Number of blanking opportunities}\right)}$
	(8) Probability of discrimination between decoy and true target as a function of range	$\frac{\left(\text{Number of times discrimination occurred between decoy and true target within a given range band}\right)}{\left(\text{Number of decoy and target opportunities within a given range band}\right)}$

TABLE 2.3 RADAR SYSTEM MOE'S

SPECIFIC OBJECTIVE	MOE	DATA FORMULATION
Determine detection performance	(1) Cumulative distribution of maximum detection range	Fraction of runs on which detection was made by given range
	(2) Single scan probability of detection as a function of range for given target speed, target altitude, and antenna lobing	$\frac{\text{Number of detections (blips)}}{\text{Number of scans}}$
	(3) Average minimum target detection range as a function of target altitude, target type, antenna polarization type and antenna tilt angle	$\frac{1}{N}\sum_{i=1}^{N}\left(i^{\underline{th}}\text{ minimum target detection range}\right)$
	(4) Average maximum target detection range as a function of target altitude, target type, antenna polarization type and antenna tilt angle	$\frac{1}{N}\sum_{i=1}^{N}\left(i^{\underline{th}}\text{ maximum target detection range}\right)$
	(5) Blip/scan ratio as a function of range for given target type, altitude, speed and radar mode	$\frac{\left(\text{Number of times target radar return was present on scope for a given range band}\right)}{\left(\text{Number of antenna scans in a given range band}\right)}$
	(6) Median detection range for given radar mode, target type and target altitude	Range such that 50% of the observed detections occurred beyond this range

TABLE 2.3 (Continued)

SPECIFIC OBJECTIVE	MOE	DATA FORMULATION
	(7) 90% cumulative detection range for given radar mode, target type and target altitude	Range such that 90% of the observed detections occurred at distances less than this range
	(8) Median minimum detection range for given target altitude and elevation scan limit	Range such that 50% of the observed minimum detection ranges were greater than this range
Determine tracking performance	(1) Percent of runs on which tracking was held to a given range	$\frac{\left(\text{Number of runs on which tracking was held to a given range}\right)}{\text{Number of tracking runs}} \times 100$
	(2) Average index of track solidity as a function of slant range for given target altitude, target type and antenna tilt angle	$\frac{\left(\text{Number of blips observed in a given range band}\right)}{\left(\text{Number of scans in a given range band}\right)}$
	(3) Mean radar range resolution	Average range difference of the leading edge of two targets at the same bearing as the two target blips started to separate or merge
	(4) Mean radar bearing resolution	Avecage bearing difference of the center of two targets at the same range as the two target blips started to separate or merge
	(5) Mean radar range error	$\frac{1}{N}\sum_{i=1}^{N}(i^{\underline{th}}\text{ radar range error})$

TABLE 2.3 (Continued)

SPECIFIC OBJECTIVE	MOE	DATA FORMULATION
	(6) Mean radar bearing error	$\frac{1}{N}\sum_{i=1}^{N}(i^{th}$ radar bearing error)
	(7) Cumulative range error distribution	Fraction of observed range errors less than a specified amount
	(8) Cumulative bearing error distribution	Fraction of observed bearing errors less than a specified amount
	(9) Cumulative altitude error distribution	Fraction of observed altitude errors less than a specified amount

(5) It must be feasible to measure or calculate.

(6) It should have exhaustive inputs and be sensitive to all variables and factors affecting the item (i.e., platform, system, subsystem or equipment). By this it is meant that anything that affects the item's effectiveness should appear as an input to the MOE in some fashion. This assures that all aspects that can affect the item's effectiveness are included in the inputs.

(7) It, as well as its inputs, should be mutually exclusive in the sense that no aspect should be "counted" more than once.

A final comment is that it is nearly impossible to compare a new system with an old one when different MOE's are being used. When the quality of the data gathered is not changing rapidly, using standard MOE's for old and new systems will make it easier to compare them as long as the test conditions are the same. Making a comparison using the same MOE under differing test conditions can (and most probably would) lead to an invalid conclusion.

3.0 MOE HIERARCHY APPROACH

Measures of effectiveness vary in structure and in formulation according to the level of the evaluation desired. To illustrate this, consider the area of Naval gunfire support. Here measures of effectiveness may be broadly categorized into those applied to individual weapons, those used to compare two types of ships, and those computed for entire fire support forces in specific scenarios and special situations. At the lowest level are those that apply to a single tube of a gun battery or a single round. In this case, measures of effectiveness are the accuracy and range of the gun, its firing rate, and the expected number of rounds required to achieve some specified damage or casualty level to a particular type of target. A first higher level measure of effectiveness is the amount of time a battery must fire to achieve specified damage or casualty levels against a representative spectrum of targets at various ranges. A second higher order measure of effectiveness is the percentage of a ship's ammunition of a given type that must be expended in order to accomplish the desired results against representative targets at various ranges. At a still higher level of sophistication are those measures of effectiveness which apply to the fire support force as a whole such as: live target time, which is the time interval from the occurrence of a target until some weapon system has fired the expected number of rounds required to achieve the required effects upon the target; target firing time, which is measured to the impact of the first fire-for-effect volley or salvo; the number of lost targets, that is, targets which have occurred within the fire support system but which disappear before fire-for-effect commences, either because they displace and are lost to the observer or because they close with (or are closed by) landing force units and can no longer be attacked by the fire support system.

Generally, there are four levels of effectiveness evaluation. These are

(1) Force (platform mix)
(2) Platform
(3) System
(4) Subsystem (or equipment)

COMOPTEVFOR Project Officers and Analysts are normally only concerned with the selection of MOE's at the last three levels, that is, excluding force level evaluations. At the platform level the Project Officer's interest may be in how well a platform would perform in conducting a particular type of mission or conducting given tactics in the course of following a scenario. At this level the measure of effectiveness is sometimes referred to as a measure of operational effectiveness (MOOE), that is, a MOOE could be regarded as a measure of how well the Naval "unit" (such as ship, aircraft, submarine, etc.) performs its mission or operational roles. A related measure, called a measure of operational success (MOOS), is a measure which considers not only the "effectiveness" as determined by the MOOE but also the reliability and operational availability of the equipment, subsystems and systems involved. The MOOE for a platform is a function of the individual system MOE's where the platform is regarded as being comprised of a collection of systems. The systems then are comprised of subsystems and so system MOE's can be expected to be functions of subsystem MOE's. This relationship between MOE's at various levels of evaluation is what is referred to as the MOE chain or the hierarchy of MOE's.

In the selection of an MOE the element being supported is critical. Since the object under evaluation either supports the next higher level in hierarchy or the next step in the evaluation process, the MOE selected should likewise be related to the next level or next step. The detection performance of a sonar or the kill capability of a torpedo should be evaluated in the context of the overall platform performance. This is why it is important to go to at least one higher level of evaluation in performing effectiveness evaluations. The MOOE is the effectiveness measure at the platform level whereas detection probability and kill probability are input MOE's from the system level. In Appendix A are presented illustrative examples of typical MOOE's that are candidates for consideration in OPTEVFOR tests and evaluation.

As the MOE hierarchy evolves from the top level (i.e., platform) to the lower levels, the nature or form of the MOE changes. At the lower levels the MOE's become less "effectiveness oriented" and more "performance oriented". For example, performance oriented MOE's are given by such quantities as detection range, tracking accuracy, and circular error probable (CEP), whereas the corresponding effectiveness oriented (or performance dependent) MOE's would be the probability of detection (a function of detection range), the probability of successful tracking (a function of tracking accuracy) and the probability of target kill (a function of weapon CEP).

Furthermore, MOE's used in platform and system level evaluations are generally functions of what are called "function MOE's", that is, MOE's which relate to how well certain necessary functions are performed as part of the platform or system level evaluation. For example, in the attack of an airborne target by an air-to-air missile, in order to obtain target kill the functions of launch, guidance, fuzing and kill must be successfully accomplished. Figure 3.1 provides an illustration of this example showing how the MOE given by single shot kill probability depends on the corresponding function MOE's.

It is important to note that at the function level the MOE depends on "other things being equal". For example, if other things are equal, an air-to-air missile with a guidance reliability of 0.95 is clearly better than one with a guidance reliability of 0.80; however, this functional MOE comparison does not tell us what this improvement in guidance reliability really means operationally. The missile with the higher guidance reliability may weigh more and thus the aircraft must carry fewer missiles on a sortie or it may be harder to maintain in an operational condition. Generally, a comparison between function MOE's is not as meaningful as a comparison at the next higher level of MOE's which depend upon these function MOE's.

A further illustration of function MOE's and their relationship to the next higher level MOE is provided in Figures 3.2 and 3.3. Referring to Figure 3.2, a platform level MOE is given by SSK versus Transitor effectiveness for a submarine on a barrier mission with the specific objective of detecting and killing any enemy submarine encountered in the patrol area. In this case the functions necessary for the conduct of the mission are detection, classification, attack and kill. The effectiveness evaluation can be conducted at the platform level by measuring the number of transitors killed by the SSK and the number of valid detection opportunities for the SSK, and then computing the ratio of these two quantities. On the other hand, depending on the circumstances of the test and the available data samples, the individual function MOE's could be estimated as shown and then multiplied to obtain an estimate of the next higher level MOE. Figure 3.3 provides a more detailed example of this point involving two sub-levels (function and sub-function) in the MOE development and formulation for the case of an ASW helicopter which is attempting to localize and attack a submarine target.

As can be seen from these two examples, the determination of data requirements for MOE computation depends upon the level of evaluation being performed. This is because the lower level MOE's are more readily evaluated,

FIGURE 3.1 EXAMPLE OF MOE AND DATA FORMULATION BY FUNCTION FOR SYSTEM: Air-to-Air Missile

SPECIFIC OBJECTIVE: Kill of an airborne target

	FUNCTION: Launch		FUNCTION: Guidance		FUNCTION: Fuzing		FUNCTION: Kill		SYSTEM MEASURE OF EFFECTIVENESS
FUNCTION MOE:	Launch reliability	x	Guidance reliability	x	Fuzing reliability	x	Lethality	=	Single shot kill probability
DATA FORMULATION:	$\frac{\text{Number of successful launches}}{\text{Number of valid attempts to fire}}$	x	$\frac{\text{Number of guidance successes}}{\text{Number of successful launches}}$	x	$\frac{\text{Number of fuzing successes}}{\text{Number of guidance successes}}$	x	$\frac{\text{Number of target kills}}{\text{Number of fuzing successes}}$	=	$\frac{\text{Number of target kills}}{\text{Number of valid attempts to fire}}$
DATA SOURCE:	Firing exercises		Firing exercises		Firing exercises or laboratory simulations		Laboratory simulations		

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FIGURE 3.2 EXAMPLE OF MOE AND DATA FORMULATION FOR PLATFORM: Submarine

SPECIFIC OBJECTIVE: Detect and kill any submarine encountered in a patrol area.

	FUNCTION: DETECTION		FUNCTION: CLASSIFICATION		FUNCTION: ATTACK		FUNCTION: KILL		PLATFORM MEASURE OF EFFECTIVENESS
FUNCTION MOE:	Probability that the SSK detects a transiting submarine without first being killed, given a detection opportunity	X	Probability that the SSK correctly classifies a transiting submarine without being killed between the time of detection and time of classification, given that the transitor has been detected	X	Probability that the SSK makes an accurate attack against a transiting submarine without being killed between the time of classification and the time the launched weapon no longer requires control by the firing ship for successful culmination of the attack, given that the transitor has been correctly classified.	X	Probability that a transiting submarine is destroyed, given that an accurate attack is made	=	SSK versus Transitor effectiveness
DATA FORMULATION:	(Number of detections of a transitor by the SSK) / (Number of valid detection opportunities for the SSK)	X	(Number of correct classifications of the transitor by the SSK) / (Number of detections of the transitor by the SSK that are valid opportunities for classification)	X	(Number of accurately placed attacks by the SSK against the transitor) / (Number of correct classifications of the transitor by the SSK that are valid approach opportunities)	X	(Number of transitors killed by the SSK) / (Number of accurately placed attacks by the SSK against the transitors)	=	(Number of transitors killed by the SSK) / (Number of valid detection opportunities for the SSK)
DATA SOURCE:	Attack exercise		Attack exercise		Attack exercise		Attack exercise reconstruction and laboratory simulation		

FIGURE 3.3 EXAMPLE OF MOE AND DATA FORMULATION BY FUNCTION FOR PLATFORM: ASW Helicopter

SPECIFIC OBJECTIVE: Localize and attack submarine target

MEASURE OF EFFECTIVENESS: MOE = Probability of successful localization and attack of submarine target

DATA REQUIREMENTS FORMULATION:

$$= \frac{N_1}{N_2} = \frac{\text{Number of times localization and attack were successful}}{\text{Number of localization and attack attempts}}$$

FORMULATION IN FUNCTION MOE's:

$$= (MOE)_L \; (MOE)_A$$

FUNCTION MOE:

$(MOE)_L$ = Probability of successful localization

$(MOE)_A$ = Probability of attack of submarine target given successful localization

DATA REQUIREMENTS FORMULATION:

$$= \frac{N_3}{N_4} = \frac{(\text{Number of times localization is successful})}{(\text{Number of localization attempts})}$$

$$= \frac{N_5}{N_6} = \frac{\text{Number of successful attacks}}{(\text{Number of attack attempts given localization})}$$

FORMULATION IN SUBFUNCTION MOE's:

= {

$(MOE)_{L1}$ = Probability of successful conversion of a sonar contact to a MAD contact

$(MOE)_{L2}\;(MOE)_{L3}$ = (Probability of successful conversion of a sonar contact to sonobuoy contact) (Probability of successful conversion of sonobuoy contact to MAD contact)

$(MOE)_{L4}$ = Probability of successful conversion from a sonar contact to sonobuoys to a MAD contact

}

DATA REQUIREMENTS FORMULATION:

= {

$$\frac{N_7}{N_8} = \frac{(\text{Number of times conversion from a sonar contact to MAD was successful})}{\text{Number of sonar to MAD conversion attempts}}$$

$$\left(\frac{N_9}{N_{10}}\right)\left(\frac{N_{11}}{N_{12}}\right) = \frac{(\text{Number of times conversion from a sonar contact to sonobuoys was successful})}{(\text{Number of sonar to sonobuoy conversion attempts})} \cdot \frac{(\text{Number of times conversion from a sonobuoy contact to a MAD contact was successful})}{(\text{Number of sonobuoy to MAD conversion attempts})}$$

$$\frac{N_{13}}{N_{14}} = \frac{(\text{Number of times conversion from a sonar contact to sonobuoy contact to MAD contact was successful})}{(\text{Number of sonar to sonobuoy to MAD conversion attempts})}$$

}

whereas the platform or system level MOE's, since they are functions of lower level MOE's, have more complex data requirements. The general approach to structuring data requirements is to start with the MOE (or MOE's) selected for evaluation purposes and to identify its formulation in terms of lower level MOE's. The next step is to identify the formulation of each lower level MOE into further lower level MOE's until one reaches the level at which data can be readily collected. Figure 3.4 provides an illustration of this process in terms of taking the function MOE's and identifying those performance parameters necessary to compute them. Furthermore, Figures 3.1—3.3 and 3.5 provide good illustrations of the complete decomposition of an MOE into lower level MOE's and their corresponding data requirements in addition to specifying where one might obtain the necessary data.

In many cases when an MOE is expressed as a function of lower level MOE's, it is possible to collect data directly at each level in the hierarchy so as to compute either the top level MOE or any of its dependent lower level MOE's. Such is the case illustrated in Figure 3.6 for detection-type MOE's. Generally accepted detection oriented MOE's are given by the average detection range and the probability of detection as a function of range. The latter can also be expressed as a function of target aspect and speed. There exists an intimate relationship between these MOE's as illustrated in Figure 3.6. The point to be made here is that at a particular evaluation level where more than one choice of an MOE exists, some of these MOE's can be computed from one or more of the others. In a sense, this implies that not only does there exist a hierarchy of MOE's between levels of evaluation, but also there exists a hierarchy between MOE's at a specified level of evaluation. The decision as to what level the data should be collected depends upon such factors as available sample sizes, statistical confidence desired in the results obtained, and the complexity of the analysis involved. These factors would normally be an integral part of the project plan.

In summary, key observations to be made relative to the MOE hierarchy and the selection of MOE's are as follows:

FIGURE 3.4 EXAMPLE OF MOE DATA STRUCTURE PROCESS FOR EVALUATION OF SUBMARINE ATTACK ON CONVOY

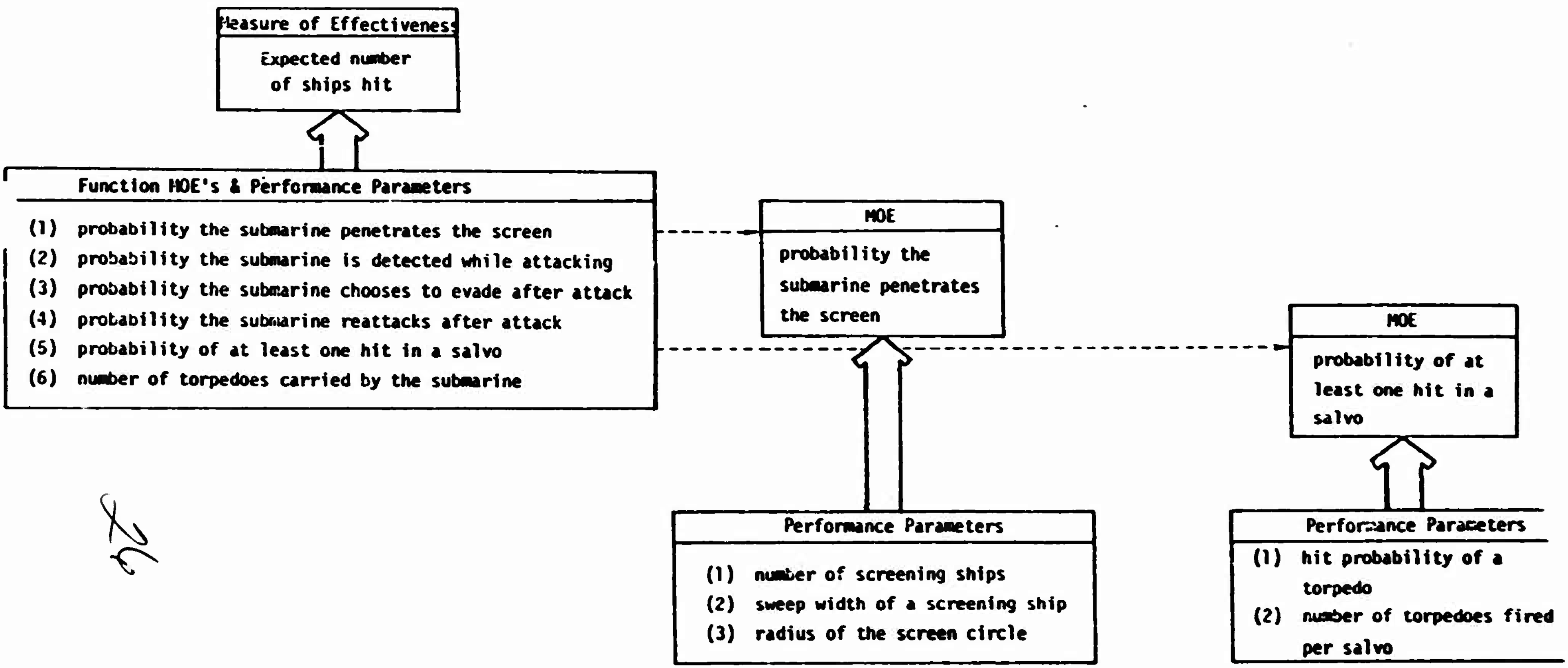
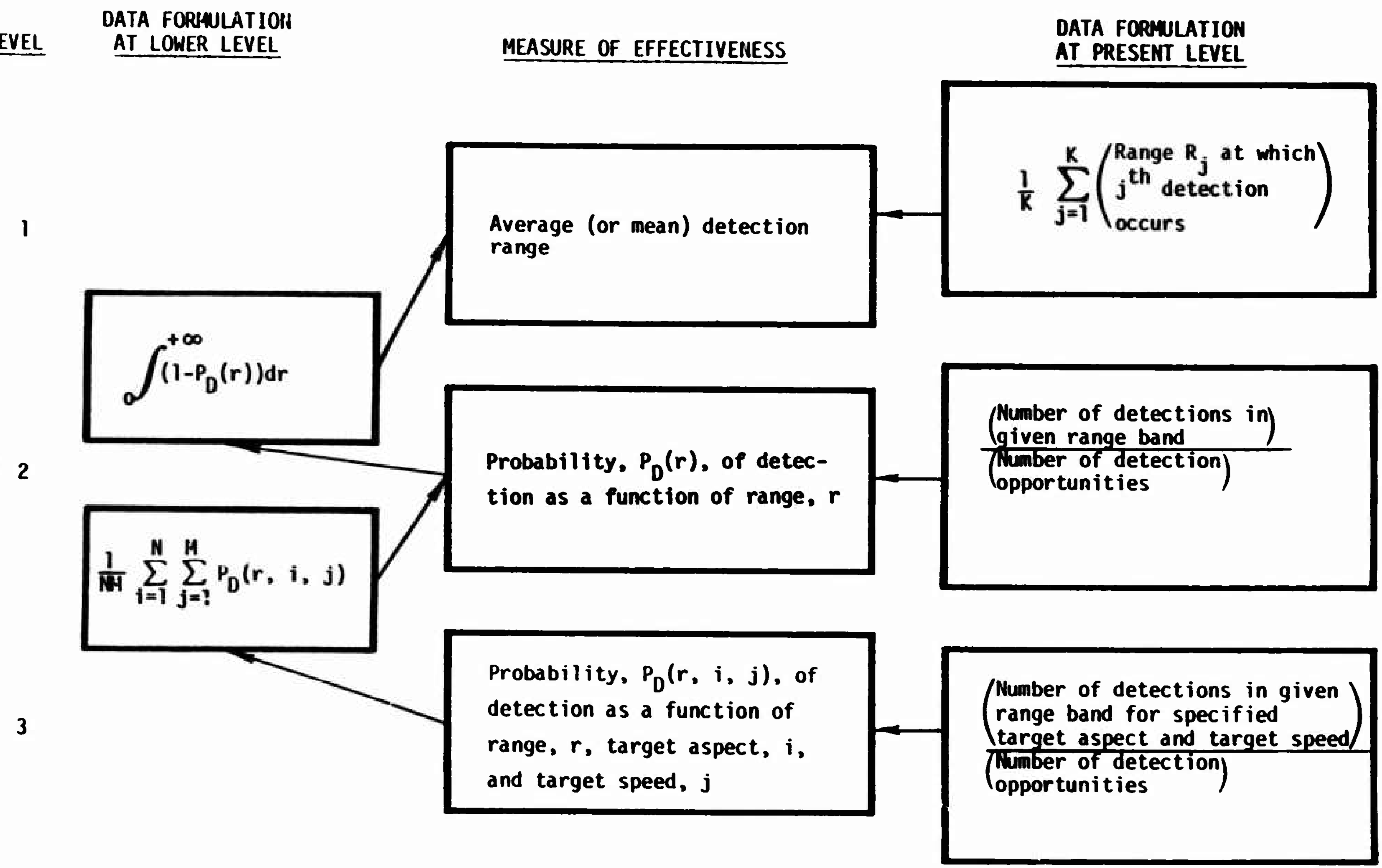


FIGURE 3.5 Example of MOE and Data Formulation for Bomb Deployment Against Surface Targets

MOE	MOE FORMULATION BY TARGET TYPE	FUNCTION MOE'S	FUNCTION MOE FORMULATION	DATA REQUIRED	SOURCE
Probability of Target Kill with n Bombs	If Bridge Target: $1-(1-P_H[1-e^{-BEI/W}])^n$	P_H = Probability of Hit on Target = (Number of Times Target is Hit) / (Number of Times Bomb is Dropped on Target)	$P_H = \frac{1}{2\pi\sigma_x\sigma_y}\int_{-L}^{L}\int_{-W}^{W} e^{-\frac{1}{2}\left(\frac{x^2}{\sigma_x^2}+\frac{y^2}{\sigma_y^2}\right)} dx\,dy$ (NOTE: $\sigma_x = 1.483$ REP, $\sigma_y = 1.483$ DEP) REP = Median Miss Distance in Range; DEP = Median Miss Distance in Deflection	BEI = Bridge Effectiveness Index	JMEM
				W = Bridge Width	Target Description
				L = Bridge Length	Target Description
				REP	Attack Exercise
				DEP	Attack Exercise
	If Point Target: $1-(\frac{1}{2})^{(LR/CEP)^{2n}}$	CEP = Circular Error Probable = Median Miss Distance from Target		LR = Lethal Radius for Bomb-Target Combination	Laboratory Test, simulation
				CEP	Attack Exercise
	If Circular or Rectangular Target: $1-e^{-nP_H(MAE)/A}$	P_H = Probability of Hit on Target = (Number of Times Target is Hit) / (Number of Times Bomb is Dropped on Target)	$P_H = 1-(\frac{1}{2})^{(R/CEP)^2}$ If Circular Target; $P_H = \frac{1}{2\pi\sigma_x\sigma_y}\int_{-L}^{L}\int_{-W}^{W} e^{-\frac{1}{2}\left(\frac{x^2}{\sigma_x^2}+\frac{y^2}{\sigma_y^2}\right)} dx\,dy$ If Rectangular Target (NOTE: $\sigma_x = 1.483$ REP, $\sigma_y = 1.483$ DEP) REP = Median Miss Distance in Range; DEP = Median Miss Distance in Deflection	R = Radius of Circular Target	Target Description
				L = Length of Rectangular Target	Target Description
				W = Width of Rectangular Target	Target Description
				A = Target Area (πR^2 or LW)	Target Description
				MAE = Mean Area of Effectiveness	JMEM
				CEP	Attack Exercise
				REP	Attack Exercise
				DEP	Attack Exercise

FIGURE 3.6 LEVELS OF DATA FORMULATION FOR DETECTION MOE's



(1) MOE's for platforms, systems and subsystems depend on the intended use of these platforms, systems and subsystems.

(2) Many times more than one MOE may be appropriate.

(3) MOE's can be combined to form higher level MOE's or, conversely, MOE's can be expressed as functions of lower level MOE's.

(4) Lower level MOE's are more readily measured because of data availability, consequently, to evaluate a higher level MOE one must know its relationship to the measurable lower level MOE's.

4.0 USE OF THE HANDBOOK DATA BASE

In order to establish a data base for use by Project Officers and Analysts in the selection of measures of effectiveness and the determination of the corresponding data requirements and MOE formulation, two types of MOE reviews were performed.

First, a review of platform level types of MOE's, representative of MOOE's, was performed using the results of a previously conducted study* for the Office of Naval Research. These measures of effectiveness, the applicable missions or operational situations, the corresponding success criteria, and the types of systems or subsystems which could be evaluated using these MOOE's are presented in Appendix A.

The second review consisted of an examination of previously completed OT&E reports. This review covered Concurrent Evaluations of shipboard and airborne systems; Operational Appraisals for shipboard and combined systems or equipments; Operational Assists for shipboard, airborne and combined systems or equipments. The objective of this review was to document for reference purposes the types of systems and equipments whose test and evaluation involves the services of OPTEVFOR personnel. Not only were specific systems and equipments identified, but so were the specific test objectives, the measure(s) of effectiveness, the data requirements,

* "A Study of Measures of Effectiveness Used In Naval Analysis Studies", Vols. 1-4, Ultrasystems, Inc., 31 Oct. 1972

data sources, and MOE formulation identified. An attempt was made, even though not including all such projects, to provide a representative sample of this type of information for OPTEVFOR projects. The results of this survey are presented in Table B-2 of Appendix B.

In order to facilitate the use of this OT&E data base, MOE usage was categorized according to the platform, system, subsystem or equipment area. Twelve basic category areas were selected representing: Aircraft (A), Acoustic Detection & Countermeasures (ADC), Communications (C), Data & Display (DD), Electromagnetic Detection & Countermeasures (EDC), Fire Control (FC), Infrared & Optical Detection (IOD), Missiles (M), Navigation & Guidance (NG), Ordnance (O), Submarines (S), and Surface Ships (SS). Within each area the MOE information from a project report was then separated according to the specific performance or evaluation objective for the platform, system, subsystem or equipment considered. As a result, this provided a "sorting out" of MOE's by type of item evaluated based on previous MOE usage in OPTEVFOR projects.

The basic steps to be followed in the use of this OT&E data base by a Project Officer or Analyst can be described as follows:

<u>Step 1</u> Select the platform, system, subsystem or equipment of interest.

<u>Step 2</u> From the project objectives define the specific objective(s) of the evaluation.

<u>Step 3</u> Use the index of Table B-3 to determine whether or not there is information in the data base regarding the evaluation of the platform, system, subsystem or equipment of interest.

<u>Step 4</u> Under the assumption that information of the type desired is in the data base, turn to the appropriate data item(s).

To illustrate these steps, suppose the Project Officer or Analyst is interested in evaluating an air-to-surface antiradiation missile to be launched from an aircraft. He is not interested in evaluating the performance of the aircraft (i.e., the platform) per se nor is he interested solely in evaluating the performance of a particular subsystem of the missile. His interest is with the missile itself. Thus, he desires to know what measures of effectiveness could be used for a system level evaluation of an air-to-surface missile — in particular, one whose intended target is a surface radar. Therefore, referring to Table B-3, he observes that under the listing for missiles, anti-radiation there is information in area code M2. Turning to page B-107 in Table B-2, for the specific objective of "killing" the radar, the MOE given is the single shot kill probability which is defined as the product of the launch, guidance and fuze reliabilities and the kill probability against the target given a reliable missile. The formulation is given for each of these reliability terms and the sources of data are specified.

If the Project Officer or Analyst is interested in a platform level type of evaluation, specifically, how well a submarine performs in the Fixed Barrier Role, that is patrolling a particular area with the objective of detecting and killing any enemy submarine encountered, then referring to Table B-3 he observes that there are three items in the data base concerned with platform level evaluations of submarines, namely, in area code S1, items S1-1, S1-2 and S1-3. Turning to page B-139 in Table B-2, he observes that the information he seeks is given by data item S1-1. There the suggested MOE for this mission is given by SSK versus Transitor effectiveness, which would also correspond to a measure of operational effectiveness. The formulation of this MOE, the data requirements for its computation and an explanation of the data sources are provided. Should he desire to read the report from which this information was obtained, the reference is given and, for ease of comparison and reading, the original notation as used in the report has been preserved.

If the Project Officer or Analyst was in reality only interested in evaluating the performance of the submarine sonar in this barrier mission, then merely selecting a system level type of MOE for the sonar would not suffice nor would he obtain as a result a realistic assessment of how this sonar supports the performance of the platform. For example, data item ADC1-1 (see page B-12) contains MOE's which could be used for submarine sonar evaluation, such as average detection range, figure-of-merit, 90% probability of detection range and the cumulative probability of detection as a function of range. These MOE's in themselves say nothing about the submarine performance in this mission. How good the sonar is should be evaluated in light of what contribution it makes to overall submarine performance, that is, we need to examine the next higher level of effectiveness, given in this case by the MOOE called SSK versus Transitor effectiveness. The first term, P_D, in the formulation of this measure, given by the probability that the SSK detects a transiting submarine without first being killed, given a detection opportunity, and the second term, P_C, in the formulation of this measure, given by the probability that the SSK correctly classifies a transiting submarine without being killed between the time of detection and time of classification, given that the transitor has been detected, also could be regarded as submarine sonar MOE's. In particular, these are function MOE's representing how well the functions of detection and classification are performed, respectively. By computing this MOOE, one can evaluate the contribution of the submarine sonar in performing both of these functions to the overall performance of the submarine in the barrier role.

A possible result of Step 3 may be that for the evaluation level and platform, system, subsystem or equipment combination of interest there is no information of the type desired in the data base. The data base is not intended to be all-inclusive, thus exceptions will occur. However, it may be possible that upon reviewing available information for similar systems and equipments at perhaps a different level of evaluation the Project Officer (or Analyst) may be able to obtain guidance as to the MOE's which he could consider. For example, most MOE's for sonobuoys could be used as MOE's for sonars, or MOE's for missiles are in many cases independent of whether or not they are air-to-air, air-to-surface, surface-to-surface or surface-to-air missiles. In any case, the data base is designed to be a starting point in the selection of MOE's to be used in OT&E projects not as an ending point.

APPENDIX A

MEASURES OF OPERATIONAL EFFECTIVENESS FOR SELECTED NAVAL PLATFORMS

TABLE A-1 Aircraft (Fixed-Wing) Measures of Operational Effectiveness

MISSION/OPERATIONAL SITUATION	SUCCESS CRITERION	SYSTEM(S) AND/OR EQUIPMENT EVALUATED	MOOE	REFERENCE
Aircraft launched from a carrier penetrate area and local defenses to attack a mix of targets.	Destruction of targets	Air-to-ground ordnance	(1) Expected number of targets destroyed in a given period of time	1
Aircraft attack hostile targets which are close to friendly forces.	Destruction of targets	Air-to-ground ordnance	(1) Expected number of targets killed per day	2
			(2) Expected number of targets killed during the system's lifetime	2
Aircraft conduct an air interdiction campaign against mobile targets located in a lines-of-communication network.	Destruction of targets	Air-to-ground ordnance	(1) Expected number of targets destroyed per sortie	3
			(2) Expected aircraft lost per target destroyed	3
An aircraft armed with an antiradiation air-to-surface missile system attacks surface-to-air missile fire control radars in a multiradar environment.	Detection of target radar and visual identification of its direction and signal intensity	Radar homing & warning system	(1) Probability of specific target radar detection in a multiradar environment and visual identification of its direction and signal intensity	4
	Detection and acquisition of target	Missile seeker subsystem	(1) Probability that the missile seeker will detect a specified target radar in a multiradar environment and that the missile will then acquire this radar as a target	4
An attack carrier with both fighter (VF) and attack (VA) aircraft conducts strikes against enemy airfield targets and is itself subjected to attacks by enemy attack aircraft.	Successful attack on enemy airfield targets	Air-to-ground ordnance	(1) Expected number of strike sorties during a specified number of engagements	5
			(2) Expected number of enemy aircraft destroyed during a specified number of engagements	5
			(3) Exchange ratio, i.e., the ratio of the number of enemy losses to the number of friendly losses in a specified number of engagements	5

A-2

TABLE A-1 (Continued)

MISSION/OPERATIONAL SITUATION	SUCCESS CRITERION	SYSTEM(S) AND/OR EQUIPMENT EVALUATED	MOOE	REFERENCE
Aircraft equipped with air-to-air missiles are engaged in anti-air warfare in a standard CAP operation to defend against bomber aircraft having no self-defense capability.	Destruction of bomber(s).	Air-to-air missile	(1) Probability that friendly aircraft will destroy a bomber	6
			(2) Expected number of kills a friendly aircraft will achieve if it is directed against two bombers per sortie	6
Aircraft equipped with air-to-air missiles are engaged in anti-air warfare in a standard CAP operation to defend against fighter aircraft (escorting a bombing force) which are also equipped with air-to-air missiles.	Survival of friendly aircraft and destruction of enemy interceptors	Air-to-air missile	(1) Probability that aircraft will survive the engagement with enemy interceptors	6
An aircraft patrols a specified area listening for submarines on passive sonobuoys. Once detected, a submarine is localized using codar buoys and final fix is obtained by MAD. The submarine is then attacked by torpedoes.	Suppression of submarine activity	Lofar sonobuoy Codar sonobuoy MAD Torpedo	(1) Probability of killing an enemy submarine	7
An aircraft places Jezebel sonobuoys in either a circular or straight line pattern to redetect a previously contacted submarine.	Detection of submarine	Sonobuoys	(1) Probability of submarine detection	8
A carrier task force (CTF) transits through an area in which it is likely that enemy submarines may be encountered. ASW aircraft are being used to provide support against any contacts obtained in the vicinity of the CTF or along its projected track. Initial contact is made by a remote surveillance system and then aircraft respond by planting a pattern of sonobuoys in the contact area in order to detect and localize the position of the submarine.	Detection of submarine	Remote surveillance system Sonobuoys	(1) Percent of a specified area in which the probability of submarine detection by the ASW support forces is equal to or greater than a stated level	9

TABLE A-1 (Continued)

MISSION/OPERATIONAL SITUATION	SUCCESS CRITERION	SYSTEM(S) AND/OR EQUIPMENT EVALUATED	MOOE	REFERENCE
A helicopter, assisting a weapon delivery aircraft in an attack on an evading submarine, has a firmly established sonar contact with the submarine. The weapon delivery aircraft must await communications and direction from the assisting helicopter and then delay for some minimum time before maneuvering to the predicted position and dropping the weapon.	Destruction of submarine	Dipping sonar Depth bomb	(1) Average kill probability	10
An aircraft patrols a barrier according to a prescribed path. If the presence of a submarine is detected, the patrolling aircraft performs a contact investigation procedure.	Detection of submarine	Sonobuoys MAD	(1) Probability of detecting a submarine at least once as it passes through the barrier	11
	Detection and localization of submarine	Sonobuoys MAD	(1) Joint probability of at least one detection and initial localization to within the performance capability of the final localization technique	11
Aircraft attempt to detect, localize and kill submarines which pass through a sonobuoy field.	Detection, localization and kill of submarine	Sonobuoys Torpedo	(1) Average effective length of air ASW barrier that can be maintained per enemy submarine	12

REFERENCES: Table A-1

(1) Addendum to "Cost-Effectiveness Evaluation for Mixes of Naval Air Weapons Systems", Operations Research, Vol. 11, No. 2, Mar.-Apr. 1963, Unclassified.

(2) Final Report Navy Close Support Aircraft Study, Report #LR 21063, Lockheed California Co., 18 December 1957, SECRET.

(3) Air Interdiction: Analysis of Self-Contained Operations Against Mobile Targets, Tactical Division Note 71-5, Analytic Services Inc., December 1971, CONFIDENTIAL.

(4) STANDARD ARM (Mod 0) Weapon System Performance Analysis, Report #TM-68-29, U. S. Naval Missile Center, 10 May 1968, SECRET.

(5) A Study of the Mix of Fighter and Attack Aircraft for Attack Carriers, Report No. R-5-63-8, Bureau of Naval Weapons, April 1963, CONFIDENTIAL.

(6) SPARROW III Effectiveness and Cost Comparison, Report #WSAO-R-63-1, U. S. Naval Weapon Systems Analysis Office, Marine Corps Air Station, 1 September 1965, SECRET.

(7) A Study of Airborne ASW, Naval Warfare Analysis Group Research Contribution No. 121, Center for Naval Analyses, October 1968, SECRET.

(8) A Comparative Analysis of VP Lofar Tactics Against a Nuclear Target, SAO Technical Memorandum 69-12, Systems Analysis Office, ASW Systems Project Office, December 1969, CONFIDENTIAL.

(9) Improved Air ASW Effectiveness by the Employment of Acoustic Countermeasures in Task Force Operations, CAL Report No. GM-2268-G-4, Cornell Aeronautical Lab., Inc., 30 September 1969, SECRET (NOFORN).

(10) Model and Computer Program for Calculating the Kill Probabilities for Certain ASW Tactics, OEG Research Contribution No. 47, Center for Naval Analyses, 25 October 1963, Unclassified.

REFERENCES (Continued)

(11) Cost Effectiveness Models for Airborne ASW Search and Detection Systems, Report #V-0513C/2.503, Veda Inc., 15 September 1967, CONFIDENTIAL.

(12) AIR ASW MOE, ASW 14 Memo Ser. 69-003 to CNO Op-953G, Systems Analysis Office, ASW Systems Project Office, 29 January 1969, SECRET.

TABLE A-2 Helicopter Measures of Operational Effectiveness

MISSION/OPERATIONAL SITUATION	SUCCESS CRITERION	SYSTEM(S) AND/OR EQUIPMENT EVALUATED	MOOE	REFERENCE
A helicopter searches for a submarine using dipping sonar. Upon detection, localization is attempted using dipping sonar or MAD. The helicopter then flies to datum and launches a torpedo.	Detection, localization and kill of submarine	Dipping sonar MAD Torpedo	(1) Probability of submarine detection, localization and kill	1
An enemy submarine is first detected by an escort's long-range sonar. A helicopter flies from the escort to redetect the target.	Detection of submarine	Sonobuoy	(1) Probability of detection	2
A helicopter, using a passive sonar system, maintains a barrier a specified distance from a task force or convoy. Upon receipt of a passive contact, the helicopter attempts to convert to an active sonar contact.	Detection of submarine	Passive sonobuoy Passive dipping sonar Active dipping sonar	(1) Maximum width of barrier that can be maintained and still ensure a 50% probability of initial detection	3
			(2) Number of detection opportunities converted to active contacts	3
A helicopter flies to a datum (obtained as an initial contact by some platform within the task force or convoy) and attempts to reacquire it passively. If a passive redetection can be achieved, the helicopter will attempt to convert to an active detection.	Detection and localization of submarine	Passive sonobuoy Passive dipping sonar Active dipping sonar	(1) Cumulative probability of reacquiring and converting the target to an active contact	3

REFERENCES: Table A-2

(1) Single Helicopter Tactical Effectiveness Study, SAG Technical Memorandum 67-3, Systems Analysis Office, ASW Systems Project Office, August 1967, CONFIDENTIAL.

(2) Redetecting An Inexactly Located Submarine, Operations Analysis Report 299-197-007, Bell Helicopter Co., 15 October 1965, Unclassified.

(3) The Effect of Adding Passive Sensors to the SH-3D Helicopter for Barrier Screening and Datum Investigation Missions, NOLTR 67-4, U. S. Naval Ordnance Lab., 27 January 1967, SECRET.

TABLE A-3 Submarine Measures of Operational Effectiveness

MISSION/OPERATIONAL SITUATION	SUCCESS CRITERION	SYSTEM(S) AND/OR EQUIPMENT EVALUATED	MOOE	REFERENCE
A submarine covers a frontage against which enemy submarines attempt to penetrate or transmit past.	Obtain secure detection of submarine	Passive sonar	(1) Secure sweep width, which is defined as the product of the width of frontage over which target crossings are equally likely at all points times the expected fraction of targets on which own ship makes secure detection	1
			(2) Expected number of secure detections the SSK will make on transitors	1
	Detection of submarine	Sonar	(1) Probability that a transiting submarine will be intercepted	2
			(2) Probability of detection per transitor	2
	Detection and destruction of submarine	Sonar	(1) Number of kills per engagement opportunity	3
		Torpedoes	(2) Expected percentage of enemy submarines killed attempting to penetrate barrier	4
		Underwater fire control system	(3) Expected number of enemy submarines killed attempting to penetrate barrier	4
			(4) SSK/Transitor Effectiveness, which is defined as the probability of the SSK killing a transiting enemy submarine given a detection opportunity	5
			(5) SSK/Transitor Vulnerability, which is defined as the probability of accurate counterattack by the SST given a detection opportunity for the SSK	5
			(6) Exchange ratio	5
			(7) Number of enemy submarines sunk in a given interval of time if a specified number of SSK's is maintained on-station continuously during the same period	6
			(8) Number of enemy submarines sunk in a given interval of time by a specified number of submarines available for use as SSK's	6

TABLE A-3 (Continued)

MISSION/OPERATIONAL SITUATION	SUCCESS CRITERION	SYSTEM(S) AND/OR EQUIPMENT EVALUATED	MOOE	REFERENCE
	Suppression of submarine activity	Sonar Torpedoes Underwater fire control system	(1) Expected number of successful enemy transits (2) Probability that the transitor is killed in an encounter	7 7
A submarine searches an area for submarine targets which are presumed to be hiding at some unknown point in the area.	Obtain secure detection of submarine	Passive sonar	(1) Secure sweep rate, which is defined as the product of the area of region in which target is equally likely at all points times the expected fraction of targets on which own ship makes secure detection divided by searching time	1
A submarine searches for hostile submarines and attacks all those that it detects and for which it has an opportunity for attack.	Destruction of submarines	Sonar Torpedoes Underwater fire control system	(1) Probability of target kill	8
Attack submarines are used as ASW escorts (SSE's) for a carrier task force passing through an area known to contain hostile submarines.	Survival of carriers	Active sonar	(1) Expected number of enemy torpedo hits on a carrier for given detection range of the SSE active sonar (2) Probability that the penetrator will attack before the task force has an opportunity to classify and react	9 9
A submarine in the role of an intruder is to seek out and destroy an enemy submarine in the enemy submarine's own patrol area.	Detection and destruction of submarine	Sonar Torpedoes Underwater fire control system	(1) Probability that the intruder will detect a target present in the patrol area in a specified time (2) Probability that the intruder will kill the target given that he has detected the target (3) Kill rate, which is defined as the rate at which enemy targets are killed as a function of intruder area size (4) Exchange ratio, which is defined as the expected number of targets killed for each intruder killed	10 10 10 10

TABLE A-3 (Continued)

MISSION/OPERATIONAL SITUATION	SUCCESS CRITERION	SYSTEM(S) AND/OR EQUIPMENT EVALUATED	MOOE	REFERENCE
A submarine attempts to penetrate a destroyer screen in order to fire torpedoes at convoy ships.	Destruction of ships	Sonar Torpedoes Underwater fire control system	(1) Expected number of ships hit	11
Submarines attack individual merchant ships and merchant ship convoys.	Destruction of ships	Sonar Torpedo Underwater fire control system	(1) Number of ships sunk per unit time spent in area	12
A submarine attempts to maintain trail, at least intermittently, of an enemy submarine without being counter-detected and with or without outside assistance.	Maintenance of at least intermittent trail	Passive sonar	(1) Mean holding time until loss of contact of duration greater than a specified time	13
			(2) Probability that the submarine will regain contact at least once in a time t since loss of contact	13
			(3) Unconditional probability of regaining contact	13

REFERENCES: Table A-3

(1) Submarine - Versus - Submarine Secure Sweep Width Manual, DHWA Log No. 13-504, Daniel H. Wagner Assoc., 17 December 1964, CONFIDENTIAL.

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(4) Submarine Measures of Effectiveness, ASW-1436 memo Ser. 69-0041, Systems Analysis Office, ASW Systems Project Office, 4 November 1969, SECRET.

(5) Measure of Effectiveness Model for the SSK Versus Transitor Mission, Report #3510, Ser. N352/0663, Commander Submarine Force, U. S. Atlantic Fleet and Commander Submarine Force, U. S. Pacific Fleet, 11 July 1969, CONFIDENTIAL.

(6) Analysis of the Effectiveness of an SSK Barrier, OEG Study No. 460, Center for Naval Analyses, 10 October 1951, CONFIDENTIAL.

(7) Barrier Measure of Effectiveness, DHWA Log. No. 64-1531, Daniel H. Wagner Assoc., 15 April 1969, CONFIDENTIAL.

(8) An Evaluative Model for SSN Active Sonar Missions, D-103-70, Mystic Oceanographic Co., 17 August 1970, SECRET.

(9) Submarines as ASW Escorts for Attack Carriers, DHWA Log No. 15-950, Daniel H. Wagner Assoc., 17 October 1966, SECRET.

(10) Measure of Effectiveness Model for a Submarine in the Intruder Role, Joint Letter - ComSubLant #0764 & ComSubPac #0710, Commander Submarine Force, U. S. Atlantic Fleet and Commander Submarine Force, U. S. Pacific Fleet, June 1968, CONFIDENTIAL.

(11) The Factors Affecting Antisubmarine Warfare Inside the Screen, Thesis for the Master of Science in Operations Research, U. S. Naval Postgraduate School, December 1968, CONFIDENTIAL.

REFERENCES (Continued)

(12) Measures of Effectiveness in Submarine Warfare and their Relation to an Integrated Research Program, OEG Report 52, Center for Naval Analyses, 20 June 1946, CONFIDENTIAL.

(13) A Three-Parameter Stochastic Submarine Trailing Model, Paper P-703, Institute for Defense Analyses, January 1971, Unclassified.

TABLE A-4 Surface Ship Measures of Operational Effectiveness

MISSION/OPERATIONAL SITUATION	SUCCESS CRITERION	SYSTEM(S) AND/OR EQUIPMENT EVALUATED	MOOE	REFERENCE
Submarine contact has been made by a sensor field and a surface ship has been directed to the area to conduct a search for the suspected submarine.	Detection of submarine	Sonar	(1) Probability that the submarine is detected by the surface ship	1
			(2) Expected time to find the submarine after the surface ship reaches the area	
A surface ship ASW screen encounters a hostile submarine.	Protection of convoy	Sonar Torpedoes Underwater fire control system	(1) Probability that the submarine fails to attack the main body of the convoy by direct or indirect action of the screen units	2
Merchant vessels are escorted by convoys that are protected by destroyers. Enemy submarines attempt to penetrate the screen.	Prevention of submarine penetration of convoy screen.	Sonar Torpedoes Underwater fire control system	(1) Expected number of merchant vessels sunk during a single attack by a submarine	3
			(2) Probability that a submarine is sunk at some point during a single attack on a convoy	3
			(3) Probability that a destroyer is sunk during a single attack on a convoy by a submarine	3
			(4) Expected number of merchant vessels sunk by submarines during one month	3
			(5) Expected number of submarines sunk during one month	3
A single destroyer attempts to detect an enemy submarine operating in a specified area.	Detection of submarine	Sonar	(1) Effective sweep rate	3
An attack unit attacks an enemy submarine which has been detected and correctly classified.	Destruction of submarine	Sonar Torpedoes Underwater fire control system	(1) Probability that submarine is damaged	4
An escort ship in a carrier screen gains contact with a submarine and then launches one or more sonar countermeasures beacons.	Denial of tracking information	Sonar beacon	(1) Time from countermeasures activation until tracking information is regained	5

TABLE A-4 (Continued)

MISSION/OPERATIONAL SITUATION	SUCCESS CRITERION	SYSTEM(S) AND/OR EQUIPMENT EVALUATED	MOOE	REFERENCE
Director-controlled guns are brought to bear against aircraft making simultaneous attacks on a ship.	Acquisition of all targets in the raid within sufficient time to attack them	Gun Gun Director Fire control radar	(1) Probability of acquiring all the aircraft in the attacking raid	6
			(2) Maximum raid size such that the probability of acquiring all members is at least a specified constant	
Surface ships provide active AAW defense of a surface fleet using SAM's against a missile raid.	Protection of the ships from missiles	Surface-to-air missile Fire control radar	(1) Expected number of hits per ship	7
			(2) Probability of successful defense, i.e., none of the missiles hit the ships	8
Bombers employ air-to-surface missiles against a carrier task group using surface-to-air missiles in defense.	Interception of attacking missiles	Surface-to-air missile Fire control radar	(1) Expected proportion of attacking missiles which are intercepted or terminated beyond a specified safe holdoff distance	9
Gunboats are employed in defense of ships from the threat of high-speed surface attack vessels.	Successful defense of surface ships	Gun Fire control radar	(1) Number of gunboats required to provide a given level of defense against a specified threat	10
Naval guns provide gunfire support for amphibious assault operations.	Destruction of target	Gun Fire control radar	(1) Number of targets defeated per hour	11
			(2) Percent of equal volume magazines required to defeat the target	11
			(3) Number of rounds to defeat the target	11
			(4) Expected number of rounds required to achieve at least one hit	12
			(5) Expected number of targets damaged per ship magazine	12

REFERENCES: Table A-4

(1) Transfer of Detection Contacts to Tracking Contacts in Surveillance, Operations Research, Vol. 14, No. 5, Sept.-Oct. 1966, Unclassified.

(2) Evaluating the Effectiveness of a Surface Ship ASW Screen, Thesis for the Master of Science in Operations Research, U. S. Naval Postgraduate School, April 1970, SECRET.

(3) The Influence of Destroyer Silencing on Mission Effectiveness, DHWA Log No. 21-982, Daniel H. Wagner Assoc., 31 December 1966, SECRET.

(4) Design of Antisubmarine Attack Models, OEG Study No. 690, Center for Naval Analyses, 6 July 1965, CONFIDENTIAL.

(5) Value of Acoustic Countermeasures Employed by ASW Escorts Against Submarine Sonars, Technical Report No. 174, Presearch Inc., 15 February 1970, SECRET (NOFORN).

(6) Naval AA Target Designation and Acquisition Systems: A Probability Method for Their Evaluation, OEG Study No. 475, Center for Naval Analyses, 25 March 1952, Unclassified.

(7) A Finite Markov Chain Computer Model for Determining the Vulnerability of a Task Force with an Active SAM Defense Against Successive Waves of Attackers, OEG Research Contribution No. 82, Center for Naval Analyses, July 1968, Unclassified.

(8) The Effect of Sea-Based Surface-to-Surface Missiles on U. S. Naval Operations in the Tonkin Gulf, OEG Study No. 728, Center for Naval Analyses, 15 April 1969, SECRET.

(9) A Naval Anti-Air Warfare Model Emphasizing Accessibility in Defense System Optimization and R&D Decision-Making, USNRDL-TR-978, U. S. Naval Radiological Defense Lab., 4 May 1966, Unclassified.

(10) Mission Effectiveness Models for Comparing Air Cushion Vehicles and Hydrofoil Craft in Selected Missions, WR 142-4, Westwood Research, Inc., May 1970, SECRET.

REFERENCES (Continued)

(11) Some Studies of the Effectiveness of Major Caliber Guns on DX's, NWAG Study No. 59, Center for Naval Analyses, May 1968, SECRET (NOFORN).

(12) Analytical Study of Shore-Bombardment Weapons, NAVWEPS REPORT 7965, NOTS TP 3010, U. S. Naval Weapons Center, November 1962, SECRET.

APPENDIX B

MEASURES OF EFFECTIVENESS HANDBOOK DATA BASE DERIVED FROM OT&E PROJECTS

TABLE B-1 OT&E Project Areas

CODE	AREA
A	Aircraft
ADC	Acoustic Detection & Countermeasures
C	Communications
DD	Data & Display
EDC	Electromagnetic Detection & Countermeasures
FC	Fire Control
IOD	Infrared & Optical Detection
M	Missiles
NG	Navigation & Guidance
O	Ordnance
S	Submarines
SS	Surface Ships

TABLE B-2 Operational Test & Evaluation MOE Data Base

Area: Aircraft (A)

CODE	ITEM
A1	Attack Aircraft (F8U-2)
A2	ASW Aircraft (S-2G)
A3	Fleet Defense Aircraft
A4	ASW Helicopter
A4-1	SH-3A
A4-2	SH-3H
A4-3	DASH

AIRCRAFT (A)

A1 - Attack Aircraft

DESCRIPTION: This is a carrier based airplane designed for a primary mission of a day or night visual fighter.

(1) SPECIFIC OBJECTIVE: Evaluate the capability of the airplane to intercept approaching targets while under ground controlled intercept.

MOE = Average kill distance, which is defined as the distance from CAP station to successful intercept of target

REFERENCE: Final Report on Project OP/V264/VV
"Evaluation of the F8U-2 Aircraft"
21 March 1960, UNCL.

A2 - ASW Aircraft

DESCRIPTION: This is a modified S-2E airplane with enhanced ASW capability. It contains passive directional sonobuoys, processing and display equipment, an acoustic data processor, tape recorder and sonobuoy receiver.

(1) SPECIFIC OBJECTIVE: Evaluate submarine detection capability using sonobuoys.

$(MOE)_1$ = Mean time from initial sonobuoy drop to target initial line-of-bearing

$(MOE)_2$ = Mean range from sonobuoy to submarine at determination of initial DIFAR line-of-bearing

$(MOE)_3$ = Probability of obtaining an initial DIFAR line-of-bearing

$$= \frac{\left(\text{Number of times initial DIFAR line-of-bearing was obtained}\right)}{\text{Number of detection attempts}}$$

(2) SPECIFIC OBJECTIVE: Evaluate submarine localization capability using sonobuoys.

$(MOE)_1$ = Average time from the initial DIFAR line-of-bearing to the designation of the initial EP (estimated position)

$(MOE)_2$ = Mean EP error

$(MOE)_3$ = Mean DFX (DIFAR fix) error

$(MOE)_4$ = Circular error probable (CEP) about the mean EP

$(MOE)_5$ = Circular error probable (CEP) about the mean DFX

$(MOE)_6$ = Mean number of EP's generated prior to generation of a DFX

$(MOE)_7$ = Mean time from EP to designation of a DFX

$(MOE)_8$ = Mean time from initial contact to designation of a DFX

$(MOE)_9$ = Average number of sonobuoys required to generate a DFX

$(MOE)_{10}$ = Mean time from the designation of an actual DFX to active pattern completion

$(MOE)_{11}$ = Average number of DIFAR sonobuoys required to generate an initial EP

ASSUMPTION: A DIFAR fix (DFX) is defined as that EP so designated by the flight crew; normally, the final EP prior to commencing active prosecution.

REFERENCE: Final Report on Project P/V3
"Conduct an Operational Appraisal of the S-2G Weapon System"
11 Sept. 1972, SECRET

A3 - Fleet Defense Aircraft

DESCRIPTION: This system is designed to provide a quick reaction, all-weather fleet defense capability against enemy surface-to-surface missile launch vessels. The aircraft is equipped with an air-to-surface missile system.

(1) SPECIFIC OBJECTIVE: Evaluate capability using airborne radar to detect surface vessels.

$(MOE)_1$ = Probability of target detection as a function of aircraft altitude

$$= \frac{\text{Number of detections}}{\text{Number of detection attempts}}$$

$(MOE)_2$ = Average detection range

(2) SPECIFIC OBJECTIVE: Evaluate capability using airborne radar to acquire surface vessels.

$(MOE)_1$ = Probability of target acquisition given detection

$$= \frac{\text{Number of acquisitions}}{\text{Number of detections}}$$

$(MOE)_2$ = Average acquisition range

(3) SPECIFIC OBJECTIVE: Evaluate capability using airborne radar to track surface vessels.

MOE = Probability of maintaining radar target track up to missile firing as a function of aircraft altitude, target speed, sea state, attack angle and target aspect

$$= \frac{\left(\text{Number of successful radar tracking tests}\right)}{\text{Number of radar tracking tests}}$$

(4) SPECIFIC OBJECTIVE: Evaluate missile attack capability of surface vessels.

MOE = Probability of successful missile-target intercept as a function of aircraft altitude, attack angle, launch range, sea state and target aspect

REFERENCE: Final Report on Project F/0255
"Conduct a Fleet Operational Investigation of Guided Missile AIM-7E-2 (Sparrow) as an Antiship Missile"
17 Oct. 1972, SECRET

A4 - ASW Helicopter

A4-1

DESCRIPTION: This is an ASW Helicopter Attack System (HATS) which is a standard SH-3A helicopter modified to incorporate multiple ASW sensors and display equipments. This system is designed to permit a single unassisted helicopter to localize and attack a high speed submarine.

(1) SPECIFIC OBJECTIVE: Evaluate localization and attack capability.

MOE = Probability of successful localization and attack of a submarine for given localization method

$$= \frac{\left(\text{Number of times localization and attack were successful}\right)}{\left(\text{Number of localization and attack attempts}\right)}$$

(2) SPECIFIC OBJECTIVE: Evaluate localization capability.

$(MOE)_1$ = Probability of successful conversion of a sonar contact to sonobuoys

$$= \frac{\left(\text{Number of times conversion from a sonar contact to sonobuoys was successful}\right)}{\left(\text{Number of sonar to sonobuoy conversion attempts}\right)}$$

$(MOE)_2$ = Probability of successful conversion of a sonar contact to MAD

$$= \frac{\left(\text{Number of times conversion from a sonar contact to MAD was successful}\right)}{\left(\text{Number of sonar to MAD conversion attempts}\right)}$$

$(MOE)_3$ = Probability of successful conversion of a single buoy contact to a MAD contact

$$= \frac{\left(\text{Number of times conversion from a single buoy contact to a MAD contact was successful}\right)}{\left(\text{Number of single buoy to MAD conversion attempts}\right)}$$

$(MOE)_4$ = Probability of successful conversion of a sonar contact to sonobuoys to a MAD contact

$$= \frac{\left(\text{Number of times conversion from a sonar contact to sonobuoys to a MAD contact was successful}\right)}{\left(\text{Number of sonar to sonobuoy to MAD conversion attempts}\right)}$$

REFERENCE: Final Report on Project F/0214
"Fleet Operational Investigation of the ASW Helicopter Attack System (HATS)"
3 March 1967, CONF.

A4-2

DESCRIPTION: This helicopter is designed to provide a multisensor, multi-mission capability. It has primary missions of ASW (antisubmarine warfare) and ASMD (anti-ship missile defense).

(1) SPECIFIC OBJECTIVE: Evaluate self navigation capability.

MOE = Circular error probable (CEP) of transit to datum navigation error as a function of range to datum

(2) SPECIFIC OBJECTIVE: Evaluate sonobuoy drop accuracy.

MOE = Circular error probable (CEP) of sonobuoy drop error as a function of pattern spacing

(3) SPECIFIC OBJECTIVE: Evaluate passive acoustic localization capability using sonobuoys.

$(MOE)_1$ = Median time to establish an EP (estimated position)
$(MOE)_2$ = Mean time to establish an EP
$(MOE)_3$ = Median EP error
$(MOE)_4$ = Mean EP error
$(MOE)_5$ = Probability of establishing an EP

$$= \frac{\left(\text{Number of trials that resulted in the establishment of an EP}\right)}{\left(\text{Number of passive acoustic localization trials}\right)}$$

(4) SPECIFIC OBJECTIVE: Evaluate initial attack capability.

MOE = Probability of valid attack

$$= \frac{\text{Number of valid attacks}}{\text{Number of attacks}}$$

(5) SPECIFIC OBJECTIVE: Evaluate active datum redetection and attack capability.

[redacted]

$$(MOE)_1 = \text{Probability of redetection} = \frac{\text{Number of valid redetections}}{\left(\begin{array}{l}\text{Number of active datum redetection}\\ \text{and attack trials}\end{array}\right)}$$

$$(MOE)_2 = \text{Probability of valid attack given redetection} = \frac{\left(\begin{array}{l}\text{Number of valid attacks}\\ \text{after redetection}\end{array}\right)}{\text{Number of valid redetections}}$$

REFERENCE: Final Report on Project P/V4
"Conduct an Operational Appraisal of the SH-3H Weapons System"
2 Oct. 1973, SECRET

A4-3

DESCRIPTION: This is a drone ASW helicopter (DASH) which is designed to position an unmanned helicopter over a submarine contact, to drop homing torpedoes on the contact, and to return the drone to the ship under all weather conditions compatible with the operation of helicopters.

(1) SPECIFIC OBJECTIVE: Determine weapon delivery capability.

MOE = Median total attack error, which is defined as the distance between the weapon water entry position and the aimpoint based on the target's actual position, course and speed at time of weapon water entry.

REFERENCE: Final Report on Project C/S18 FY61
"Evaluation of the DASH System Using the USS Hazelwood and DSN-1"
7 Aug. 1961, CONF.

TABLE B-2 Operational Test & Evaluation MOE Data Base (Continued)

Area: Acoustic Detection & Countermeasures (ADC)

CODE	ITEM
ADC1	Sonar
ADC1-1	Submarine Sonar (AN/BQR-16, AN/BQR-19)
ADC1-2	Towed Array Sonar (AN/BQR-15)
ADC1-3	Surface Ship Sonar (AN/SQQ-23)
ADC1-4	Mine Detection/Classification Sonar (AN/SQQ-14, AN/SQQ-16)
ADC2	Command Active Sonobuoy System (CASS)
ADC3	Sonobuoy (AN/SSQ-20, AN/SSQ-1)
ADC4	Submarine Classification and Tracking Device (SCAT)
ADC5	Electro-Acoustic Decoy (NIXIE)
ADC6	Acoustic Noisemaker (NAE Beacon Mk 3 Mod 1)
ADC7	Acoustic Minesweeping Device (ROTOVAC 6X, ROTOVAC 7X)
ADC8	Acoustic Intercept Receiver (AN/WLR-9)
ADC9	Submarine Acoustic Warfare System (SAWS)

ACOUSTIC DETECTION & COUNTERMEASURES (ADC)

ADC1 - Sonar

ADC1-1 Submarine sonar

DESCRIPTION: This is a passive sonar system designed to provide submarines with a capability to passively detect and track surface targets.

(1) SPECIFIC OBJECTIVE: Determine detection capability.

$(MOE)_1$ = Average detection range against surface ships

$(MOE)_2$ = Figure of merit
= SL - NL + DI - RD

where

SL = target radiated noise level
NL = background noise level
DI = directivity index
RD = recognition differential, which is defined as the signal-to-noise ratio at which the probability of detection is 50%.

$(MOE)_3$ = 90% probability of detection range as a function of target relative bearing sector (forward or hindsight), target type, target speed and isothermal layer depth

$(MOE)_4$ = Cumulative probability of detection as a function of range

REFERENCES: (1) Final Report on Project C/S56
"Conduct a Concurrent Evaluation of the AN/BQR-16 HINDSIGHT Sonar"
16 Feb. 1970, CONF.

(2) Final Report on Project C/S61
"Conduct a Concurrent Evaluation of the AN/BQR-19 Sonar System"
13 May 1970, SECRET

ADC1-2 Towed Array Sonar

DESCRIPTION: This is a low frequency, passive, towed array sonar which is designed to detect surface vessels and submerged submarines including high performance nuclear submarines.

(1) SPECIFIC OBJECTIVE: Determine detection performance.

$(MOE)_1$ = Probability of detection as a function of range for given target relative bearing sector (bow, beam, stern), target depth in relation to isothermal layer bcundary (layer separation, no layer separation), target speed, target type, and own ship speed

$$= \frac{\text{Number of detections}}{\text{Number of opportunities}}$$

$(MOE)_2$ = 50% detection range, which is defined as the range to target at which the cumulative probability of detection is 50%

$(MOE)_3$ = Figure of merit, given target relative bearing sector, line spectrum, target speed, and target type

= SL - NL + DI - RD

where

SL = target radiated noise level

NL = background noise level

DI = directivity index

RD = recognition differential

(2) SPECIFIC OBJECTIVE: Evaluate classification capability.

$(MOE)_1$ = Probability of a correct classification as a function of target speed, target type, and target relative bearing sector

$$= \frac{\text{Number of correct classifications}}{\text{Number of classifications made}}$$

$(MOE)_2$ = Average time to classify after making a detection

REFERENCE: Final Report on Project C/S59
"Conduct a Concurrent Evaluation of the AN/BQR-15 Sonar System"
26 June 1970, SECRET

[redacted]

ADC1-3 Surface ship sonar

DESCRIPTION: This is a computer coordinated, high powered, simultaneous active/passive sonar system which utilizes the direct propagation path. The major features of the sonar are a simultaneous search while tracking capability, digital computer control and signal processing, and semi-automatic performance monitoring and fault localization.

(1) SPECIFIC OBJECTIVE: Determine detection performance against submarine targets.

$(MOE)_1$ = Range for 50% cumulative probability of detection for given target characteristics (in-layer or below-layer, deep water or shallow water, aspect angle)

$(MOE)_2$ = Probability of target detection

$$= \frac{\text{Number of detections}}{\text{Number of opportunities}}$$

$(MOE)_3$ = Mean detection range

$(MOE)_4$ = Cumulative probability of detection versus range for given target characteristics (in-layer or below-layer, deep water or shallow water, aspect angle, mean wind velocity, mean sea state, mean target depth (keel) and mean layer depth)

(2) SPECIFIC OBJECTIVE: Determine classification performance.

$(MOE)_1$ = Probability of correct classification

$$= \frac{\text{Number of correct classifications}}{\text{Number of classification events}}$$

$(MOE)_2$ = Probability of classifying a submarine as a submarine

$$= \frac{\left(\text{Number of times submarine target was classified as submarine}\right)}{\left(\text{Number of classification events in which sonar target was submarine}\right)}$$

$(MOE)_3$ = Probability of classifying a non-submarine as a submarine

$$= \frac{\left(\text{Number of times non-submarine target was classified as submarine}\right)}{\left(\text{Number of classification events in which sonar target was non-submarine}\right)}$$

$(MOE)_4$ = Probability of classifying a submarine as non-submarine

$$= \frac{\left(\text{Number of times submarine target was classified as non-submarine}\right)}{\left(\text{Number of classification events in which sonar target was submarine}\right)}$$

$(MOE)_5$ = Probability of an incorrect classification occurring

$$= \frac{\text{Number of incorrect classifications}}{\text{Number of classification events}}$$

$(MOE)_6$ = Probability of an undetermined classification

$$= \frac{\left(\text{Number of times submarine targets and non-submarine targets were unclassified (undetermined)}\right)}{\text{Number of classification events}}$$

$(MOE)_7$ = Probability of a sonar target submarine - classified as submarine event occurring

$$= \frac{\left(\text{Number of times sonar target submarine - classified as submarine event occurred}\right)}{\text{Number of classification events}}$$

$(MOE)_8$ = Probability of a sonar target submarine - classified as non-submarine event occurring

$$= \frac{\left(\text{Number of times sonar target submarine - classified as non-submarine event occurred}\right)}{\text{Number of classification events}}$$

$(MOE)_9$ = Probability of a sonar target non-submarine - classified as submarine event occurring

$$= \frac{\left(\text{Number of times sonar target non-submarine - classified as submarine event occurred}\right)}{\text{Number of classification events}}$$

$(MOE)_{10}$ = Probability of a sonar target non-submarine - classified as non-submarine event occurring

$$= \frac{\left(\text{Number of times sonar target non-submarine - classified as non-submarine event occurred}\right)}{\text{Number of classification events}}$$

$(MOE)_{11}$ = Probability of a sonar target submarine - unclassified event occurring

$$= \frac{\left(\text{Number of times sonar target submarine - unclassified event occurred}\right)}{\text{Number of classification events}}$$

$(MOE)_{12}$ = Probability of sonar target non-submarine - unclassified event occurring

$$= \frac{\left(\text{Number of times sonar target non-submarine-unclassified event occurred}\right)}{\text{Number of classification events}}$$

$(MOE)_{13}$ = Probability of a missed opportunity

$$= \frac{\left(\text{Number of times sonar target submarine - classified as non-submarine events or sonar target submarine - unclassified events occurred}\right)}{\left(\text{Number of classification events in which sonar target was submarine}\right)}$$

$(MOE)_{14}$ = Clue availability, which is defined as the probability of a clue being present

$$= \frac{\text{Number of times clue used}}{\text{Number of classifications made}}$$

$(MOE)_{15}$ = Clue reliability, which is defined as the probability of a correct classification when the clue was used

$$= \frac{\left(\text{Number of correct classifications when the clue was used}\right)}{\text{Number of times clue was used}}$$

$(MOE)_{16}$ = Clue effectiveness, which is defined as the probability that the clue was present and a correct classification occurred

$$= \frac{\left(\text{Number of correct classifications when the clue was used}\right)}{\text{Number of classifications made}}$$

$(MOE)_{17}$ = False alarm rate, which is defined as the mean time between false alarms

$$= \frac{\text{Total time of detection exercise}}{\left(\text{Number of sonar target non-submarine - classified as submarine events}\right)}$$

ASSUMPTIONS:

(1) Classification events consist of six possible types, namely, either submarine or non-submarine targets and then for each type of target it is either unclassified, classified as submarine or classified as non-submarine.

(2) The operator correlates active and passive detections of the same target in making a classification.

(3) The event counted was the final classification that occurred in time, regardless if it was entered on a passive or active track. This was done in order to avoid double classification on the same target and assumed that the operator utilized all available information.

(4) Typical clues are TCD (target center display) echo length, echo intensity, echo quality, echo consistency and echo smoothness.

(3) SPECIFIC OBJECTIVE: Determine tracking capability by mode of operation (alerted or non-alerted).

$(MOE)_1$ = Mean percent range error for given tracking interval (target range interval)

$(MOE)_2$ = Mean bearing error (deg) for given tracking interval (target range interval)

$(MOE)_3$ = Mean in-range error (yds) for given tracking interval (target range interval)

$(MOE)_4$ = Mean cross-range error (yds) for given tracking interval (target range interval)

$(MOE)_5$ = Mean tracking radial error (yds)

$(MOE)_6$ = Radial probable error of observed target position

ASSUMPTIONS:

(1) For the purposes of analysis, the true target position was assumed to be a predicted target position obtained from a linear least square process using a moving sequence of the latest ten tracking observations.

(2) The track quality vector (Q-number) is an estimate of the difference error in position between the true target position and the sonar measured position.

(3) Radial probable error is the radius of the circle around the superimposed or mean prediction range positions in a range interval or moving interval such that 50% of the Q-vectors terminate inside the circle.

REFERENCE: First Partial Report on Project P/S1 (Phase 1) "Conduct an Operational Appraisal of the AN/SQQ-23 Sonar System" 19 Aug. 1971, CONF.

ADC1-4 Mine Detection/Classification Sonar

DESCRIPTION: This is a sonar system whose purpose is to detect and classify mine-like objects.

(1) SPECIFIC OBJECTIVE: Determine mine detection capability.

$(MOE)_1$ = Probability of mine detection

$$= \frac{\text{Number of mine detections}}{\text{Number of detection opportunities}}$$

$(MOE)_2$ = Probability of mine detection versus range

$$= \frac{\left(\text{Number of mine detections within given range band}\right)}{\left(\text{Number of detection opportunities within given range band}\right)}$$

$(MOE)_3$ = Mean initial detection range

$(MOE)_4$ = Detection probability of mines as a function of search path width (or lateral range from ship's track)

$$= \frac{\left(\text{Number of mine detections within specified search path width}\right)}{\left(\text{Number of mines within specified search path width}\right)}$$

$(MOE)_5$ = Average slant range at which bottom objects were detected

$(MOE)_6$ = Average number of objects detected per run

$$= \frac{\text{Number of objects detected}}{\text{Number of valid runs}}$$

$(MOE)_7$ = Percent of mines and minelike objects detected

$$= \frac{\text{Number of mines and minelike objects detected}}{\left(\text{Number of detection opportunities for mines and minelike objects}\right)} \times 100$$

$(MOE)_8$ = Percent of mines detected

$$= \frac{\text{Number of mines detected}}{\text{Number of detection opportunities for mines}} \times 100$$

$(MOE)_9$ = Percent of total detections which were mines

$$= \frac{\text{Number of mines detected}}{\left(\text{Number of detection opportunities for mines and minelike objects}\right)} \times 100$$

ASSUMPTION: Criterion used for detection was: illumination of a bottom object by the sonar, recognition of this illumination on the search indicator PPI scope by the operator, and the determination and marking of the range and bearing of the illuminated object.

(2) SPECIFIC OBJECTIVE: Evaluate mine classification capability.

$(MOE)_1$ = Average slant range at which contacts were classified, i.e., the slant range at which a contact, which has been detected and transferred to the classify indicator B-scope, is initially classified

$(MOE)_2$ = Probability of correct classification of mines

$$= \frac{\left(\text{Number of correct classifications of mines as minelike}\right)}{\left(\text{Number of classification attempts on mines (including regained contacts)}\right)}$$

$(MOE)_3$ = Percent correct classifications of minelike non-mine objects as non-mine

$$= \frac{\left(\text{Number of correct classifications of non-minelike objects}\right)}{\left(\text{Number of classification attempts on non-minelike objects (including regained contacts)}\right)} \times 100$$

$(MOE)_4$ = Percent detections classified

$$= \frac{\text{Number of classifications made at least once}}{\text{Number of mines and minelike objects detected}} \times 100$$

$(MOE)_5$ = Percent correct classifications at least once

$$= \frac{\text{Number of classifications correct at least once}}{\text{Number of classifications made at least once}} \times 100$$

$(MOE)_6$ = Percent detection opportunities detected, classified and classified correctly at least once

$$= \frac{\text{Number of classifications correct at least once}}{\left(\text{Number of detection opportunities for mines and minelike objects}\right)} \times 100$$

$(MOE)_7$ = Mean time required to classify a mine as minelike after gaining initial contact

REFERENCES: (1) Final Report on Project C/S12 FY 61
"Concurrent Evaluation of the AN/SQQ-14 Mine Classifying/Detecting Set"
3 Dec. 1962, CONF.

(2) Final Report on Project 0/S153
"Conduct an Operational Evaluation of the Mine Detection/Classification Sonar Set AN/SQQ-16"
4 Aug. 1970, CONF.

ADC2 - Command Active Sonobuoy System (CASS)

DESCRIPTION: This system consists of sonobuoys, a command signal generator and a signal data processor which operates in conjunction with the sonobuoy receivers. The sonobuoys are radio controlled and launched from an airplane to detect, locate, track and classify underwater targets. This system is designed to provide the airplane with a command-active sonar capability.

(1) SPECIFIC OBJECTIVE: Evaluate the detection capability of the system against submarines.

$(MOE)_1$ = Cumulative percentage of contacts as a function of range and pulse mode

$(MOE)_2$ = Mean maximum contact range

ASSUMPTIONS:

(1) Contact percentage is the ratio of the number of trials in which target contact is gained to the total number of trials conducted for a given set of test variables.

(2) Contact range is the range at which contact was lost on an outbound transit and gained on an inbound transit.

(2) SPECIFIC OBJECTIVE: Evaluate the capability of the aircraft to convert from passive DIFAR fixing to a CASS detection.

MOE = Probability of conversion to at least one valid echo as a function of DIFAR fix error

$$= \frac{\text{Number of successful conversions}}{\text{Number of conversion attempts}}$$

(3) SPECIFIC OBJECTIVE: Evaluate CASS/MAD localization capability.

MOE = Localization success percentage

$$= \frac{\left(\begin{array}{l}\text{Number of times localization} \\ \text{is successful}\end{array}\right)}{\text{Number of localization attempts}} \times 100$$

(4) SPECIFIC OBJECTIVE: Evaluate the capability of the airplane to reattack submarine contacts.

MOE = Percent successful reattacks, called the reattack success rate

$$= \frac{\text{Number of successful reattacks}}{\text{Number of reattack attempts}} \times 100$$

(5) SPECIFIC OBJECTIVE: Evaluate active tracking capability.

$(MOE)_1$ = Percent contact time on at least one buoy as a function of range and sea state

$$= \frac{\left(\text{Total contact time on at least one buoy}\right)}{\text{Total opportunity time}} \times 100$$

$(MOE)_2$ = Percent contact time on at least two buoys as a function of range and sea state

$$= \frac{\left(\text{Total contact time on at least two buoys}\right)}{\text{Total opportunity time}} \times 100$$

ASSUMPTION: The time during which the submarine is within sonobuoy range is the opportunity time.

(6) SPECIFIC OBJECTIVE: Evaluate classification capability.

$(MOE)_1$ = Valid contact percentage as a function of pulse mode

$$= \frac{\text{Number of valid contacts reported}}{\text{Total contacts reported}} \times 100$$

$(MOE)_2$ = False contact percentage as a function of pulse mode

$$= \frac{\text{Number of false contacts reported}}{\text{Total contacts reported}} \times 100$$

REFERENCE: First Partial Report of Phase II on Project 0/V84 "Conduct an Operational Evaluation of the Command Active Sonobuoy System (CASS)" 30 August 1971, CONF.

ADC3 - Sonobuoy

DESCRIPTION: This sonobuoy is designed for launching from ASW aircraft for the purpose of detecting and tracking submerged cavitating submarines.

(1) SPECIFIC OBJECTIVE: Determine bearing accuracy.

$(MOE)_1$ = Average bearing error
$(MOE)_2$ = Average bearing error as a function of target azimuth

(2) SPECIFIC OBJECTIVE: Evaluate detection capability.

$(MOE)_1$ = Average maximum detection and tracking range as a function of aspect (bow or stern)
$(MOE)_2$ = Average maximum detection range
$(MOE)_3$ = Percentage detections versus range for given target aspect

(3) SPECIFIC OBJECTIVE: Evaluate sonobuoy reception capability.

MOE = Average maximum radio frequency (RF) range as a function of type of approach (inbound or outbound)

ASSUMPTIONS:

(1) The maximum outbound range is that range at which either the compass signal or the audio signal is lost.
(2) The maximum inbound range is that range at which both compass and audio signals are regained.

(4) SPECIFIC OBJECTIVE: Evaluate sonobuoy classification capability.

MOE = Percentage classifications versus range for given target aspect

(5) SPECIFIC OBJECTIVE: Evaluate sonobuoy capability to fix the position of a submarine.

MOE = Average radial fix error as a function of range and angle

(6) SPECIFIC OBJECTIVE: Evaluate capability to convert sonobuoy bearings to MAD detections.

MOE = Percent MAD conversions

$$= \frac{\text{Number of MAD marks}}{\text{Number of runs}} \times 100$$

REFERENCES: (1) Final Report on Project OP/V218/J15-11
"Tactical Evaluation of the AN/SSQ-20 Passive Directional Sonobuoy in ASW Operations"
25 Nov. 1960, CONF.

(2) Final Report on Project 0/V42 FY64
"Conduct an Operational Evaluation of the AN/SSQ-1 Directional Listening Sonobuoy"
5 Oct. 1964, SECRET

(3) Supplementary Report on Project C/V2 FY61
"Lofar Detection and Classification Capability Against USS Nautilus (SSN-571)"
8 Feb. 1963, SECRET

ADC4 - Submarine Classification and Tracking (SCAT) Device

DESCRIPTION: This device is a mechanical noise maker which, when attached to the hull of a moving submarine, generates noise that can be tracked by a destroyer's sonar.

(1) SPECIFIC OBJECTIVE: Determine the surface ship's ability to classify and track a submerged submarine using the SCAT device.

$(MOE)_1$ = Average detection range of submarine with SCAT device attached

$(MOE)_2$ = Average maintenance of contact range

(2) SPECIFIC OBJECTIVE: Determine the capability of a SCAT device to hit and attach to the hull of a submerged submarine.

$(MOE)_1$ = Probability of hit

$$= \frac{\text{Number of hits recorded}}{\text{Number of rounds fired}}$$

$(MOE)_2$ = Probability of hit and attachment

$$= \frac{\left(\text{Number of devices which hit and attached to the submarine}\right)}{\text{Number of rounds fired}}$$

$(MOE)_3$ = Probability of hit, attachment and proper operation

$$= \frac{\left(\text{Number of devices which hit and attached to a submarine and then operated properly}\right)}{\text{Number of rounds fired}}$$

REFERENCES:

(1) Final Report on Project C/S25 FY62 "Concurrent Evaluation of SCAT Using Hedgehog Delivery" 4 Sep. 1962, CONF.

(2) Final Report on Project C/V10 FY64 "Concurrent Evaluation of Airborne Dispensing System for Submarine Classification and Tracking Device (SCAT), Mk 1 Mod 0" 28 Sep. 1964, CONF.

ADC5 - Electro-Acoustic Decoy

DESCRIPTION: This system is designed for the protection of destroyer-type ships from acoustic homing torpedoes. It is a towed acoustic projector that transmits a selectable variety of sound signals into the sea to decoy torpedoes away from the intended target ship.

(1) SPECIFIC OBJECTIVE: Determine ability of system to decoy passive torpedoes.

$(MOE)_1$ = Percent time decoy controlled the torpedo

$$= \frac{\begin{pmatrix}\text{Total amount of time} \\ \text{torpedo was influ-} \\ \text{enced by decoy}\end{pmatrix} + \begin{pmatrix}\text{Total amount of time} \\ \text{torpedo spent search-} \\ \text{ing after acquiring} \\ \text{decoy}\end{pmatrix}}{\begin{pmatrix}\text{Total run time after the torpedo enabled} \\ \text{until first hit or motor cut-off}\end{pmatrix}} \times 100$$

$(MOE)_2$ = Probability of preventing a hit on the target ship

$$= 1 - \frac{\text{Number of hits on target ship}}{\text{Number of valid torpedo runs}}$$

ASSUMPTIONS:

(1) If no countermeasure is present, the torpedo would hit the target ship on initial attack.

(2) The target ship is unaware of the torpedo being launched and therefore remains on steady course and speed.

(3) The target ship was considered to be hit when either the torpedo entered a given length line conformal to the edges of the target ship or the torpedo was looking within a given azimuth angle of the target ship's propellers and had entered a circle of given radius about the propellers.

(4) Valid torpedo runs are based on subtracting from the number of torpedo launches the number of runs with torpedo malfunctions, improper geometry, erratic torpedo behavior, lost torpedoes, improper torpedo settings and decoy off.

REFERENCE: Final Report on Project C/S63
"Evaluate the NIXIE Torpedo Countermeasure System"
21 April 1971, SECRET

ADC6 - Acoustic Noisemaker

DESCRIPTION: This is an expendable, elec'.'o-mechanical, broadband acoustic noisemaker designed as a torpedo countermeasure.

(1) SPECIFIC OBJECTIVE: Determine capability of noisemaker to decoy torpedoes.

$$\text{MOE} = \text{Probability of decoying a torpedo}$$

$$= \frac{\text{Number of runs on which torpedo was decoyed}}{\text{Number of valid torpedo runs}}$$

ASSUMPTION: To be considered effective the beacon must prevent the torpedo from completing an attack on the target at anytime during the operation of the beacon.

REFERENCE: Final Report on Project 0/S97
"Conduct an Operational Evaluation of the NAE Beacon Mk 3 Mod 1"
28 July 1967, SECRET

ADC7 - Acoustic Minesweeping Device

DESCRIPTION: This is a motor-driven, cavitation-type acoustic minesweeping device which is designed to counter acoustic sea mines by generation of broadband sound.

(1) SPECIFIC OBJECTIVE: Determine minesweep capabilities of device.

$(MOE)_1$ = Maximum lateral actuation range for given mine type and depth

$(MOE)_2$ = Sweep width against a given mine type and depth

$$= 2\int_0^{+\infty} p(x)\,dx$$

$$\approx 2 \sum_{i=1}^{k} \frac{\begin{pmatrix}\text{Number of actuations}\\ \text{in range band i}\end{pmatrix}}{\begin{pmatrix}\text{Number of opportunities}\\ \text{in range band i}\end{pmatrix}} \begin{pmatrix}\text{Length of}\\ \text{range band i}\end{pmatrix}$$

where

p(x) = lateral range probability of detection function

k = number of non-overlapping range bands

REFERENCE: Final Report on CNO Project C/S44
"Concurrent Evaluation of the Minesweeping and Clearance System S26-01, 200-HP Cavitation Acoustic Sweep Device, ROTOVAC 6X and 100-HP Cavitation Acoustic Sweep Device ROTOVAC 7X"
6 Dec. 1968, SECRET

ADC8 - Acoustic Intercept Receiver (AIR)

DESCRIPTION: This device is designed to automatically alert submarine personnel to active underwater acoustic signals emitted from other platforms and/or weapons.

(1) SPECIFIC OBJECTIVE: Determine detection capability against active acoustic torpedoes.

MOE = Cumulative probability of detection versus range

(2) SPECIFIC OBJECTIVE: Determine detection capability against active search sonars and active sonobuoys.

$(MOE)_1$ = Average detection range as a function of active sonar type, AIR platform depth, active sonar transducer depth and layer depth

$(MOE)_2$ = Average range advantage over counterdetection

$$= \frac{\text{Average detection range}}{\text{Average counterdetection range}}$$

(3) SPECIFIC OBJECTIVE: Determine ability to detect underwater communications.

MOE = Average detection range

REFERENCE: Final Report on Project C/S71
"Conduct a Concurrent Evaluation of the AN/WLR-9"
18 Nov. 1971, SECRET

ADC9 - Submarine Acoustic Warfare System (SAWS)

DESCRIPTION: This system is designed to provide enhancement of the ability to detect and classify acoustic emissions from active and passive targets. It provides for an automatic sonar alert upon receipt of radiated line spectrum from a torpedo or platform.

(1) SPECIFIC OBJECTIVE: Evaluate detection capability of sonar system in conjunction with this subsystem.

MOE = Average detection range as a function of submarine type, submarine speed and torpedo approach bearing

(2) SPECIFIC OBJECTIVE: Evaluate sonar system classification capability in conjunction with this subsystem.

$(MOE)_1$ = Percent correct classification given detection

$$= \frac{\text{Number of correct classifications}}{\text{Number of detections}} \times 100$$

$(MOE)_2$ = Percent runs on which both detection and classification occurred

$$= \frac{\left(\begin{array}{l}\text{Number of runs on which detection and}\\ \text{classification occurred}\end{array}\right)}{\text{Number of valid runs}} \times 100$$

$(MOE)_3$ = Percent runs on which both detection and correct classification occurred

$$= \frac{\left(\begin{array}{l}\text{Number of runs on which detection and}\\ \text{correct classification occurred}\end{array}\right)}{\text{Number of valid runs}} \times 100$$

$(MOE)_4$ = Average classification time when correct

$(MOE)_5$ = Average classification time when incorrect

(3) SPECIFIC OBJECTIVE: Evaluate capability of submarine to react to impending torpedo attack.

MOE = Probability of detection, correct classification and successful evasion

$= P_1 P_2 P_3$

where

P_1 = probability of timely detection and classification

$= \frac{\text{Number of detection and classification successes}}{\text{Number of valid runs}}$

$= \frac{f(T_1, T_2, T_3, T_4)}{\text{Number of valid runs}}$

(NOTE: For determination of f see assumption.)

P_2 = probability of correct classification given detection

$= \frac{\text{Number of correct classifications}}{\text{Number of detections}}$

P_3 = probability of successful evasion

$= g(T_1)$

(NOTE: g is determined using a simulation program developed by the Naval Coastal Systems Laboratory.)

T_1 = minimum time available to successfully evade, which represents the time prior to impact at which evasion action must begin in order to be successful

T_2 = time to impact, which represents the time from torpedo detection to torpedo impact if no evasive action were to be taken and the torpedo ran a direct intercept course

T_3 = time to classify

T_4 = time for OOD reaction

ASSUMPTION: If $T_2 - T_1 > T_3 + T_4$, then a run is considered to be successful in terms of detection and classification; otherwise, unsuccessful. In other words, the MOE is established by measuring detection range, converting that to time to impact and, after subtracting reaction time, assessing whether or not sufficient time remains to successfully evade the torpedo.

REFERENCE: Final Report on Project C/S85
"Concurrent Evaluation of SAWS (Submarine Acoustic Warfare System)"
7 Dec. 1973, SECRET

TABLE B-2 Operational Test & Evaluation MOE Data Base (Continued)

Area: Communications (C)

CODE	ITEM
C1	UHF Transceiver (AN/WSC-3)
C2	Sounder Receiver System (SRS)
C3	Report Receiver-Transmitter (RRT)
C4	Radio Transmitter (AN/WRA-3)
C5	Data Communications Set (HICAPCOM)
C6	Drone Control Set
C7	Message Processing and Distribution System (MPDS) and Facilities Control System (FCS)

COMMUNICATIONS (C)

C1 - UHF Transceiver

DESCRIPTION: This is designed to provide a satellite communications capability for small ships and submarines. It also has a line-of-sight (LOS) mode which provides for direct path communications between stations.

(1) SPECIFIC OBJECTIVE: Determine the adequacy of voice communications for both plain voice and secure voice.

$(MOE)_1$ = Mean error rate, which is defined as the number of words missed per 25-word message

$(MOE)_2$ = Probability that a rhyme word transmitted by this system is correctly interpreted

$$= 1 - \frac{\left(\text{Average number of words wrong per N-word message}\right)}{N}$$

$(MOE)_3$ = Percent sentence intelligibility

(NOTE: $(MOE)_3$ is determined from $(MOE)_2$ using a conversion scheme developed in "Speech Intelligibility in Naval Aircraft Radios", NELC Report, 2 Aug. 1972.)

(2) SPECIFIC OBJECTIVE: Determine teletype communications performance.

$(MOE)_1$ = Mean character error rate, which is defined as the average number of character errors per 1000 character message as a function of satellite elevation angle

$(MOE)_2$ = Gross error rate, which is defined as the percent of messages that had more than 10 character errors per 1000 character message as a function of satellite elevation angle

(3) SPECIFIC OBJECTIVE: Determine data communications performance.

MOE = Bit error rate, which is defined as the number of bits missed per second for a given data rate (in bits per second) and transmission mode

REFERENCE: Final Report on Project O/S181
"Conduct an Operational Evaluation of the UHF Satellite Ship/
Submarine SATCOM Terminal (AN/WSC-3)"
7 Jan. 1974, CONF.

C2 - Sounder Receiver System (SRS)

DESCRIPTION: This is a specialized high frequency radio receiver which receives a signal consisting of a specified number of discrete frequencies from a sounder transmitter. These frequencies provide an indication of the bands of frequencies which may be propagating within a specified range band when received and displayed by the Sounder Receiver System.

(1) SPECIFIC OBJECTIVE: Determine consistency of SRS optimum antenna determination.

$$MOE = \frac{\text{Number of usable CER's}}{\text{Total number of CER determinations}}$$

where

CER = character error rate, which is that number of erroneous characters received on a teletype versus a known number of correct characters transmitted.

(2) SPECIFIC OBJECTIVE: Determine consistency of SRS frequency indications.

$$(MOE)_1 = \frac{\left(\text{Number of times a desired frequency was ascertained}\right)}{\left(\text{Number of times a decision was made to select a new frequency}\right)}$$

$$(MOE)_2 = \frac{\left(\text{Number of usable non-SRS operating frequencies lying outside of the recommended operating ranges of both the non-SRS circuit antenna and the optimum antenna}\right)}{\left(\text{Total number of usable operating frequencies for each radio path}\right)}$$

(NOTE: $(MOE)_2$ is called the ratio of failures to total attempts, since a usable frequency outside the recommended operating range was considered a failure of the SRS to indicate a usable frequency.)

REFERENCE: Final Report on Project 0/S107
"Conduct an Operational Evaluation of the Oblique Incidence Ionospheric Sounder System"
23 Sept. 1969, UNCL.

C3 - Report Receiver-Transmitter (RRT)

DESCRIPTION: This equipment is designed to apply and detect information in the form of low frequency signals modulating the carrier of any voice communication equipment. It is used in conjunction with shipboard and aircraft communications equipment.

(1) SPECIFIC OBJECTIVE: Determine communication capability.

$$(MOE)_1 = \text{Percent of RRT messages received}$$

$$= \frac{\text{Number of RRT messages received}}{\text{Number of RRT transmissions}} \times 100$$

$$(MOE)_2 = \text{Percent RRT messages received that were displayed accurately}$$

$$= \frac{\left(\text{Number of accurately displayed RRT messages}\right)}{\left(\text{Number of RRT messages received}\right)} \times 100$$

REFERENCE: Final Report on Project F/O 148 FY63
"Fleet Operational Investigation of ASW Report Receiver-Transmitter"
16 April 1964, CONF.

C4 - Radio Transmitter

DESCRIPTION: This radio communications transmitting equipment is designed for use as a modulator for standard shipboard and submarine transmitters.

(1) SPECIFIC OBJECTIVE: Evaluate transmission accuracy.

$(MOE)_1$ = Percent of transmissions detected which are satisfactorily transcribed into legible copy

$$= \frac{\left(\begin{array}{l}\text{Number of detected transmissions} \\ \text{satisfactorily transcribed into} \\ \text{legible copy}\end{array}\right)}{\text{Number of detected transmissions}} \times 100$$

$(MOE)_2$ = Percent transmissions with textual errors

$$= \frac{\left(\begin{array}{l}\text{Number of transmissions} \\ \text{with textual errors}\end{array}\right)}{\text{Number of transmissions}} \times 100$$

$(MOE)_3$ = Average number of errors per message

$(MOE)_4$ = Average number of errors per character sent

REFERENCE: Final Report on Project 0/S66 FY63
"Conduct an Evaluation of the AN/WRA-3 Radio Transmitter"
11 April 1963, SECRET

C5 - Data Communications Set

DESCRIPTION: This set is designed to provide secure and rapid tactical communications between ships in dispersed formations.

(1) SPECIFIC OBJECTIVE: Determine traffic handling capability.

MOE = Data rate achieved (in words per minute)

REFERENCE: Final Report on Project C/S19 FY 61
"Concurrent Evaluation of a High Capacity Communications (HICAPCOM) System"
21 August 1962, CONF.

C6 - Drone Control Set

DESCRIPTION: This system is designed to send commands, receive telemetry and track a drone, both in range and azimuth, via an RF (radio frequency) link from either a shore or shipboard installation.

(1) SPECIFIC OBJECTIVE: Determine message decoding performance.

MOE = Command message error probability, which is defined as the probability that the system transponder will error in decoding a word in the command message link for given maximum word length (bits) and received target strength (dbm)

$$= \frac{\text{Number of words with decoding errors}}{\text{Number of word decoding attempts}}$$

REFERENCE: Phase II Report on Project X/C8
"Conduct an Operational Assist of the Integrated Target Control System"
5 March 1974, UNCL.

C7 - Message Processing and Distribution System (MDPS) and Facilities Control System (FCS)

DESCRIPTION: The MPDS is a stored program, three computer system designed to process, store, log and internally distribute record message traffic and digital data "on-line" with radio receiving and transmitting equipment. The FCS provides for quality monitoring of communications circuits, for generation of central frequency and time signals, and for patching and adjusting of radio frequency and terminal equipments.

(1) SPECIFIC OBJECTIVE: Evaluate the capability of the MPDS to do message processing.

$$MOE = \prod_{i=1}^{7} P_i$$

where

P_1 = message recognition factor

P_2 = message distribution factor

P_3 = message journaling factor

P_4 = message transmittal relay factor

P_5 = broadcast screening accuracy

$$= 1 - \frac{\text{Number of broadcast screening errors}}{\text{Number of broadcast messages}}$$

P_6 = operational availability

$$= 1 - \frac{\text{Total downtime}}{\text{Total time in use}}$$

P_7 = measure of effectiveness for the FCS

$$= \text{antilog } \frac{1}{n} \sum_{i=1}^{n} \log C_i$$

n = number of circuits

C_i = i^{th} individual circuit/channel reliability percentage

$$= \frac{\left(\text{Time } i^{th} \text{ circuit/channel is of traffic quality}\right)}{\text{Demand usage time}} \times 100$$

(NOTE: P_7 expresses the success of the FCS in maintaining teletype circuits of traffic quality.)

ASSUMPTION: A reliable traffic quality circuit is a circuit condition of 15% or less black bias distortion and the MPDS receiving messages of sufficient quality to process.

REFERENCE: Final Report on Project X/S7
"Conduct an Operational Assist for CVAN 68 Message Processing and Distribution System (MPDS)/Facilities Control System (FCS)"
29 Nov. 1972, CONF.

TABLE B-2 Operational Test & Evaluation MOE Data Base (Continued)

Area: Data & Display (DD)

CODE	ITEM
DD1	Naval Tactical Data System (NTDS)
DD2	Computer Controlled Command and Control System (DATACOURTS)
DD3	Antisubmarine Contact Analysis Center (ASCAC)
DD4	ASW Avionics System (ANEW)
DD5	Electronic Display System (EDS)
DD6	Teletype Integrated Display System (TIDY)
DD7	Data Relay System

DATA & DISPLAY (DD)

DD1 - Naval Tactical Data System (NTDS)

DESCRIPTION: This is a computerized tactical control system which is designed to collect, exchange, process and evaluate information in an anti-air warfare situation.

(1) SPECIFIC OBJECTIVE: Determine the accuracy of the system to depict the location of a given air target using three NTDS-equipped ships.

$(MOE)_1$ = Accuracy with which the system (based on 3 ships) is able to locate a given target as compared to the position determined by a precision radar tracking system used as a standard

(NOTE: A measure of this accuracy would be either the average 50th or the 90th percentile radius of a circle centered on the actual positions which would enclose the three NTDS positions.)

$(MOE)_2$ = Position radius of the NTDS target among the three NTDS ships, which is defined as the radius of the smallest circle which will enclose all three NTDS symbol positions

(NOTE: This is a measure of the relative accuracy of position of a NTDS target independent of an outside reference system.)

REFERENCE: Final Report on the Naval Tactical Data System Service Test
Part III Materiel Aspects of the Service Test Equipment
Task IV of Phase II, Project C/S5 FY60
"Concurrent Evaluation of the Naval Tactical Data System (NTDS)"
18 Sept. 1962, CONF.

DD2 - Computer Controlled Command,and Control System

DESCRIPTION: This system is designed to unite the ship's sensors and weapon systems. It consists of a general purpose digital computer, an Evaluation Display and Control Console, a Teletype and Paper Tape Reader.

(1) SPECIFIC OBJECTIVE: Evaluate sensor alerting capability.

$(MOE)_1$ = Probability of ESM (Electronic Warfare Support Measures) detection causing an alert

$$= \frac{\left(\text{Number of times ESM detection was successful in causing an alert to the proper sensor}\right)}{\left(\text{Number of alert attempts due to ESM detection}\right)}$$

$(MOE)_2$ = Probability of search radar detection causing an alert

$$= \frac{\left(\text{Number of times search radar detection was successful in causing an alert to the proper sensor/sensors}\right)}{\left(\text{Number of alert attempts due to search radar detection}\right)}$$

$(MOE)_3$ = Probability of evaluator input causing an alert

$$= \frac{\left(\text{Number of times evaluator inputs were successful at alerting ESM and/or search radars}\right)}{\left(\text{Number of alert attempts due to evaluator inputs}\right)}$$

ASSUMPTIONS:

(1) When one sensor notifies this C&C system that is has detected a target, the system evaluates the sensor in relation to the threat. If this sensor does not provide sufficient information, is not the hest sensor for the threat, or if the sensor is overloaded, another sensor is alerted to track the threat. If an alert to any sensor is not responded to from that sensor by an entry, the system will continue alerting the sensor until it does receive a reply entry.

(2) The evaluator can cause alerts when he acts as initial detector, designates to a reaction system, or deletes a target from the system.

(2) SPECIFIC OBJECTIVE: Evaluate capability to correlate sensor inputs.

$(MOE)_1$ = Probability of successful search radar-to-search radar correlation

$$= \frac{\text{(Number of times search radar-to-search radar correlation is achieved)}}{\text{(Number of search radar-to-search radar correlation attempts)}}$$

$(MOE)_2$ = Probability of successful ESM-to-search radar correlation

$$= \frac{\text{(Number of times ESM-to-search radar correlation is achieved)}}{\text{(Number of ESM-to-search radar correlation attempts)}}$$

$(MOE)_3$ = Probability of successful FCS (Fire Control System) lock-on-to-search radar correlation

$$= \frac{\text{(Number of times FCS lock-on-to-search radar correlation is achieved)}}{\text{(Number of FCS lock-on-to-search radar correlation attempts)}}$$

(NOTE: $(MOE)_1$, $(MOE)_2$ and $(MOE)_3$ are measures of search radar correlation success.)

$(MOE)_4$ = Probability of successful search radar-to-ESM correlation

$$= \frac{\text{(Number of times search radar-to-ESM correlation is achieved)}}{\text{(Number of search radar-to-ESM correlation attempts)}}$$

$(MOE)_5$ = Probability of successful FCS lock-on-to-ESM correlation

$$= \frac{\text{(Number of times FCS lock-on-to-ESM correlation is achieved)}}{\text{(Number of FCS lock-on-to-ESM correlation attempts)}}$$

(NOTE: $(MOE)_4$ and $(MOE)_5$ are measures of ESM correlation success.)

$(MOE)_6$ = Probability of successful search radar-to-FCS lock-on correlation

$$= \frac{\left(\text{Number of times search radar-to-FCS lock-on correlation is achieved}\right)}{\left(\text{Number of search radar-to-FCS lock-on correlation attempts}\right)}$$

$(MOE)_7$ = Probability of successful ESM-to-FCS lock-on correlation

$$= \frac{\left(\text{Number of times ESM-to-FCS lock-on correlation is achieved}\right)}{\left(\text{Number of ESM-to-FCS lock-on correlation attempts}\right)}$$

$(MOE)_8$ = Probability of successful FCS-to-FCS lock-on correlation

$$= \frac{\left(\text{Number of times FCS-to-FCS lock-on correlation is achieved}\right)}{\left(\text{Number of FCS-to-FCS lock-on correlation attempts}\right)}$$

(NOTE: $(MOE)_6$, $(MOE)_7$ and $(MOE)_8$ are measures of fire control system correlation success.)

$(MOE)_9$ = Probability of evaluator correlation success

$$= \frac{\left(\text{Number of threats initially entered by the evaluator and subsequently entered by a search radar}\right)}{\left(\text{Number of threats initially entered by the evaluator}\right)}$$

ASSUMPTIONS:

(1) As each new entry arrives in the system, it is compared with all existing items in the threat file. If the new entry is within the prescribed correlation bins in range and bearing, and if the classification is consistent with the classification in the threat file, then the two items are said to correlate.

(2) Search radar correlation success is assumed to occur when the threat file track is initiated by a search radar entry and a new input is received from another search radar, ESM, or FCS lock-on.

(3) ESM correlation success is assumed to occur when the threat file track is initiated by an ESM entry and a new input is received from either a search radar or a FCS lock-on.

(4) Fire control system correlation success is assumed to occur when the threat file track is being updated by a FCS and search radar enters a new track, ESM enters a bearing and classification, or another FCS locks on the same target.

(3) SPECIFIC OBJECTIVE: Evaluate weapons system engagement capability.

$$(MOE)_1 = \text{Probability of successful engagement} = \frac{\text{Number of threats effectively engaged}}{\text{Number of threats detected}}$$

$$(MOE)_2 = \text{Median total reaction time} = R_{DA} + R_{ARF} + R_{RFF}$$

where

R_{DA} = median reaction time from detection to assign

R_{ARF} = median reaction time from assign to ready-to-fire

R_{RFF} = median reaction time from ready-to-fire to fire

REFERENCE: Final Report on Project C/S68
"Conduct a Concurrent Evaluation of ASMD (Anti-Ship Missile Defense) Near Term Program Equipments DATACOURTS (Data Correlation and Transfer System) Portion"
17 Oct. 1972, SECRET

DD3 - Antisubmarine Contact Analysis Center (ASCAC)

DESCRIPTION: This is a system using specially configured analysis equipment and specially trained personnel (called the Antisubmarine Contact Team (ASCAT)) to process and interpret raw sonic intelligence received via radio link or other means from airborne, surface and subsurface sensors.

(1) SPECIFIC OBJECTIVE: Evaluate the ability of the ASCAT and/or sensors to classify contacts.

$$(MOE)_1 = \text{Percent correct classifications}$$

$$= \frac{\left(\text{Number of correctly classified signatures}\right)}{\left(\text{Number of classification opportunities}\right)} \times 100$$

$$(MOE)_2 = \text{Median time for classification}$$

REFERENCE: Final Report on Project F/O 117
"Fleet Operational Investigation of a CVS Antisubmarine Contact Analysis Center (ASCAC)"
11 July 1963, SECRET

DD4 - ASW Avionics System

DESCRIPTION: This system consists of integrated navigation, communications, sensor, display, maintenance, ordnance and data processing subsystems.

(1) SPECIFIC OBJECTIVE: Evaluate the capability of an aircraft equipped with this system to perform detection, classification, localization and attack operations.

$(MOE)_1$ = Average time to detect/classify, which is the average of times from the first detection opportunity until a valid target detection was announced by a sensor operator

$(MOE)_2$ = Average time from detection to attack, which is defined as the average of times from the first valid detection until a simulated attack was delivered against the target

$(MOE)_3$ = Average time to attack for short range localization, which is defined as the average of times from the first valid contact by Julie, active sonobuoy or MAD until a simulated attack was delivered against the target

$(MOE)_4$ = Average total time to attack, which is defined as the average of times from the first detection opportunity to the time of delivery of a simulated attack

$(MOE)_5$ = Lofar detection/opportunity ratio

$$= \frac{\text{Number of events with valid Lofar detections}}{\text{Number of events containing a valid opportunity}}$$

$(MOE)_6$ = Valid classification/total classification ratio

$$= \frac{\text{Number of valid target submarine classifications}}{\text{Number of announced target submarine classifications}}$$

$(MOE)_7$ = Successful attack/short range localization ratio

$$= \frac{\left(\text{Number of successful attacks, given a short range sensor contact}\right)}{\left(\text{Number of events with a valid Julie, active sonobuoy or MAD contact}\right)}$$

$(MOE)_8$ = Successful attack/total attack ratio

$$= \frac{\text{Number of successful attacks}}{\text{Number of attacks conducted}}$$

$(MOE)_9$ = Successful attack/total event ratio

$$= \frac{\text{Number of successful attacks}}{\text{Number of events conducted}}$$

$(MOE)_{10}$ = Probability of successful attack

(NOTE: $(MOE)_{10}$ is computed via a detailed Markov chain model described in an enclosure.)

REFERENCE: Final Report on Project F/0228
"Fleet Operational Investigation to Establish the Effectiveness of the P-3 ANEW Compared to the DELTIC P-3A/B"
31 Oct. 1967, CONF.

DD5 - Electronic Display System

DESCRIPTION: This is a data handling, display and exchange system used in fleet air defense to provide data link exchange or detection and tracking information on airborne targets.

(1) SPECIFIC OBJECTIVE: Evaluate accuracy capability against air targets.

$(MOE)_1$ = Percent of total number of valid tracks as a function of store tracking error (deg)

$(MOE)_2$ = Percent of total number of valid tracks as a function of store speed error (kts)

$(MOE)_3$ = Percent of total number of valid tracks as a function of maximum separation of tracks (nm)

REFERENCE: Final Report on Project OP/S480/S67
"Evaluation of the Electronic Data System (EDS)"
1 Feb. 1960, UNCL.

DD6 - Teletype Integrated Display System (TIDY)

DESCRIPTION: This is a small-scale data processing system designed to improve current methods of displaying the tactical data available from the NTDS Link 14.

(1) SPECIFIC OBJECTIVE: Determine plot accuracy.

$(MOE)_1$ = Percent range accuracy

= 100% - % absolute range error

$(MOE)_2$ = Cumulative distribution of absolute range error as a percent of range scale

(2) SPECIFIC OBJECTIVE: Determine capability of the TIDY computer to accurately maintain the navigational position of own ship (OS) with respect to Data Link Reference Point (DLRP).

$(MOE)_1$ = Average navigation error rate (nm/hr)

$(MOE)_2$ = Maximum navigation error rate (nm/hr)

$(MOE)_3$ = Maximum navigation error (nm)

(3) SPECIFIC OBJECTIVE: Determine track processing capability.

$(MOE)_1$ = Average actions per minute (APM)

$$= \frac{\left(\text{Number of actions which took place in a given interval}\right)}{\text{Interval Length}}$$

(NOTE: The "actions" consist of new tracks which appear on the plot, old tracks which are dropped, and those tracks that are updated. This APM figure does not necessarily represent the true number of actions during the interval due to the possibility that a particular track may have been added or updated and then dropped, or it may have been updated once and then, upon a second update, the symbol may have been moved with all previous data scrubbed from the plot board.)

$$(MOE)_2 = \text{Plot track ratio} = \frac{\left(\text{Number of plot positions appearing on the Summary Plot}\right)}{\text{Total number of tracks}}$$

(NOTE: $(MOE)_2$ is a measure of track coherency.)

REFERENCE: Final Report on Project 0/S179
"Operational Evaluation of the TIDY (Teletype Integrated Display System)"
10 May 1973, CONF.

DD7 - Data Relay System

DESCRIPTION: This system is designed to provide a two way radio link for intermittent exchange of sonic data between an aircraft and elements of SOSUS. The system provides a side by side display of sonobuoy and Sound Search Station (SOSS) data on either the SOSS or aircraft display equipments.

(1) SPECIFIC OBJECTIVE: Evaluate operator classification capability.

$(MOE)_1$ = Percent correct classifications as submarine or non-submarine

$$= \frac{\text{Number of correct classifications}}{\text{Number of classification opportunities}} \times 100$$

$(MOE)_2$ = Percent friendly targets correctly recognized

$$= \frac{\left(\text{Number of friendly targets correctly recognized}\right)}{\left(\text{Number of friendly target classification opportunities}\right)} \times 100$$

$(MOE)_3$ = Percent unfriendly targets correctly recognized

$$= \frac{\left(\text{Number of unfriendly targets correctly recognized}\right)}{\left(\text{Number of unfriendly target classification opportunities}\right)} \times 100$$

$(MOE)_4$ = Average classification time per operator

$(MOE)_5$ = Difficulty index for submarine or non-submarine decision

$$= \frac{\left(\text{Number of correct operator decisions as submarine or non-submarine}\right)}{\left(\text{Number of operators classifying the signature}\right)}$$

$(MOE)_6$ = Difficulty index for friendly or non-friendly decision

$$= \frac{\left(\text{Number of correct operator decisions as friendly or non-friendly}\right)}{\left(\text{Number of operators classifying the signature}\right)}$$

$(MOE)_7$ = Difficulty index for conventional or nuclear powered decision

$$= \frac{\left(\text{Number of correct operator decisions as conventional or nuclear powered}\right)}{\left(\text{Number of operators classifying the signature}\right)}$$

REFERENCES: (1) Final Report on Project F/0116 FY62
(Title Classified)
15 Oct. 1963, SECRET

(2) Supplementary Report on Project F/0116 FY62
(Title Classified)
23 Jan. 1964, SECRET

TABLE B-2 Operational Test & Evaluation MOE Data Base (Continued)

Area: Electromagnetic Detection & Countermeasures (EDC)

CODE	ITEM
EDC1	Radar
EDC1-1	Air Search Radar (AN/SPS-49(XN-1), AN/SPS-50 (XN-1), AN/SPS-52, AN/SPS-58)
EDC1-2	Air Traffic Control Radar (AN/SPN-43)
EDC1-3	Airborne Early Warning Radar
EDC2	IFF System (AN/SLQ-20, AN/UPX-24)
EDC3	Target Recognition Set (AN/ASX-2 (TRISAT))
EDC4	Mine Control Wire Detector (L Mk 3X Mod 0 Locator (RADRAG))
EDC5	Early Warning and Surveillance Receiver (AN/WLR-8(V)2 ESM Receiver)
EDC6	Minesweeping Equipment (Mk 105 Mod 0, Mk 104 Mod 1)
EDC7	Mine Defense System (SHADOWGRAPH)
EDC8	Degaussing System
EDC9	Automatic Permanent Magnetic Compensator (APMC)
EDC10	MAD Device (AN/ASQ-8)
EDC11	Electronic Warfare System (AN/SLQ-27 (XN-1) SHORTSTOP)
EDC12	ECM Receiving Antenna (AS-899/SLR)
EDC13	Shipboard Direction Finding System (AN/SRD-19 (XN-1))
EDC14	Radio Direction Finder (AN/BRD-7)
EDC15	Radio Frequency Oscillator (RFO) (O-1331 (XN-1)/ULQ-6)
EDC16	Deception Repeater (AN/SLQ-17(V))
EDC17	Aircraft Radar/Missile Homing and Warning Receiver

Area: Electromagnetic Detection & Countermeasures (EDC) (Continued)

CODE	ITEM
EDC18	Radio Frequency Amplifier (AM-4530/ULQ-6A)
EDC19	Decoy Repeater Buoy (AN/ULQ-5)
EDC20	Noise Jammer (ALT-27)

ELECTROMAGNETIC DETECTION & COUNTERMEASURES (EDC)

EDC1 - Radar

EDC1-1 Air search radar

DESCRIPTION: This system is a shipboard air search radar designed for operation in the presence of countermeasures.

(1) SPECIFIC OBJECTIVE: Evaluate radar detection performance.

$(MOE)_1$ = Cumulative distribution of maximum detection range, i.e., percent of runs on which detection was made by given range

$(MOE)_2$ = Single scan probability of detection as a function of range for given target speed, target altitude and antenna lobing

$$= \frac{\text{Number of detections (blips)}}{\text{Number of scans}}$$

$(MOE)_3$ = Median detection range for given radar mode, target type and target altitude

$(MOE)_4$ = 90% cumulative detection range for given radar mode, target type and target altitude.

$(MOE)_5$ = Median minimum detection range for given target altitude and elevation scan limit

ASSUMPTION: Two types of detection criteria employed for computation of $(MOE)_1$ were: (1) first detection of an incoming aircraft by an alerted operator, and (2) observation of two blips in any three consecutive scans. Use of the second criterion reduced the influence of random, strong, noise returns with characteristics similar to aircraft target returns, and more closely approximated the detection decision point of an unalerted operator.

(2) SPECIFIC OBJECTIVE: Evaluate radar tracking performance.

$(MOE)_1$ = Percent of runs on which tracking was held to a given range

$(MOE)_2$ = Average index of track solidity as a function of slant range for given target altitude and video category, which is defined as the ratio of blips observed to the total number of scans within a specified range band

(3) SPECIFIC OBJECTIVE: Evaluate radar capability to estimate target position/location.

$(MOE)_1$ = Cumulative range error distribution
$(MOE)_2$ = Cumulative bearing error distribution
$(MOE)_3$ = Cumulative altitude error distribution
$(MOE)_4$ = Mean bearing resolution for target within given range band

(4) SPECIFIC OBJECTIVE: Evaluate capability of system to perform control of air intercepts.

MOE = Probability of successful intercept

$$= \frac{\text{Number of successful intercepts}}{\text{Number of intercept attempts}}$$

(5) SPECIFIC OBJECTIVE: Evaluate the capability of the system to provide interface with the Weapons Designation Equipment (WDE).

MOE = Mean acquisition time

REFERENCES: (1) Final Report on Project C/S34
"Concurrent Evaluation of AN/SPS-49(XN-1) and AN/SPS-50(XN-1)"
7 Feb. 1966, CONF.

(2) Final Report on Project C/S46
"Conduct a Concurrent Evaluation of the AN/SPS-52 Radar"
25 March 1970, CONF.

(3) Final Report on Project C/S72
"Conduct a Concurrent Evaluation of the AN/SPS-58 Radar System"
27 July 1971, CONF.

EDC1-2 Air traffic control radar

DESCRIPTION: This shipboard system is a medium range, two-coordinate CATC (Carrier Air Traffic Control) radar.

(1) SPECIFIC OBJECTIVE: Determine radar detection and tracking performance.

$(MOE)_1$ = Average index of track solidity as a function of slant range for given target altitude, target type and antenna tilt angle

$(MOE)_2$ = Mean radar range resolution, where range resolution is based on the range difference of the leading edge of two targets at the same bearing as the two target blips started to separate or merge

$(MOE)_3$ = Mean radar bearing resolution, where bearing resolution is based on the bearing difference of the center of two targets at the same range as the two target blips started to separate or merge

$(MOE)_4$ = Mean radar range error

$(MOE)_5$ = Mean radar bearing error

$(MOE)_6$ = Average minimum target detection range as a function of target altitude, target type, antenna polarization type and antenna tilt angle

$(MOE)_7$ = Average maximum target detection range as a function of target altitude, target type, antenna polarization type and antenna tilt angle

REFERENCE: Final Report on Project 0/S123
"Conduct an Operational Evaluation of the Improved AN/SPN-43"
7 Sept. 1967, CONF.

<u>EDC1-3</u> Airborne early warning radar

DESCRIPTION: This system is designed to detect, identify and track airborne (overland and overwater) and surface targets.

(1) SPECIFIC OBJECTIVE: Determine the capability to detect, identify (IFF) and track targets

$(MOE)_1$ = Blip/scan ratio as a function of range for given target type, altitude, speed and radar mode

$$= \frac{\left(\text{Number of times target radar return was present on the scope for a given range band}\right)}{\left(\text{Number of antenna scans in a given range band}\right)}$$

$(MOE)_2$ - Probability of successful target aircraft identification

$$= \frac{\text{Number of valid replies}}{\text{Number of IFF interrogations}}$$

(2) SPECIFIC OBJECTIVE: Determine the capability of the passive detection system (PDS) to fix stationary electromagnetic emitters.

MOE = Circular error probable (CEP) of emitter site position

REFERENCE: First Partial Report on Project C/V22
"Conduct a Concurrent Evaluation of the E-2C Weapon System"
19 April 1973, SECRET

EDC2 - IFF System

DESCRIPTION: An IFF system, as part of a radar system, is designed for interrogating and identifying aircraft.

(1) SPECIFIC OBJECTIVE: Evaluate system ability to identify aircraft.

MOE = Single scan probability of detection as a function of target range and azimuth separation of target aircraft

$$= \frac{\text{Number of aircraft identifications}}{\text{Number of radar scans}}$$

(2) SPECIFIC OBJECTIVE: Evaluate detection capability.

$(MOE)_1$ = Probability of aircraft detection

$$= \frac{\text{Number of detections}}{\text{Number of detection opportunities}}$$

$(MOE)_2$ = Percent of warning alerts detected or confirmed

$$= \frac{\left(\begin{array}{c}\text{Number of warning alerts}\\ \text{detected or confirmed}\end{array}\right)}{\text{Number of warning alerts}} \times 100$$

REFERENCES: (1) Final Report on Project P/S3
"Conduct an Operational Appraisal of SEESAW II (AN/SLQ-20)"
2 Feb. 1970, SECRET

(2) Final Report on Project C/S82
"Conduct a Concurrent Evaluation of the AN/UPX-24 Central IFF System"
17 Oct. 1973, CONF.

EDC3 - Target Recognition Set

DESCRIPTION: The TRISAT (Target Recognition Through Integral Spectral Analysis Techniques) recognition set is used to recognize jet aircraft engines.

(1) SPECIFIC OBJECTIVE: Evaluate the ability of the system to correctly identify (i.e., classify) programmed aircraft targets.

$(MOE)_1$ = Probability of target correct classification

$$= \frac{\text{Number of targets correctly classified}}{\text{Number of runs against programmed targets}}$$

$(MOE)_2$ = Classification range as a function of track initiation range

$(MOE)_3$ = Average low confidence classification range

$(MOE)_4$ = Average high confidence classification range

REFERENCE: Summary Report of Project X/V17
"Conduct an Operational Assist for the AN/ASX-2 (TRISAT) Recognition Set"
17 Oct. 1972, SECRET

EDC4 - Mine Control Wire Detector

DESCRIPTION: This system is designed to detect control wires leading to command-detonated mines.

(1) SPECIFIC OBJECTIVE: Evaluate detection performance.

$$(MOE)_1 = \text{Probability of successfully detecting a mine wire} = \frac{\text{Number of successes}}{\text{Number of opportunities}}$$

$$(MOE)_2 = \text{False alarm rate} = \frac{\text{Number of false alarms reported}}{\text{Number of miles swept}}$$

REFERENCE: Final Report on Project 0/S178
"Conduct an Operational Evaluation of the L Mk 3X Mod 0
Locator (RADRAG)"
22 June 1973, CONF.

EDC5 - Early Warning and Surveillance Receiver

DESCRIPTION: This device is designed as a tactical early warning and surveillance receiver for submarine use.

(1) SPECIFIC OBJECTIVE: Evaluate detection performance.

$(MOE)_1$ = Average operator integration time as a function of frequency

$(MOE)_2$ = Maximum detection range

ASSUMPTION: Integration time was measured from the time of signal intercept to the time of completed analysis.

(2) SPECIFIC OBJECTIVE: Evaluate system accuracy.

$(MOE)_1$ = Mean percentage error in frequency

$$= \frac{\text{Actual frequency - Observed frequency}}{\text{Actual frequency}} \times 100$$

$(MOE)_2$ = Mean percentage error in PW (pulse width)

$$= \frac{\text{Actual PW - Observed PW}}{\text{Actual PW}} \times 100$$

$(MOE)_3$ = Mean percentage error in PRF (pulse repetition frequency)

$$= \frac{\text{Actual PRF - Observed PRF}}{\text{Actual PRF}} \times 100$$

$(MOE)_4$ = Mean bearing error (deg)

(3) SPECIFIC OBJECTIVE: Evaluate ability to intercept signals.

MOE = Probability of signal intercept

$$= \frac{\text{Actual intercepts}}{\text{Attempted intercepts}}$$

REFERENCE: Final Report on Project C/S94
"Conduct a Concurrent Evaluation of the AN/WLR-8(V)2 ESM Receiver"
26 Oct. 1973, SECRET

EDC6 - Minesweeping Equipment

DESCRIPTION: This is a helicopter towed, unmanned device designed to counter magnetic, acoustic or combination magnetic-acoustic sea mines that present a hazard to conventional minesweepers and amphibious craft.

(1) SPECIFIC OBJECTIVE: Evaluate the capability to sweep mines.

$(MOE)_1$ = Probability of actuation as a function of lateral range

$$= \frac{\left(\text{Number of mines actuated in a given range band}\right)}{\left(\text{Number of runs in a given range band}\right)}$$

$(MOE)_2$ = Aggregate sweep width, which is defined as twice the area under the probability of actuation versus lateral range curve

$(MOE)_3$ = Maximum sweep (actuation) range

(2) SPECIFIC OBJECTIVE: Evaluate the vulnerability of the helicopter and minesweeping platform to mine actuations.

MOE = Damage probability

$$= \frac{\left(\text{Number of actuations causing plume damage to the helicopter or platform}\right)}{\left(\text{Number of actuations where the helicopter's or platform's closest point of approach is less than the plume's projected radius}\right)}$$

ASSUMPTION: If the plume of the actuated mine touched either the helicopter or platform, damage is assumed to occur.

REFERENCE: Final Report on Project 0/V71
"Conduct an Operational Evaluation of the Magnetic Minesweeping Gear Mk 105 Mod 0 and the Combined Magnetic (Mk 105 Mod 0) -- Acoustic (Mk 104 Mod 1) Minesweeping Gear, PAGE"
19 August 1970, SECRET

EDC7 - Mine Defense System

DESCRIPTION: This system is designed to locate, classify and destroy bottom mines. It consists of a classification subsystem, using underwater classification vehicles and associated shipboard display and control facilities, a precise navigation subsystem, an automatic plotting subsystem and a mine neutralization subsystem.

(1) SPECIFIC OBJECTIVE: Determine classification subsystem capability to locate and classify mines.

$$(MOE)_1 = \text{Mine and non-mine detection probability} = \frac{\left(\text{Number of detections of mines and non-mines}\right)}{\left(\text{Number of detection opportunities}\right)}$$

$$(MOE)_2 = \text{Mine detection probability} = \frac{\text{Number of mine detections}}{\left(\text{Number of detection opportunities for mines}\right)}$$

$$(MOE)_3 = \text{Probability of classifying a mine correctly} = \frac{\text{Number of mines correctly classified}}{\text{Number of mine detections}}$$

$$(MOE)_4 = \text{Probability of classifying a non-mine correctly} = \frac{\left(\text{Number of known non-mines correctly classified}\right)}{\left(\text{Number of opportunities to classify known non-mine targets}\right)}$$

$(MOE)_5$ = Average time to locate and classify mines

(2) SPECIFIC OBJECTIVE: Determine system capability to neutralize and clear minefields.

$(MOE)_1$ = Average diving time per mine for neutralization

$(MOE)_2$ = Average time to locate, classify and neutralize mines in a minefield of specified size

$(MOE)_3$ = Clearance rate, i.e., area neutralized per hour

$$(MOE)_4 = \text{Percent mines neutralized} = \frac{\text{Number of mines neutralized}}{\text{Number of mines in field}} \times 100$$

REFERENCE: Final Report on Project F/096 FY62
"Fleet Operational Investigation of Mine Defense System S-101 (SHADOWGRAPH)"
4 Jan. 1963, SECRET

EDC8 - Degaussing System

DESCRIPTION: Miniaturized degaussing system for use in submarines.

(1) SPECIFIC OBJECTIVE: Determine reduction in the magnetic field/ signature of submarines using a degaussing system.

$(MOE)_1$ = Percent reduction in average MAD detection range

$(MOE)_2$ = Percent reduction in average magnetic mine actuation distance

REFERENCE: Final Report on Project C/S11 FY 61
"Concurrent Evaluation of a Miniaturized Degaussing System for Use in Submarines"
14 Aug. 1962, CONF.

EDC9 - Automatic Permanent Magnetic Compensator (APMC)

DESCRIPTION: This equipment is designed for use in aircraft equipped with inboard MAD equipment and to enable automatic permanent magnetic field compensation by semiautomatically adjusting and then maintaining the current in the compensating coil assembly.

(1) SPECIFIC OBJECTIVE: Determine the capability to provide improved permanent magnetic compensation.

$(MOE)_1$ = Figure-of-merit (FOM), which is the sum, disregarding polarity, of the maneuver averaged noise signals, in gammas, generated during a MAD noise box (i.e., the procedure for determining MAD maneuver signal noise levels).

(NOTE: FOM is an indication of the overall degree of compensation.)

$(MOE)_2$ = Average slant detection range

$(MOE)_3$ = Average time required to perform a complete APMC compensation of the permanent magnetic field of the aircraft

REFERENCE: Final Report on Project F/0151 FY64
"Fleet Operational Investigation of Automatic Permanent Magnetic Field Compensator"
2 June 1964, CONF.

EDC10 - MAD Device

DESCRIPTION: This equipment is essentially a highly sensitive airborne magnetometer designed to detect the magnetic field of a submerged submarine from low flying aircraft.

(1) SPECIFIC OBJECTIVE: Evaluate detection capability against submarines.

$(MOE)_1$ = Average slant range of detection

$(MOE)_2$ = Sweep width

$(MOE)_3$ = Probability of detection of a submarine penetrating a standard trapping circle as a function of submarine speed and vertical separation between aircraft and submarine

$$= \frac{\text{Number of detections}}{\text{Number of detection attempts}}$$

ASSUMPTIONS:

(1) When an aircraft attempts magnetic detection of a submarine, the distance between the aircraft and the submarine at the point of closest approach is regarded as the slant range.

(2) Average detection range is the maximum range at which, on the average, detection can be obtained under a given set of conditions.

(3) Average slant range of detection is the mean of the average detection ranges for all angles of elevation and azimuth of the aircraft from the submarine.

(4) MAD sweep width is a function of two primary factors, namely, the average detection range of the MAD installation and the vertical separation between the submarine and aircraft.

REFERENCE: Final Report on Project OP/V126/J15-6
"Evaluation of the AN/ASQ-8 Magnetic Airborne Detection Set"
16 June 1955, UNCL.

EDC11 - Electronic Warfare System

DESCRIPTION: This is a shipboard system which performs the functions of electromagnetic signal intercept, analysis, identification, display, ECM, and ship command and control system interfacing.

(1) SPECIFIC OBJECTIVE: Determine surveillance capability against airborne radars for given receiver/antenna combination.

MOE = average maximum intercept range as a function of relative bearing

(2) SPECIFIC OBJECTIVE: Determine range performance in ECM modes.

$(MOE)_1$ = Mean DECM (defensive electronic countermeasures) burnthrough range

$(MOE)_2$ = Mean noise jamming burnthrough range

(3) SPECIFIC OBJECTIVE: Determine reaction time capability in ECM modes.

$(MOE)_1$ = Mean DECM reaction time for given mode of operation

$(MOE)_2$ = Mean noise jamming reaction time

ASSUMPTIONS:

(1) DECM modes of operation are either automatic or machine-assist.

(2) DECM reaction time is defined as the elapsed time from detection of the threat emitter to radiation against the threat emiter. Detection time was taken to be the time when emitter activity was reported to the computer by the Activity Indicator Module (AIM).

(4) SPECIFIC OBJECTIVE: Evaluate the capability of the system to analyze and identify signals.

$(MOE)_1$ = Percent correctly identified EMCON violators

$$= \frac{\left(\text{Number of EMCON violators correctly identified}\right)}{\left(\text{Number of Unique Friendly identifications}\right)} \times 100$$

$(MOE)_2$ = Percent correctly identified EMCON non-violators

$$= \frac{\left(\text{Number of EMCON non-violators correctly identified}\right)}{\left(\text{Number of Unique Friendly identifications}\right)} \times 100$$

$(MOE)_3$ = Percent signals identified that were unique identifications

$$= \frac{\left(\text{Number of unique signal identifications}\right)}{\left(\text{Number of signals identified}\right)} \times 100$$

$(MOE)_4$ = Percent signals identified that were ambiguous identifications

$$= \frac{\text{Number of ambiguous signal identifications}}{\text{Number of signals identified}} \times 100$$

$(MOE)_5$ = Percent emitters identified that were unique identifications

$$= \frac{\left(\text{Number of unique emitter identifications}\right)}{\left(\text{Number of emitters identified}\right)} \times 100$$

$(MOE)_6$ = Percent emitters identified that were ambiguous identifications

$$= \frac{\left(\text{Number of ambiguous emitter identifications}\right)}{\left(\text{Number of emitters identified}\right)} \times 100$$

$(MOE)_7$ = Percent of time PRF (pulse repetition frequency) was present in unique identifications

$$= \frac{\text{Number of times PRF was present}}{\text{Number of unique identifications}} \times 100$$

$(MOE)_8$ = Percent of time PW (pulse width) was present in unique identifications

$$= \frac{\text{Number of times PW was present}}{\text{Number of unique identifications}} \times 100$$

$(MOE)_9$ = Percent of time frequency was present in unique identifications

$$= \frac{\left(\text{Number of times frequency was present}\right)}{\text{Number of unique identifications}} \times 100$$

$(MOE)_{10}$ = Percent of time scan information was present in unique identifications

$$= \frac{\left(\text{Number of times scan information was present}\right)}{\text{Number of unique identifications}} \times 100$$

ASSUMPTIONS:

(1) Unique identifications include Unique Hostile and Unique Friendly.

(2) Ambiguous identifications include Ambiguous, Multiple Friendly, and Multiple Hostile, all of which require operator resolution of the ambiquity.

(3) Unknown identifications are generic identifications for which there is no specific match in the emitter library.

REFERENCE: Final Report on Project 0/S163
"Conduct an Operational Evaluation of the AN/SLQ-27 (XN-1) SHORTSTOP System"
12 July 1972, SECRET

EDC12 - ECM Receiving Antenna

DESCRIPTION: This is an antenna assembly which is designed to permit detection, accurate direction finding, and signal analysis when used with passive ECM receivers.

(1) SPECIFIC OBJECTIVE: Determine direction finding accuracy.

$(MOE)_1$ = Mean direction finding (DF) error (deg)

$(MOE)_2$ = Direction finding error probability, which is defined as the probability of DF error within $\pm 1\sigma$ of the mean DF error.

ASSUMPTION: A normal distribution of DF error is assumed for computation of $(MOE)_2$.

(2) SPECIFIC OBJECTIVE: Determine signal detection range capability.

$(MOE)_1$ = Mean detection range

$(MOE)_2$ = Median detection range

REFERENCE: Final Report on Project C/S2 FY60
"Concurrent Evaluation of the Antenna AS-899/SLR"
7 Nov. 1960, CONF.

EDC13 - Shipboard Direction Finding System

DESCRIPTION: This system is designed to provide radio frequency (RF) spectrum surveillance, intercept and direction finding to surface and land-based threat emitters.

(1) SPECIFIC OBJECTIVE: Determine ability to obtain bearing angles of target emitters.

MOE = Mean absolute bearing error (deg), which is defined as the average absolute difference between the system estimated bearing angle and an applicable reference bearing angle (such as fire control radar, visual or plotted)

REFERENCE: Final Report on Project 0/S200
"Conduct an Operational Evaluation of the AN/SRD-19 (XN-1) Direction Finding System"
1974, CONF.

EDC14 - Radio Direction Finder

DESCRIPTION: This equipment is designed to aid nuclear submarines in performing direction finding on enemy radio signals, surveillance and threat assessment.

(1) SPECIFIC OBJECTIVE: Determine signal intercept capability.

MOE = Number of tactically significant signals intercepted per hour of antenna exposure

REFERENCE: Final Report on Project 0/S150
"Conduct an Operational Evaluation of the AN/BRD-7"
26 June 1970, SECRET

EDC15 - Radio Frequency Oscillator (RFO)

DESCRIPTION: The RFO is designed to provide an additional protection for ships by denying accurate range information required for radar directed bombing and missile attacks. This is a subsystem to a radar blip enhancer and deception repeater countermeasures system used against pulsed radars.

(1) SPECIFIC OBJECTIVE: Determine the effective ranges and trackbreak capability of the countermeasures system against attacking track radar systems.

$(MOE)_1$ = Average maximum lock-on range for given trackbreak mode

$(MOE)_2$ = Average maximum trackbreak range for given trackbreak mode

$(MOE)_3$ = Average crossover range (i.e., minimum effective range) for given trackbreak mode

$(MOE)_4$ = Average number of trackbreaks per radar run for given trackbreak mode

$$= \frac{\text{Number of trackbreaks}}{\text{Number of radar runs}}$$

REFERENCE: Final Report on Project C/S43
"Conduct a Concurrent Evaluation of the Radio Frequency Oscillator O-1331 (XN-1)/ULQ-6"
28 Nov. 1966, SECRET

EDC16 - Deception Repeater

DESCRIPTION: This countermeasures set is a device having potential electronic warfare application against enemy search and tracking radars. It is intended to present either a false radar target or cause the enemy radar to "break-track" or do both. Using it as a target decoy device, a small ship can present a blip comparable to that of a capital ship on the scope of an enemy radar. Using it as a track-break (jammer) device to introduce false scan modulation, a ship can divert the beam of an enemy's conical scan missile control or tracking radar and thereby disrupt his weapon control solution.

(1) SPECIFIC OBJECTIVE: Determine effective range capability in various modes of operation.

$(MOE)_1$ = Average triggering range of deception repeater by airborne radar

$(MOE)_2$ = Average maximum effective range in target decoy mode

$(MOE)_3$ = Average minimum effective range in target decoy mode

$(MOE)_4$ = Average maximum effective range in track-break mode

$(MOE)_5$ = Average minimum effective range in track-break mode

(2) SPECIFIC OBJECTIVE: Determine authenticity of enhanced radar echoes.

MOE = Probability of discrimination between decoy and true target as a function of range

$$= \frac{\left(\text{Number of times discrimination occurred between decoy and true target within a given range band}\right)}{\left(\text{Number of decoy and target opportunities within a given range band}\right)}$$

(3) SPECIFIC OBJECTIVE: Determine the capability of performing radar deception.

MOE = Probability of successful deception for given mode of operation

$$= \frac{\text{Number of successful deceptions}}{\text{Number of deception attempts}}$$

(4) SPECIFIC OBJECTIVE: Determine the capability to blank signals from friendly radars.

MOE = Probability of successful blanking

$$= \frac{\text{Number of times radar signals were blanked}}{\text{Number of blanking opportunities}}$$

REFERENCES: (1) Final Report on Project C/S70
"Evaluate the AN/SLQ-17(V) Countermeasures Set"
29 July 1971, SECRET

(2) Final Report on Project 6/S10 FY61
"Concurrent Evaluation of Deception Repeaters"
10 March 1961, CONF.

EDC17 - Aircraft Radar/Missile Homing and Warning Receiver

DESCRIPTION: This system provides aural and visual indications of the presence and bearing of threat associated radars, as well as aural and visual warnings of surface-to-air missile threats.

(1) SPECIFIC OBJECTIVE: Provide correct warning indications when operated in a multiple threat environment against both surface-to-air and air-to-air radars.

MOE = Probability of correct warning indication

$$= \frac{\text{Number of correct indications}}{\text{Number of signals actually emitted}}$$

(2) SPECIFIC OBJECTIVE: Provide missile warning during the ingress, attack and egress segments of representative strike missions.

MOE = Percentage of time missile warning was provided

$$= \frac{\text{Total time warning observed}}{\text{Total test time}}$$

REFERENCE: Twenty-sixth Partial Report on Project F/0210
"Evaluation of the Charger Blue Equipment Installed in F-4 Aircraft"
9 April 1973, SECRET

EDC18 - Radio Frequency Amplifier

DESCRIPTION: This unit is designed to increase the power output of a countermeasures set which functions as a radar decoy (blip enhancer) and deception repeater against pulsed radars.

(1) SPECIFIC OBJECTIVE: Determine ability of the system (countermeasures set) to counter tracking radars for each mode of operation.

$(MOE)_1$ = Average time to lock-on

$(MOE)_2$ = Average time to breaklock

$(MOE)_3$ = Burnthrough range, which is defined as the range at which the reflected energy is theoretically just equal to the countermeasures set signal

$(MOE)_4$ = Average number of breaks per run

$(MOE)_5$ = Average crossover range, which is defined as the minimum effective range

ASSUMPTION: Burnthrough range is estimated as the range where the last lock-on occurred.

REFERENCE: Final Report on Project C/S52
"Conduct a Concurrent Evaluation of Amplifier R.F., AM-4530/ULQ-6A"
1 May 1968, SECRET

EDC19 - Decoy Repeater Buoy

DESCRIPTION: This is a buoy mounted version of a countermeasures set whose purpose is to create aircraft carrier size radar returns to deceive surface search radars.

(1) SPECIFIC OBJECTIVE: Evaluate deception capability.

$(MOE)_1$ = Average maximum range at which an airborne radar could receive its own signal returned by the buoy for given aircraft altitude

$(MOE)_2$ = Average minimum range at which the radar operators were not able to discriminate between a large ship target and the buoy

REFERENCE: Final Report On Project F/O 145 FY63
"Fleet Operational Evaluation of Decoy Repeater Buoy, AN/ULQ-5"
10 July 1963, CONF.

EDC20 - Noise Jammer

DESCRIPTION: This equipment is utilized on strike aircraft and is designed to jam both the elevation and azimuth tracking channels of a surface-to-air missile tracking radar.

(1) SPECIFIC OBJECTIVE: Evaluate the capability of the noise jammer to provide protection for a strike aircraft.

MOE = Percentage of missile miss distances within a given range (the lethal radius) of the aircraft

$= f(X_1, X_2, X_3)$

where

X_1 = jam-to-signal ratio as a function of distance from the radar

X_2 = tracking error in elevation as a function of jam-to-signal ratio

X_3 = tracking error in azimuth as a function of jam-to-signal ratio

ASSUMPTION: Effectiveness is defined as follows:

(a) Good - A MOE value of 20% or less

(b) Fair - A MOE value between 20% to 40%

(c) Poor - A MOE value greater than 40%

DATA REQUIREMENTS SUMMARY:

DATA ITEM	ATTACK EXERCISE	LABORATORY SIMULATION
X_1, X_2, X_3	X	
$f(X_1, X_2, X_3)$		X

REFERENCE: Twentieth Partial Report on Project F/0210 "Develop Aircraft Tactics Against Surface-to-Air Weapons Sites, Evaluation of the ALT-27 in the EKA-3B Aircraft" 31 May 1972, SECRET

TABLE B-2 Operational Test & Evaluation MOE Data Base (Continued)

Area: Fire Control (FC)

CODE	ITEM
FC1	Aircraft Navigation/Weapon Delivery System
FC2	Shipboard Gun Fire Control System (Mk 87, Mk 86 Mod 0)
FC3	Underwater Fire Control System (Mk 114)
FC4	Missile Fire Control System
FC4-1	Shipboard Missile Fire Control Radar (AN/SPG-51B)
FC4-2	Airborne Missile Fire Control Radar (F-4 AMCS Aero 1A, F-8 AWG-4)
FC4-3	Shipboard Missile Fire Control System

FIRE CONTROL (FC)

FC1 - Aircraft Navigation/Weapon Delivery System

DESCRIPTION: This is an aircraft bombing system capable of delivering sticks of bombs.

(1) SPECIFIC OBJECTIVE: Determine closest bomb and stick centroid miss distances for given stick size and release interval.

$(MOE)_1$ = Range error probable (REP), which is defined as the median of the absolute values of the range error measured from a reference point (namely, the intended target)

$(MOE)_2$ = Deflection error probable (DEP), which is defined as the median of the absolute values of the deflection error measured from a reference point (namely, the intended target)

$(MOE)_3$ = Circular error probable (CEP), which is defined as the median miss distance from the target

HIGHER LEVEL EVALUATION:

MOE = Probability of target kill for given stick size and release interval

$$= \begin{cases} f_1\ (MAE,\ X_1,\ldots,X_5) & \text{for soft targets} \\ f_2\ (EMD,\ X_1,\ldots,X_5) & \text{for hard targets} \\ f_3\ (BEI,\ X_1,\ldots,X_5) & \text{for bridge targets} \end{cases}$$

where

MAE = mean area of effectiveness, which depends on target type, bomb type, damage (or kill) criterion and bomb impact angle

EMD = effective miss distance, which depends on target type, bomb type and damage (or kill) criterion

BEI = bridge effectiveness index, which depends on bridge type, bomb type and fuzing type

X_1 = number of bombs per stick

X_2 = ratio of the minor axis length of the elliptical fragmentation pattern per bomb to the major axis length of the elliptical fragmentation pattern per bomb

X_3 = stick length

X_4 = stick width

X_5 = CEP of stick centroid (i.e., $(MOE)_3$)

(NOTE: The indices MAE, EMD and BEI are given in the Joint Munitions Effectiveness Manual (JMEM) and the formulas for the MOE, as determined by the functions f_1, f_2 and f_3, are given by target type in the JMEM.)

LOWER LEVEL EVALUATION:

For the case of stick centroid accuracy,

$(MOE)_1$ = stick centroid total range error

$$= \left[\begin{pmatrix}\text{REP due to}\\ \text{system/aiming error}\end{pmatrix}^2 + \begin{pmatrix}\text{REP due to stick}\\ \text{centroid ballistic}\\ \text{dispersion}\end{pmatrix}^2\right]^{1/2}$$

$$= \left[\begin{pmatrix}\text{REP due to}\\ \text{system/aiming error}\end{pmatrix}^2 + \frac{\begin{pmatrix}\text{REP due to individual}\\ \text{bomb ballistic}\\ \text{dispersion}\end{pmatrix}^2}{\begin{pmatrix}\text{Number of bombs in}\\ \text{stick}\end{pmatrix}}\right]^{1/2}$$

$(MOE)_2$ = stick centroid total deflection error

$$= \left[\begin{pmatrix}\text{DEP due to}\\ \text{system/aiming error}\end{pmatrix}^2 + \begin{pmatrix}\text{DEP due to stick}\\ \text{centroid ballistic}\\ \text{dispersion}\end{pmatrix}^2\right]^{1/2}$$

$$= \left[\begin{pmatrix}\text{DEP due to}\\ \text{system/aiming error}\end{pmatrix}^2 + \frac{\begin{pmatrix}\text{DEP due to individual}\\ \text{bomb ballistic dis-}\\ \text{persion}\end{pmatrix}^2}{\begin{pmatrix}\text{Number of bombs in}\\ \text{stick}\end{pmatrix}}\right]^{1/2}$$

$(MOE)_3$ = stick centroid total circular error

$$= \left[\begin{pmatrix} \text{CEP due to} \\ \text{system/aiming error} \end{pmatrix}^2 + \begin{pmatrix} \text{CEP due to stick} \\ \text{centroid ballistic} \\ \text{dispersion} \end{pmatrix}^2 \right]^{1/2}$$

$$= \left[\begin{pmatrix} \text{CEP due to} \\ \text{system/aiming error} \end{pmatrix}^2 + \frac{\begin{pmatrix} \text{CEP due to individual} \\ \text{bomb ballistic dis-} \\ \text{persion} \end{pmatrix}^2}{\begin{pmatrix} \text{Number of bombs in} \\ \text{stick} \end{pmatrix}} \right]^{1/2}$$

ASSUMPTIONS:

(1) Stick centroid is defined as the mean point of impact of the bombs in the stick.

(2) Closest bomb in the stick is defined as that bomb impact in the stick having the shortest radial miss distance from the target.

(3) For the higher level evaluation, bomb range and deflection errors are assumed to be each approximately normally distributed.

(4) For the lower level evaluation, the formulations are valid for a salvo (instantaneous) release from the centerline of the aircraft.

REFERENCE: Final Report on Project O/V28E08
"A-7E Computer Accuracy (MRI Evaluation)"
6 June 1973, CONF.

FC2 - Shipboard Gun Fire Control System

DESCRIPTION: This is an integrated lightweight system which includes the capabilities of continuous air and surface radar search, rapid acquisition of targets, simultaneous track on more than one target, and solutions for gun orders to simultaneously engage separate targets.

(1) SPECIFIC OBJECTIVE: Determine surface target detection and tracking capability.

$(MOE)_1$ = Mean minimum discernible range of a small surface target as a function of pulse width

$(MOE)_2$ = Mean maximum detection range of a destroyer as a function of aspect

$(MOE)_3$ = Mean maximum tracking range of a destroyer as a function of aspect

$(MOE)_4$ = Mean range resolution of two targets while in the SEARCH mode

$(MOE)_5$ = Mean bearing resolution of two targets while in the SEARCH mode

$(MOE)_6$ = Percentage of runs on which track was maintained on a target in proximity to another target while in the TRACK WHILE SCAN mode as a function of ship-to-target range and target speed

(2) SPECIFIC OBJECTIVE: Determine system capability to control gunfire against airborne targets.

$(MOE)_1$ = Initial salvo error in range for given target range band

$(MOE)_2$ = Initial salvo error in deflection for given target range band

(3) SPECIFIC OBJECTIVE: Determine system capability to control gunfire in shore bombardment.

$(MOE)_1$ = Percent target hits

$$= \frac{\text{Number of direct hits}}{\text{Number of rounds fired}} \times 100$$

$(MOE)_2$ = Mean impact error in range for given target range band

$(MOE)_3$ = Mean impact error in deflection for given target range band

$(MOE)_4$ = Initial salvo error in range for given target range band

$(MOE)_5$ = Initial salvo error in deflection for given target range band

(4) SPECIFIC OBJECTIVE: Determine the capability of the system to track surface radar targets in an ECM environment.

MOE = Probability of not breaking track in the presence of jamming

$$= 1 - \frac{\text{Number of times jamming causes trackbreak}}{\text{Number of valid runs}}$$

REFERENCES: (1) Final Report on Project C/S48
"Conduct a Concurrent Evaluation of the Gun Fire Control System Mk 87"
8 April 1970, CONF.

(2) Supplement to Final Report on Project C/S45
"Conduct a Concurrent Evaluation of the Gun Fire Control System Mk 86 Mod 0"
4 April 1967, SECRET

FC3 - Underwater Fire Control System

DESCRIPTION: The system is an antisubmarine computing system, providing for fire control computations, weapon control outputs, and launcher orders. While primarily designed to control ASROC firing, the system also provides fire control data for the control of over-the-side launched torpedo attacks, both fixed and trainable hedge-hog projectors, and provides an aimpoint display suitable for use as an aid in controlling DASH attacks.

(1) SPECIFIC OBJECTIVE: Determine the accuracy of the system's fire control solution.

$(MOE)_1$ = Mean target course error (deg) based on sonar input for given target range band and speed interval

$(MOE)_2$ = Mean target course error (deg) based on radar input for given target range band and speed interval

$(MOE)_3$ = Mean target speed error (kts) based on sonar input for given target range band and speed interval

$(MOE)_4$ = Mean target speed error (kts) based on radar input for given target range band and speed interval

$(MOE)_5$ = Mean computer error (yds), which is defined as the distance between the location of the computer's aimpoint at time of fire and an aimpoint graphically reconstructed using the same target information available to the computer at time of fire

$(MOE)_6$ = Mean sonar location error in range (yds)

$(MOE)_7$ = Mean sonar location error in bearing (deg)

(2) SPECIFIC OBJECTIVE: Determine the accuracy of the system's fire control solution as an aid in controlling DASH.

$(MOE)_1$ = Mean delivery error (yds), based on a comparison of the computed range and bearing to the aimpoint, and the actual radar range and bearing to the helicopter at the launch point

$(MOE)_2$ = Mean computer error (yds), which is defined as the distance between the location of the computer's aimpoint at time of weapon drop and an aimpoint reconstructed graphically using the same target information available to the computer at time of fire.

$(MOE)_3$ = Mean target course error (deg) based on attack console computation

$(MOE)_4$ = Mean target speed error (kts) based on attack console computation

(3) SPECIFIC OBJECTIVE: Determine the accuracy of the system's fire control solution for over-the-side launched torpedo attacks.

$(MOE)_1$ = Mean torpedo launch error (yds), which is defined as the distance between the computed torpedo aimpoint as generated by the attack console and the aimpoint at which the torpedo was actually fired

$(MOE)_2$ = Mean computer error (yds)

$(MOE)_3$ = Mean computed target course error (deg)

$(MOE)_4$ = Mean computed target speed error (kts)

REFERENCE: Final Report on Project C/S24 FY62
"Concurrent Evaluation of the Fire Control System Mk 114"
3 Dec. 1962, CONF.

FC4 - Missile Fire Control System

FC4-1 Shipboard missile fire control radar

DESCRIPTION: This shipboard missile fire control radar is designed to track and illuminate both airborne and surface targets.

(1) SPECIFIC OBJECTIVE: Determine target acquisition and tracking capability.

$(MOE)_1$ = Mean time to initial acquisition for given target altitude

$(MOE)_2$ = Mean target initial acquisition range for given target altitude

$(MOE)_3$ = Acquisition rate (%)

$$= \frac{\text{Number of targets successfully acquired}}{\text{Number of valid acquisition opportunities}} \times 100$$

ASSUMPTIONS:

(1) Acquisition time is assumed to mean the elapsed time between designation of the radar to a designation channel and the subsequent reliable acquisition (track) of the target by the radar.

(2) An acquisition was normally considered reliable if an "on-target" indication was not followed within five seconds by a "not on-target" signal.

(3) Acquisition range is assumed to be the range of the target at the time of reliable acquisition.

REFERENCE: Final Report on Project C/S47
"Conduct a Concurrent Evaluation of the AN/SPG-51B Radar Improved Data Converter"
30 Aug. 1968, SECRET

FC4-2 Airborne missile fire control radar

DESCRIPTION: This fire control radar is part of an airborne missile control system (AMCS) with the capability of performing radar search, target acquisition and target track.

(1) SPECIFIC OBJECTIVE: Determine system acquisition and tracking capability against airborne targets employing countermeasures.

$(MOE)_1$ = Probability of successful track of target in the chaff only environment

$$= \frac{\text{(Number of successfully tracked targets in chaff only environment)}}{\text{(Number of intercept attempts in the chaff only environment)}}$$

$(MOE)_2$ = Probability of lock transfer to chaff in the chaff only environment

$$= \frac{\text{(Number of times lock transfer to chaff occurred in the chaff only environment)}}{\text{(Number of intercept attempts in the chaff only environment)}}$$

$(MOE)_3$ = Probability of successful intercept in the noise jamming only environment

$$= \frac{\text{(Number of successful target intercepts in the noise jamming only environment)}}{\text{(Number of intercept attempts in the noise jamming only environment)}}$$

$(MOE)_4$ = Probability of noise jammer programming preventing target acquisition

$$= \frac{\text{(Number of times noise jammer programming prevented target acquisition)}}{\text{(Number of intercept attempts in the noise jamming only environment)}}$$

$(MOE)_5$ = Probability of successful track of target employing spot or spot sequential noise

$$= \frac{\text{(Number of successfully tracked targets employing spot or spot sequential noise)}}{\text{(Number of intercept attempts in the spot or spot sequential noise environment)}}$$

$(MOE)_6$ = Probability of successfully completed intercept in the deception only environment

$$= \frac{\text{(Number of successfully completed intercepts in the deception only environment)}}{\text{(Number of intercept attempts in the deception only environment)}}$$

$(MOE)_7$ = Probability of successfully completed intercept in the evading target environment

$$= \frac{\begin{pmatrix}\text{Number of successfully completed intercepts} \\ \text{in the evading target environment}\end{pmatrix}}{\begin{pmatrix}\text{Number of intercept attempts in the} \\ \text{evading target environment}\end{pmatrix}}$$

$(MOE)_8$ = Probability of successful intercept in the noise jamming, chaff and evading target environment

$$= \frac{\begin{pmatrix}\text{Number of successful intercepts in the noise} \\ \text{jamming, chaff and evading target environment}\end{pmatrix}}{\begin{pmatrix}\text{Number of intercept attempts in the noise} \\ \text{jamming, chaff and evading target environment}\end{pmatrix}}$$

$(MOE)_9$ = Probability of successful intercept in the chaff and deception environment

$$= \frac{\begin{pmatrix}\text{Number of successful intercepts in the chaff} \\ \text{and deception environment}\end{pmatrix}}{\begin{pmatrix}\text{Number of intercept attempts in the chaff} \\ \text{and deception environment}\end{pmatrix}}$$

$(MOE)_{10}$ = Probability of successful intercept in the chaff, noise, deception and evading target environment

$$= \frac{\begin{pmatrix}\text{Number of successful intercepts in the chaff,} \\ \text{noise, deception and evading target environment}\end{pmatrix}}{\begin{pmatrix}\text{Number of intercept attempts in the chaff,} \\ \text{noise, deception and evading target environment}\end{pmatrix}}$$

$(MOE)_{11}$ = Probability of successful reattack

$$= \frac{\text{Number of successful reattacks}}{\text{Number of reattack attempts}}$$

$(MOE)_{12}$ = Probability that target countermeasures are effective in preventing radar or IR tracks in reattack attempts

$$= \frac{\begin{pmatrix}\text{Number of times target countermeasures are} \\ \text{effective in preventing radar or IR tracks} \\ \text{in reattack attempts}\end{pmatrix}}{\begin{pmatrix}\text{Number of reattack attempts in the presence} \\ \text{of target countermeasures}\end{pmatrix}}$$

$(MOE)_{13}$ = Probability that target evasive maneuvers are effective in preventing successful reattack attempts

$$= \frac{\begin{pmatrix}\text{Number of times target evasive maneuvers} \\ \text{are effective in preventing successful} \\ \text{reattack attempts}\end{pmatrix}}{\begin{pmatrix}\text{Number of reattack attempts in the} \\ \text{presence of target evasive maneuvers}\end{pmatrix}}$$

$(MOE)_{14}$ = Probability that target countermeasures and evasive maneuvers are effective in preventing successful reattack attempts

$$= \frac{\begin{pmatrix}\text{Number of times target countermeasures} \\ \text{and evasive maneuvers are effective in} \\ \text{preventing successful reattack attempts}\end{pmatrix}}{\begin{pmatrix}\text{Number of reattack attempts in the} \\ \text{presence of target countermeasures and} \\ \text{evasive maneuvers}\end{pmatrix}}$$

$(MOE)_{15}$ = Probability of successful intercept in the communications countermeasures only environment

$$= \frac{\begin{pmatrix}\text{Number of successful intercepts in the} \\ \text{communications countermeasures only} \\ \text{environment}\end{pmatrix}}{\begin{pmatrix}\text{Number of intercept attempts in the} \\ \text{communications countermeasures only} \\ \text{environment}\end{pmatrix}}$$

$(MOE)_{16}$ = Probability of successful intercept in the combined communications and weapon system countermeasures environment

$$= \frac{\begin{pmatrix}\text{Number of successful intercepts in the com-} \\ \text{bined communications and weapon system} \\ \text{countermeasures environment}\end{pmatrix}}{\begin{pmatrix}\text{Number of intercept attempts in the combined} \\ \text{communications and weapon system counter-} \\ \text{measures environment}\end{pmatrix}}$$

ASSUMPTIONS:

(1) By "deception" is meant angle or range gate deception.

(2) Intercepts were scored successful if the fighter reached final position within the missile launch envelope, and the weapon system tracked the target, irrespective of tracking mode except boresight, for a specified period prior to simulated missile launch and throughout the predicted time of missile flight.

(3) Reattacks were scored successful only if completed on radar or Air Intercept Controller (AIC) information and radar track could be maintained for a missile launch.

(4) Communications countermeasures are effective if the intelligible reception of the required transmissions is prevented.

REFERENCE: First Partial Report on F/0198
"F-4 AMCS Aero 1A and F-8 AWG-4 in Single and Combined Countermeasures Environments"
27 Oct. 1966, SECRET

FC4-3 Shipboard missile fire control system

DESCRIPTION: This is a shipboard guided missile fire control system (GMFCS) which fires a surface-to-air or surface-to-surface missile.

(1) SPECIFIC OBJECTIVE: Evaluate ability to engage surface launched cruise missile (SLCM) raids.

$(MOE)_1$ = Percent targets engaged

$$= \frac{\text{Number of targets engaged}}{\text{Number of missile targets}} \times 100$$

$(MOE)_2$ = Percent of attacks in which all targets were engaged

$$= \frac{\left(\text{Number of attacks in which all targets were engaged}\right)}{\text{Number of missile raids}} \times 100$$

$(MOE)_3$ = Average total engagement time

$(MOE)_4$ = Minimum total engagement time

$(MOE)_5$ = Maximum total engagement time

ASSUMPTION: Total engagement time is the time from launch of the first SLCM to fire of a shipboard missile at the last SLCM in the raid.

(2) SPECIFIC OBJECTIVE: Evaluate the ability of the system to acquire surface launched cruise missile targets for selected acquisition methods.

$(MOE)_1$ = Average acquisition time

$(MOE)_2$ = Acquisition reliability

$= \frac{\text{Number of missiles acquired}}{\text{Number of missile targets}}$

$(MOE)_3$ = Cumulative percent acquisitons as a function of time

$(MOE)_4$ = Cumulative percent acquisitions for given range band

(3) SPECIFIC OBJECTIVE: Evaluate the ability of the system to launch missiles against surface launched cruise missile targets.

$(MOE)_1$ = Average time from acquisition to initial fire

$(MOE)_2$ = Cumulative percent of firings as a function of time from acquisition to initial fire

$(MOE)_3$ = Firing success rate (%)

$= \frac{\text{Number of intercepts}}{\text{Number of missiles fired}} \times 100$

$(MOE)_4$ = Firing success rate (%) given an opportunity to engage the target

$= \frac{\text{Number of intercepts}}{\left(\text{Number of missiles fired at targets for which an opportunity for engagement existed}\right)} \times 100$

$(MOE)_5$ = Average reaction time from SLCM launch to shipboard missile firing

$(MOE)_6$ = Median reaction time

$(MOE)_7$ = Average refire time

ASSUMPTION: Refire time is the time from fire of a missile with one missile fire control system at the target to fire again with a different missile fire control system.

(4) SPECIFIC OBJECTIVE: Evaluate the ability of the system to acquire surface targets.

$(MOE)_1$ = Mean detection range

$(MOE)_2$ = Mean time to acquire the surface target

$(MOE)_3$ = Cumulative percent acquisitions as a function of time

(5) SPECIFIC OBJECTIVE: Evaluate tracking capability.

$(MOE)_1$ = Average initial acquisition range, which is defined as the slant range from the project ship to the target at the time of initial acquisition

$(MOE)_2$ = Average initial acquisition time, which is defined as the elapsed time from designation to GMFCS lock

$(MOE)_3$ = Average final acquisition range, which is defined as the slant range from the project ship to the target at the time of final acquisition

$(MOE)_4$ = Average final acquisition time, which is defined as the elapsed time from designation to final acquisition

$(MOE)_5$ = Tracking quality, which is defined as the percentage of time, from initial acquisition to end-of-run, during which the GMFCS speedgate was locked-on the target

$(MOE)_6$ = Acquisition success rate

$$= \frac{\text{Number of targets acquired}}{\left(\text{Number of target acquisition opportunities}\right)}$$

ASSUMPTIONS:

(1) In order to be considered a valid acquisition, the GMFCS lock had to be held continuously for at least 10 secs.

(2) Final acquisition occurred when the GMFCS achieved a lock-on which was continuous until the target passed the minimum GMFCS tracking range, or turned out-bound (end-of-run).

REFERENCES: (1) Final Report on Project F/0237 "Conduct a Fleet Operational Investigation of Tartar Weapon System Capability Against Various Threats" 13 Dec. 1968, SECRET

(2) Final Report on Project C/S50 "Conduct a Concurrent Evaluation of the Basic Point Defense Surface Missile System as Installed in a Destroyer Type Ship" 7 Nov. 1968, SECRET

TABLE B-2 Operational Test & Evaluation MOE Data Base (Continued)

Area: Infrared and Optical Detection (IOD)

CODE	ITEM
IOD1	Infrared Wake Detector
IOD2	IR Decoy
IOD3	Marine Location Marker (EX-19, EX-20)

Infrared and Optical Detection (IOD)

IOD1 - Infrared Wake Detector

DESCRIPTION: This infrared equipment is designed to detect surface wakes generated by submarines by presenting to an operator a thermal picture of the sea surface.

(1) SPECIFIC OBJECTIVE: Determine wake detection capability.

$(MOE)_1$ = Average submarine wake persistence time (WPT) as a function of sea state

$(MOE)_2$ = Average detectable wake persistence time (DWPT), which is defined as that portion of the measurable wake which can be detected by semialerted operators using random crossing angle airplane passes.

ASSUMPTION: The DWPT, while not directly known, falls between the time of last detection and the time of no detection. The ratio of the time difference between COMEX and the time over the buoy* on last wake detection by either operator, to the measurable WPT was determined for each submarine run and these ratios averaged to obtain a lower limit. The same procedure was followed using the time difference from COMEX to the time over the buoy with first "no detection" by both operators to obtain the upper limit. These ratios are used to express the limits of DWPT as a percent of WPT. (*NOTE: Flashing light buoy, ejected by the submarine, was used to mark submarine COMEX.)

(2) SPECIFIC OBJECTIVE: Determine operator classification capability.

$(MOE)_1$ = Probability of correct classification as submarine

$$= \frac{\text{Number of correct submarine classifications}}{\left(\text{Number of submarine classification opportunities}\right)}$$

$(MOE)_2$ = Probability of correct classification as non-submarine

$$= \frac{\left(\text{Number of correct non-submarine classifications}\right)}{\left(\text{Number of non-submarine classification opportunities}\right)}$$

REFERENCE: Final Report on Project F/O 143
(Title Classified)
3 Jan. 1966, SECRET

IOD2 - IR Decoy

DESCRIPTION: This is a hand launched flare which is intended to decoy an infrared homing antiship missile away from small combatants.

(1) SPECIFIC OBJECTIVE: Determine the capability of a single flare to cause an IR seeker to break-lock on a destroyer type ship under conditions of various ship IR signatures.

MOE = Probability of seeker break-lock on ship

$$= \frac{\left(\text{Number of times flare caused seeker to break-lock on ship}\right)}{\text{Number of times seeker locked-on ship}}$$

(2) SPECIFIC OBJECTIVE: Determine capability of a single flare to a decoy IR seeker.

$(MOE)_1$ = Mean maximum range the IR seeker attained its initial lock-on the flare

$(MOE)_2$ = Mean maximum range at which the seeker attained a tight lock-on the flare

(3) SPECIFIC OBJECTIVE: Determine capability of an array of flares to decoy IR seeker.

MOE = Probability seeker is attracted to the array of flares

$$= \frac{\left(\text{Number of times seeker was attracted to the array of flares}\right)}{\left(\text{Number of attempts to attract the seeker by an array of flares}\right)}$$

(4) SPECIFIC OBJECTIVE: Determine the capability of an array of flares to cause and maintain break-lock on a destroyer type ship.

MOE = Probability that flare array successfully broke lock and maintained seeker decoy

$$= \frac{\left(\text{Number of times flare array caused seeker to break-lock on ship and not reacquire}\right)}{\left(\text{Number of times seeker initially locked-on ship}\right)}$$

REFERENCE: Final Report on Project 0/S165 (Title Classified) 10 Feb. 1971, SECRET

IOD3 - Marine Location Marker

DESCRIPTION: This is an aircraft launched location marker which is designed to produce continuous clouds of colored smoke for a fixed period of time.

(1) SPECIFIC OBJECTIVE: Evaluate visibility of marker.

$(MOE)_1$ = Minimum visibility range for given sea state
$(MOE)_2$ = Maximum visibility range for given sea state

REFERENCE: Final Report on Project F/O 134 FY63
"Operational Investigation of Marine Location Markers
EX-19 and EX-20"
6 June 1963, UNCL.

TABLE B-2 Operational Test & Evaluation MOE Data Base (Continued)

Area: Missiles (M)

CODE	ITEM
M1	Air-to-Air Missile (AIM-9C)
M2	Air-to-Surface Anti-Radiation Missile (YAGM-45A SHRIKE)
M3	Air-to-Surface Missile (AGM-12B Bullpup)
M4	Surface-to-Air Missile
M4-1	IR Missile (REDEYE)
M4-2	Shipboard Surface-to-Air Missile (STANDARD)
M5	Rocket Propelled Ballistic Missile System (Mk 1 Mod 0 (TERNE III))

MISSILES (M)

M1 - Air-to-Air Missile

DESCRIPTION: This is a supersonic, air-to-air guided missile employing semi-active radar head, torque-balance control, and proportional navigation. The missile functions in two modes, semi-active and passive. In the semi-active mode, the missile homes on the pulsed radar energy emitted by the launching aircraft and reflected off the target into the radar seeker. In the passive mode, the missile homes on the target's radar jammer.

(1) SPECIFIC OBJECTIVE: Determine the kill capability against airborne targets.

MOE = Single shot kill probability

$= R_R \, R_L \, R_G \, R_F \, R_{LE}$

where

R_R = reliability of the launching aircraft radar

R_L = missile launch reliability

$= \dfrac{\text{Number of successful launches}}{\text{Number of valid attempts to fire}}$

R_G = missile guidance reliability

$= \dfrac{\text{Number of guidance successes}}{\text{Number of successful launches}}$

R_F = fuzing reliability

R_{LE} = lethality of the warhead/fuze combination

DATA REQUIREMENTS SUMMARY:

DATA ITEM	FIRING EXERCISES	LABORATORY TESTS, SIMULATIONS, ETC.
R_R, R_L, R_G, R_F	X	
R_{LE}		X

REFERENCE: Third Partial Report on Project C/V1 FY61
"Operational Evaluation of the AIM-9C (Mk 30) Guided Missile"
2 Aug. 1965, CONF.

M2 - Air-to-Surface Anti-Radiation Missile

DESCRIPTION: This is a passive air-to-surface missile designed to home on radar transmitters.

(1) SPECIFIC OBJECTIVE: Determine the capability of the system to indicate to the pilot whether or not a radar target is radiating.

$(MOE)_1$ = Percent of runs on which the pilot was able to determine whether or not the primary radar target was radiating between the initial point (IP) and the pull-up point (PUP)

$(MOE)_2$ = Percent of runs on which the pilot was able to determine that the primary target commenced radiating after the pilot passes IP

$(MOE)_3$ = Percent of runs on which the pilot correctly determined that the pulse repetition rate (PRR) of the primary target was low (i.e., not in the missile firing mode), given that the pilot recognized that the primary target was radiating between IP and PUP

$(MOE)_4$ = Percent of runs on which the pilot correctly determined that the pulse repetition rate (PRR) of the primary target was high (i.e., in the missile firing mode), given that the pilot recognized that the primary target was radiating between IP and PUP

(2) SPECIFIC OBJECTIVE: Determine the capability of the system to indicate to the pilot whether or not he was being tracked by gun fire control radars.

$(MOE)_1$ = Percent of runs on which the pilot was able to determine that a gun fire control radar was tracking the aircraft

$(MOE)_2$ = Percent of runs on which the pilot correctly determined whether the radar was left, right or ahead, given that the pilot recognized that a gun fire control radar was tracking the aircraft.

(3) SPECIFIC OBJECTIVE: Determine kill capability against radar targets.

MOE = Single shot kill probability

$= R_{mf} P_k$

where

R_{mf} = missile flight reliability

$= R_e R_g R_f$

P_k = kill probability against a given target, assuming a reliable missile

R_e = launch reliability

$= \frac{\text{Number of missiles launched}}{\text{Number of launch attempts}}$

R_g = guidance reliability

$= \frac{\left(\text{Number of missiles which satisfactorily guided to target}\right)}{\text{Number of missiles launched}}$

R_f = fuzing reliability

$= \frac{\left(\text{Number of missiles which satisfactorily fuzed}\right)}{\left(\text{Number of missiles which satisfactorily guided to target}\right)}$

DATA REQUIREMENTS SUMMARY:

DATA ITEM	FIRING EXERCISES	LABORATORY TESTS, SIMULATIONS, ETC.
R_e, R_g, R_f	X	
P_k		X

REFERENCE: First Partial Report on C/V9
"Concurrent Evaluation of the SHRIKE Guided Missile System, YAGM-45A"
13 March 1967, SECRET

M3 - Air-to-Surface Missile

DESCRIPTION: This is a supersonic air-to-surface, line of sight (LOS) radio command guided missile. This missile is designed to be used by attack class airplanes against small tactical targets and to permit the attacking airplane to remain beyond the effective small arms envelope.

(1) SPECIFIC OBJECTIVE: Determine performance against surface targets.

$(MOE)_1$ = Maximum effective slant range as a function of launch mode (such as level flight or LOS at given dive angle)

$(MOE)_2$ = Circular Error Probable (CEP) about the aim point in the horizontal plane through the target

$(MOE)_3$ = Circular Error Probable (CEP) about the aim point in the plane normal to the launch LOS.

ASSUMPTION: Miss distance is the distance as measured in the plane perpendicular to the line of sight at time of launch and passing through the target center.

REFERENCE: Final Report on Project F/0186
"Fleet Operational Investigation of AGM-12B (Bullpup) Missile System"
2 Feb. 1966, CONF.

M4 - Surface-to-Air Missile

M4-1 IR missile (REDEYE)

DESCRIPTION: This is a man-transportable, shoulder fired, surface-to-air infrared homing guided missile weapon system used against attacking aircraft, including single engine propeller and jet aircraft.

(1) SPECIFIC OBJECTIVE: Determine tracking capability against air targets in the at-sea environment.

$(MOE)_1$ = Average tracking error (deg)

$(MOE)_2$ = Percent targets successfully engaged

$$= \frac{\text{Number of targets engaged}}{\left(\text{Number of target engagement opportunities}\right)} \times 100$$

$(MOE)_3$ = Percent of raids on which tracking error was greater than the maximum acceptable error

$$= \frac{\left(\text{Number of raids on which tracking error was greater than the maximum acceptable error}\right)}{\text{Number of raids engaged}} \times 100$$

(2) SPECIFIC OBJECTIVE: Determine detection and acquisition capability.

$(MOE)_1$ = Mean (visual) detection range

$(MOE)_2$ = Mean target acquisition range

$(MOE)_3$ = Percent raids visually acquired

$$= \frac{\text{Number of raids acquired}}{\text{Number of acquisition attempts}} \times 100$$

(3) SPECIFIC OBJECTIVE: Determine missile intercept capability.

MOE = Probability of target intercept within a given altitude band

$$= \frac{\text{Number of target intercepts}}{\text{Number of missiles fired}}$$

REFERENCES: (1) Final Report on Project 0/S126 "Conduct an Operational Evaluation of the REDEYE Missile for Use from PTF Craft Against Attacking Aircraft, to Include Single Engine Propeller Aircraft" 21 Sept. 1967, CONF.

(2) Final Report on Project 0/S145
"Conduct an Operational Evaluation of the REDEYE Weapon System"
23 Oct. 1969, CONF.

M4-2 Shipboard surface-to-air missile

DESCRIPTION: This system is designed to enhance the anti-air warfare capability of a surface ship by providing a surface-to-air missile capability.

(1) SPECIFIC OBJECTIVE: Evaluate overall firing capability of the missile against air targets.

MOE = Overall success rate

$$= R_{sl}\ R_{fp}\ R_{mr}\ R_{hr}\ R_{fr}$$

where

R_{sl} = launch phase success rate

$$= \frac{\text{Number of successful launches}}{\text{Number of missile launch attempts}}$$

R_{fp} = GMFCS and personnel success rate

$$= \frac{\text{Number of valid tests}}{\text{Number of flight tests}}$$

R_{mr} = missile reliability

$$= \frac{\text{Number of missiles which do not fail}}{\text{Number of missiles with an opportunity to home}}$$

R_{hr} = homing success rate

$$= \frac{\left(\text{Number of missiles which home to a successful intercept}\right)}{\left(\text{Number of missiles which do not fail}\right)}$$

R_{fr} = fuze reliability

$$= \frac{\left(\text{Number of missiles with successful fuze operation}\right)}{\left(\text{Number of missiles which home to a successful intercept}\right)}$$

ASSUMPTION: A valid test is assumed to be a test in which the specified test environment, test conditions and missile performance were such that the missile system performance against the (simulated) threat coult be evaluated.

(2) SPECIFIC OBJECTIVE: Determine intercept capability against airborne targets.

MOE = Overall success rate, which is defined as the probability that the shipboard system will not fail either before or during missile flight, and that the missile will home to a successful intercept with proper fuze action, or a direct hit is achieved, killing the target

$= P_{mr} F_{sh}$

where

P_{mr} = missile round success rate, which is defined as the probability that a missile will home to a successful intercept with proper fuze action, or a direct hit is achieved killing the target, given that the shipboard system functions properly

$$= \frac{\left(\text{Number of missiles which home to a successful intercept with proper fuze action, or a direct hit, killing the target}\right)}{\text{Number of valid missile firings}}$$

P_{sh} = shipboard system reliability, which is defined as the probability that a shipboard fire control system will properly support the missile firing

$$= \frac{\left(\text{Number of times the shipboard fire control system properly supported the missile firing independent of missile success or failure}\right)}{\left(\text{Number of valid missile firings less undetermined failures}\right)}$$

LOWER LEVEL EVALUATION:

P_{mr} = missile round success rate

$= P_{re} P_{ie}$

where

P_{re} = missile reliability, which is defined as the probability that a missile will home successfully to the vicinity of the intercept region, given that the shipboard system functions properly

$$= \frac{\begin{pmatrix}\text{Number of times missile homed successfully to} \\ \text{the vicinity of the intercept region and ship-} \\ \text{board system functioned properly}\end{pmatrix}}{\begin{pmatrix}\text{Number of missile homing attempts when ship-} \\ \text{board system functioned properly}\end{pmatrix}}$$

P_{ie} = intercept effectiveness, which is defined as the probability that a reliable missile, having homed to the intercept region with proper shipboard system support, will enter region R (a specified maximum distance from the target) and the fuze will function properly, or the missile will hit and destroy the target

$$= \frac{\begin{pmatrix}\text{Number of times the missile miss} \\ \text{distance did not exceed R}\end{pmatrix}}{\begin{pmatrix}\text{Number of times missile homed} \\ \text{successfully to the vicinity of the} \\ \text{intercept region and shipboard system} \\ \text{functioned properly}\end{pmatrix}}$$

(3) SPECIFIC OBJECTIVE: Determine guidance capability.

MOE = Guidance success rate, which is defined as the probability that the missile will properly home to within a maximum miss distance R from the target

$$= \frac{\begin{pmatrix}\text{Number of times missile properly homed} \\ \text{to within a maximum miss distance R} \\ \text{from the target}\end{pmatrix}}{\text{Number of guidance attempts}}$$

REFERENCES: (1) Final Report on Project O/S138
"Conduct an Operational Evaluation of the STANDARD Missile in the TERRIER and TARTAR Weapons Systems"
1 May 1970, SECRET

(2) Final Report on Project C/S50
"Conduct a Concurrent Evaluation of the Basic Point Defense Surface Missile System as Installed in a Destroyer Type Ship"
7 Nov. 1968, SECRET

M5 - Rocket Propelled Ballistic Missile System

DESCRIPTION: The system is designed to deliver a straight line pattern of 6 rocket propelled ballistic missiles normal to the computed target course.

SPECIFIC OBJECTIVE: Determine the hit probability of the system against non-maneuvering targets.

$$\text{MOE} = \text{Hit probability} = \frac{\text{Number of salvo hits}}{\text{Number of salvos fired}}$$

REFERENCE: Final Report on Project C/S23 FY 62
"Concurrent Evaluation of Anti-Submarine Weapon System Mk 1 Mod 0 (TERNE III)"
15 Nov. 1962, CONF.

TABLE B-2 Operational Test & Evaluation MOE Data Base (Continued)

Area: Navigation & Guidance (NG)

CODE	ITEM
NG1	Shipboard Navigation System (OMEGA Receiver)
NG2	TACAN Beacon System (AN/URN-20)
NG3	Submarine Navigation Set (AN/BRN-7 OMEGA Receiver)
NG4	Aircraft Navigation System (AN/APN-126)

NAVIGATION & GUIDANCE (NG)

NG1 - Shipboard Navigation System

DESCRIPTION: The system is a Very Low Frequency (VLF) long range electronic navigation system using phase comparison of CW signals from two shore-based transmitting stations to give a hyperbolic line of position.

(1) SPECIFIC OBJECTIVE: Evaluate geographic navigational position accuracy.

MOE = Average (radial) position error (in yards)

REFERENCE: Final Report on Project C/S21 FY 61
"Concurrent Evaluation of the Omega Navigation System Utilizing the Type II Omega Receiver"
7 Sept. 1962, CONF.

NG2 - TACAN Beacon System

DESCRIPTION: This is a short range air navigation aid intended for ship or shore installation. It transmits signals which provide a properly equipped aircraft with distance and bearing information relative to the installation.

(1) SPECIFIC OBJECTIVE: Evaluate system accuracy performance.

$(MOE)_1$ = Average distance error as percent of range

$(MOE)_2$ = Cumulative distribution of range error as percent of range

$(MOE)_3$ = Percent of bearing errors within maximum acceptable bearing error

REFERENCE: Final Report on Project 0/S155
"Conduct an Operational Evaluation of the AN/URN-20 TACAN Beacon System"
25 Aug. 1970, UNCL.

NG3 - Submarine Navigation Set

DESCRIPTION: This receiver is primarily designed to supply the submarine with instantaneous navigation information when operating in the OMEGA signal environment. Additicnally, it provides a dead reckoning capability when no OMEGA signals are received or during submerged submarine operations.

(1) SPECIFIC OBJECTIVE: Determine navigation accuracy.

$(MOE)_1$ = RMS (root-mean-square) error from actual position

$(MOE)_2$ = RMS error referenced to the time position

$(MOE)_3$ = Mean error bias in latitude referenced to actual position

$(MOE)_4$ = Mean error bias in longitude referenced to actual position

$(MOE)_5$ = Circular error probable (CEP) about the mean bias point referenced to actual position.

(2) SPECIFIC OBJECTIVE: Determine dead reckoning capability.

MOE = Mean DR (dead reckoning) radial error (nm)

REFERENCE: Final Report on Project O/S170
"Operational Evaluation of the AN/BRN-7 OMEGA Receiver in Submarines"
2 June 1972, UNCL.

NG4 - Aircraft Navigation System

DESCRIPTION: This is a continuous wave doppler radar navigation system designed to provide continuous readouts of track, ground speed, drift angle, latitude, longitude and true bearing and great circle distance to a selected target and destination.

(1) SPECIFIC OBJECTIVE: Evaluate system accuracy performance.

$(MOE)_1$ = Mean navigation error in range (% distance traveled)
$(MOE)_2$ = Mean cross-track error

ASSUMPTIONS:

(1) Range error is the component of total error which is parallel to the ground track between the target and base.
(2) Errors in navigation are determined by recording the computed latitude and longitude when over the target and comparing them to actual latitude and longitude.

REFERENCE: First Partial Report on Project OP/V261/H
"Evaluation of the Automatic Navigator AN/APN-126"
10 May 1960, UNCL.

TABLE B-2 Operational Test & Evaluation MOE Data Base (Continued)

Area: Ordnance (O)

CODE	ITEM
01	Bomb Cluster Weapon (CBU-59/B APAM, Mk 15 Mod 0 SADEYE)
02	Television Guided Bomb (Walleye Mk 1 Mod 0, Walleye II Mk 5)
03	Laser Guided Bomb (A-6A/RABFAC/Paveway)
04	Aircraft Gun Pod (Mk 4 Mod 0, GPU-2/A)
05	Rocket (ZAP)
06	Rocket Assisted Depth Bomb (SUBROC)
07	Mine Hunting and Surveillance System (SEANETTLE)
08	Torpedo
08-1	Wire-guided torpedo (Mk 48 Mod 1)
08-2	Rocket Assisted Torpedo (ASROC)
08-3	Active/Passive Torpedo (Mk 46 Mod 1)
09	Magnetic Influence Bottom Mine (Destructor Mk 30 Mod 0)

ORDNANCE (O)

01 - Bomb Cluster Weapon

DESCRIPTION: This is a cluster weapon designed for use against personnel and materiel targets including trucks, light and medium tanks, aircraft, and surface warships.

(1) SPECIFIC OBJECTIVE: Determine weapon delivery accuracy.

MOE = Circular error probable (CEP) as a function of dive angle and delivery mode

ASSUMPTION: A circular normal distribution of impact points is assumed.

(2) SPECIFIC OBJECTIVE: Determine bomblet pattern.

MOE = Percentage of bomblets within the effective pattern

$$= \frac{\left(\text{Number of bomblets falling within the effective pattern}\right)}{\text{Number of bomblets in weapon}} \times 100$$

ASSUMPTION: Due to the inability during testing to locate all (inert) bomblets on the ground following any drop, two estimates of this percentage can be made. The first, or low estimate, pessimistically assumes that all unobserved inert bomblets fell outside the effective pattern; hence the number of observed bomblets falling within the effective pattern is divided by the total number of bomblets. A second more optimistic estimate assumes that the numbers of unobserved bomblets falling within and outside the effective pattern are proportional to the observed numbers of bomblets falling within and outside the pattern; it is further assumed that the same constant of proportionality holds for both cases. The estimate of the percentage is then obtained by dividing the number of observed bomblets within the pattern by the total number of observed bomblets. These two estimates provide low and high estimates, respectively, of the true value of the percentage.

(3) SPECIFIC OBJECTIVE: Evaluate kill capability against surface targets.

$(MOE)_1$ = Mean fractional coverage

$$= \frac{\text{Pattern lethal area}}{\text{Total pattern area}}$$

$(MOE)_2$ = Probability of target kill

$= f(X_1, \ldots, X_5)$

where

X_1 = circular error probable of weapon burst point

X_2 = number of bomblets released

X_3 = target size

X_4 = bomblet lethal radius

X_5 = pattern size

(NOTE: $(MOE)_2$ is determined via a computer program developed by the Naval Weapons Center.)

ASSUMPTION: Pattern lethal area is the sum of the individual bomblet lethal areas, counting overlapping portions only once.

REFERENCES: (1) Final Report on Project 0/V98
"CBU-59/B APAM Bomb Cluster Weapon System"
26 Sept. 1973, CONF.

(2) Final Report on Project 0/V28, Section A, Task 6
"Mk 15 Mod 0 SADEYE Weapon System"
26 March 1968, SECRET

02 - Television Guided Bomb

DESCRIPTION: This is a television guided glide bomb which uses automatic video tracking for homing and guidance against visually acquired surface targets.

(1) SPECIFIC OBJECTIVE: Evaluate bomb delivery accuracy performance.

$$(MOE)_1 = \text{Hit probability} = \frac{\text{Number of target hits}}{\text{Number of bombs dropped}}$$

$(MOE)_2$ = Average miss distance

$(MOE)_3$ = Median miss distance

(2) SPECIFIC OBJECTIVE: Evaluate target acquisition capability.

$(MOE)_1$ = Average lock-on range

$(MOE)_2$ = Minimum lock-on range

$(MOE)_3$ = Maximum lock-on range

REFERENCES: (1) Final Report on CNO Project 0/V52
"Walleye, Mk 1 Mod 0"
26 March 1968, SECRET

(2) Final Report on Project F/0263
"Conduct a Fleet Operational Evaluation of the Guided Weapon Mk 5 (Walleye II)"
14 Dec. 1972, CONF.

03 - Laser Guided Bomb

DESCRIPTION: This is an aircraft delivered bomb which acquires reflected laser energy from an illuminated target.

(1) SPECIFIC OBJECTIVE: Evaluate target acquisition capability.

MOE = Average normalized acquisition range

ASSUMPTION: Normalized range, R_n, in meters is computed from the equation

$$\frac{R_n^2}{R^2} = \frac{E_n}{E}$$

where

R = range (in meters) from target to seeker

E = laser energy (millijoules)

E_n = normalized laser energy (millijoules)

(2) SPECIFIC OBJECTIVE: Evaluate weapon delivery accuracy.

$(MOE)_1$ = Circular error probable (CEP)

$(MOE)_2$ = Probability of weapon release within envelope as a function of CEP for given ceiling height and release conditions

REFERENCE: Final Report on Project F/0257
"Conduct of a Fleet Operational Investigation of the A-6A/RABFAC/Paveway Concept"
5 April 1972, CONF.

04 - Aircraft gun pod

DESCRIPTION: This is a self-contained gun pod for use on aircraft.

(1) SPECIFIC OBJECTIVE: Evaluate firing capability against airborne targets.

$(MOE)_1$ = Percent sorties on which hits occur

$$= \frac{\left(\text{Number of sorties on which hits occur}\right)}{\text{Number of sorties}} \times 100$$

$(MOE)_2$ = Probability of 100% gun pod fireout

$$= \frac{\text{Number of round fired}}{\text{Number of rounds attempted}}$$

(2) SPECIFIC OBJECTIVE: Evaluate delivery accuracy of system.

$(MOE)_1$ = Circular error probable about the target

$(MOE)_2$ = Circular error probable about the mean point of impact

$(MOE)_3$ = Mean point of impact range

$(MOE)_4$ = Mean point of impact deflection

REFERENCES: (1) Final Report on Project 0/V37 "Operational Evaluation of the Gun Pod, Mk 4 Mod 0 (F-4 Air-to-Air Phase)" 17 March 1969, CONF.

(2) First Partial Report on Project 0/V95, Phase I "Conduct an Operational Evaluation of the 20mm GPU-2/A Lightweight Gun Pod" 12 June 1973, CONF.

05 - Rocket

DESCRIPTION: This is a hypervelocity, air-launched, free rocket employing a flechette warhead activated by a radar altimeter fuze.

(1) SPECIFIC OBJECTIVE: Evaluate kill capability against flak sites and other light or medium material targets.

$(MOE)_1$ = Probability of suppression of an enemy flak site
$(MOE)_2$ = Probability of kill against light or medium material targets

(NOTE: These MOE's were computed using simulation models developed by the Naval Weapons Center.)

REFERENCE: First Partial Report on Project 0/V86
"Conduct an Operational Evaluation of the ZAP (Zero Anti-aircraft Potential) Rocket"
24 April 1970, SECRET

06 - Rocket Assisted Depth Bomb

DESCRIPTION: This is a rocket assisted depth bomb fired from a submarine at a submarine target.

(1) SPECIFIC OBJECTIVE: Determine the capability to deliver the warhead within "lethal" radius of a submarine target.

$(MOE)_1$ = Probability of seaworthy impairment for given impairment radius as a function of burst depth, type of target and target depth

$$= 1 - \left(\frac{1}{2}\right)^{\left(\text{Seaworthy impairment radius} / \text{CEP of attack error}\right)^2}$$

$(MOE)_2$ = Probability of mobility impairment for given impairment radius as a function of burst depth, type of target and target depth

$$= 1 - \left(\frac{1}{2}\right)^{\left(\text{Mobility impairment radius} / \text{CEP of attack error}\right)^2}$$

$(MOE)_3$ = Probability of weapon delivery impairment for given impairment radius as a function of burst depth, type of target and target depth

$$= 1 - \left(\frac{1}{2}\right)^{\left(\text{Weapon delivery impairment radius} / \text{CEP of attack error}\right)^2}$$

LOWER LEVEL EVALUATION:

CEP of attack error = median attack error, which is the difference between actual point of detonation and actual target position at time of detonation

$= f(X_1, \ldots, X_5)$

where

X_1 = missile delivery error, which is defined as the difference between the actual point of detonation and the computed aimpoint (i.e., the detonation point)

X_2 = aimpoint error, which is the difference between the correct aimpoint for the existing solution and the aimpoint set into the missile

X_3 = prediction error, which is the error in computing the correct aimpoint resulting from an incorrect target course and speed solution

X_4 = location error, which is the difference between the position of the target at time-of-fire (TOF) by fire control solution and the actual target position at TOF

X_5 = maneuver error, which is the error resulting from the target not making good its actual TOF course and speed

ASSUMPTIONS:

(1) Probability of seaworthy impairment is a measure of damage which a submarine's hull can withstand and still allow the submarine to remain afloat. The level of seaworthy impairment is that damage to the hull sufficient to cause the submarine to be in danger of settling to the bottom. Seaworthy impairment radius refers to the range from the target at which a detonation will produce this level of damage.

(2) Probability of mobility impairment is a measure of the damage to a submarine's ability to maneuver. The level of mobility impairment is that damage sufficient to cause the submarine to lose steerage in a desired direction. Mobility impairment radius refers to the range from the target at which a detonation will produce this level of damage.

(3) Probability of weapon delivery impairment is a measure of the damage to a submarine's fire control, sonar, or launch equipment such that the capability to successfully and accurately launch its store of weapons is curtailed or reduced. The level of weapon delivery impairment is that damage sufficient to cause a low probability of weapon launching and a corresponding lower probability of successful detonation in the target area. Weapon delivery impairment radius refers to the range from the target at which a detonation will produce this level of damage.

(4) Attack error is the vectorial sum of the missile delivery error, aimpoint error, prediction error, location error and maneuver error.

(5) The distribution of attack error is circular normal.

DATA REQUIREMENTS SUMMARY:

DATA ITEM	ATTACK EXERCISES	WEAPON TESTS, LABORATORY TESTS, ETC.
Attack error	X	
Seaworthy impairment radius		X
Mobility impairment radius		X
Weapon delivery impairment radius		X

REFERENCE: Final Report on Project C/S17
"Concurrent Evaluation of the SUBROC Weapon System"
21 Jan. 1966, SECRET

07 - Mine Hunting and Surveillance System

DESCRIPTION: A torpedo shaped, wire guided, self-propelled underwater vehicle designed to neutralize bottom mines through the detonation of a self-contained warhead is used in conjunction with a mine hunting sonar for mine neutralization without the use of underwater swimmers.

(1) SPECIFIC OBJECTIVE: Determine mine hunting and clearance performance.

$(MOE)_1$ = Probability of mine neutralization given correct classification

$$= \frac{\left(\text{Number of correctly classified mines neutralized}\right)}{\text{Number of mines correctly classified}}$$

$(MOE)_2$ = Probability of mine correct classification given detection

$$= \frac{\left(\text{Number of detected mines correctly classified}\right)}{\text{Number of mine detections}}$$

$(MOE)_3$ = Percent of total mines in field successfully neutralized

$$= \frac{\text{Number of mines neutralized}}{\text{Number of mines in field}} \times 100$$

$(MOE)_4$ = Mean range at which the contacts were classified as minelike or non-minelike

$(MOE)_5$ = Mean time expended per non-minelike contact

$(MOE)_6$ = Mean time expended per minelike contact

$(MOE)_7$ = Mean time expended in classifying a contact as minelike

$(MOE)_8$ = Average mine field clearance rate

$$= \frac{\text{Mine field area}}{\text{Total time spent in area}}$$

$(MOE)_9$ = Probability of hit as a function of water depth and sonar range

$$= \frac{\left(\text{Number of hits for given depth interval and sonar range band}\right)}{\text{Number of runs}}$$

(2) SPECIFIC OBJECTIVE: Determine reattack performance.

MOE = Percent of attempted reattacks which were successful

$$= \frac{\text{Number of successful reattacks}}{\text{Number of reattack attempts}} \times 100$$

(3) SPECIFIC OBJECTIVE: Determine warhead detonation performance.

MOE = Percent of attempted warhead detonations which were successful

$$= \frac{\text{Number of successful warhead detonations}}{\text{Number of attempted warhead detonations}} \times 100$$

(4) SPECIFIC OBJECTIVE: Determine vehicle placement accuracy.

MOE = Average radial miss distance between contact and intended impact point

REFERENCE: Final Report on Project 0/S108
"Conduct an Operational Evaluation of Mine Hunting and Surveillance System S2602, SEANETTLE Subsystem"
6 Jan. 1967, CONF.

08 - Torpedo

08-1 Wire-guided torpedo

DESCRIPTION: This is a wire-guided weapon with an active/passive system for use against submarines and surface ships.

(1) SPECIFIC OBJECTIVE: Determine performance against submarine and surface ship targets.

MOE = Probability of mission success (MOMS) for given target type, target depth, target speed, target tactic (evasion or no evasion) and torpedo search speed

$$= P_d \, P_c \, P_s \, P_e \, P_a \, P_v \, P_{ci} \, P_m \, P_x \, P_k$$

where

P_d = probability of detection given a target

$$= \frac{\text{Number of target detections}}{\text{Number of target detection opportunities}}$$

P_c = probability of correctly classifying the target given target detection

$$= \frac{\left(\begin{array}{l}\text{Number of correct classifications}\\ \text{of detected targets}\end{array}\right)}{\text{Number of target detections}}$$

P_s = probability of obtaining a fire control solution given classification and decision to fire

$$= \frac{\left(\begin{array}{l}\text{Number of times a fire control solution}\\ \text{was obtained on a classified target}\end{array}\right)}{\left(\begin{array}{l}\text{Number of attempts to obtain a fire}\\ \text{control solution on a classified target}\\ \text{once the decision was made to fire}\end{array}\right)}$$

P_e = probability of torpedo enable given a decision to fire

$$= \frac{\text{Number of times torpedo enabled}}{\text{Number of torpedo enable attempts}}$$

P_a = probability of torpedo acquisition given torpedo enable

$$= \frac{\text{Number of times torpedo acquired target}}{\left(\begin{array}{l}\text{Number of acquisition attempts for}\\ \text{an enabled torpedo}\end{array}\right)}$$

P_v = probability of torpedo validation given torpedo acquisition

$$= \frac{\text{Number of times torpedo validation occurred}}{\left(\text{Number of torpedo validation attempts when target was acquired}\right)}$$

P_{ci} = probability of reaching close-in attack given torpedo validation

$$= \frac{\text{Number of times close-in attack is reached}}{\left(\text{Number of close-in attack attempts when torpedo validation has occurred}\right)}$$

P_m = probability of reaching exploder actuation range given close-in attack

$$= \frac{\left(\text{Number of times exploder actuation range is reached}\right)}{\left(\text{Number of attempts to reach exploder actuation range in close-in attacks}\right)}$$

P_x = probability of exploder actuation given exploder actuation range is reached

$$= \frac{\text{Number of exploder actuations}}{\left(\text{Number of exploder actuation attempts within exploder actuation range}\right)}$$

P_k = probability of acceptable target damage given exploder actuation

$$= \frac{\left(\text{Number of times acceptable target damage occurred upon exploder actuation}\right)}{\text{Number of exploder actuations}}$$

HIGHER LEVEL EVALUATION:

MOE = (MOMS) x (R)

where

R = torpedo in-water reliability

$$= \frac{\text{Number of torpedoes that ran as programmed}}{\text{Number of torpedoes that are launched}}$$

DATA REQUIREMENTS SUMMARY:

DATA ITEM	ATTACK EXERCISES	WEAPON TESTS, LABORATORY TESTS, COMPUTER SIMULATIONS, ETC.
P_d, P_c, P_s, P_e, P_a, P_v, P_{ci}	X	
P_m, P_x, P_k		X

REFERENCE: Final Report on Project 0/S167
"Torpedo Mk 48 Mod 1 Operational Evaluation"
21 Sept. 1972, SECRET

08-2 Rocket assisted torpedo (ASROC)

DESCRIPTION: This is a rocket assisted torpedo used against submarine targets.

(1) SPECIFIC OBJECTIVE: Determine the capability of the weapon system against submarines.

$(MOE)_1$ = Probability of hit

$$= \frac{\text{Number of hits}}{\text{Number of torpedoes fired}}$$

$(MOE)_2$ = Total attack error (median), which is defined as the distance between the weapon water entry point and the aimpoint based on the target's actual position, course and speed at the time of weapon water entry

LOWER LEVEL EVALUATION:

$$(MOE)_2 = f(X_1,\ldots,X_5)$$

where

X_1 = prediction error, which is defined as the error in aimpoint caused by an incorrect solution for target course and speed at time of fire

X_2 = evasion error, which is defined as the error resulting from evasive maneuvers of the target between time of fire and time of weapon water entry

X_3 = ballistic error, which is defined as the horizontal distance from computed aimpoint to the point of weapon water entry

X_4 = sonar location error, which is defined as the horizontal distance from the actual position of the submarine to the position of the submarine as determined by sonar at the time of fire

X_5 = computer error, which is defined as the difference between the computed aimpoint generated by the computer and the aimpoint determined graphically using the computer's solution for target course and speed

(NOTE: $(MOE)_2$ is the vectorial sum of the prediction, evasion, ballistic, sonar location and computer errors.)

REFERENCE: Second Partial Report on Project C/S4 FY60 "Concurrent Evaluation of the ASROC Weapon System Using the Rocket Thrown Torpedo Mk 2" 29 May 1961, CONF.

<u>08-3</u> Active/passive torpedo

DESCRIPTION: This is a high speed, active/passive homing device capable of detecting and homing on submarines.

(1) SPECIFIC OBJECTIVE: Determine performance and acquisition capability against both submarines and mobile acoustic targets (MOACT).

$(MOE)_1$ = Overall acquisition probability

$$= \frac{\text{Number of runs on which torpedo acquired target}}{\text{Number of runs valid for overall acquisition}}$$

$(MOE)_2$ = Overall attack probability

$$= \frac{\left(\text{Number of runs on which the torpedo attacked the target to hit or to turnaway}\right)}{\text{Number of runs valid for overall attack}}$$

$(MOE)_3$ = Conditional acquisition probability

$$= \frac{\text{Number of runs on which torpedo acquired target}}{\left(\text{Number of runs valid for overall acquisition, excluding those runs which experienced type A malfunctions}\right)}$$

(NOTE: A type A malfunction is a destructive malfunction occurring before an acquisition at a time when acquisition and attack were considered probable. $(MOE)_3$ is a measure of torpedo acquisition performance in the absence of destructive malfunctions.)

$$(MOE)_4 = \text{Conditional attack probability}$$

$$= \frac{\left(\begin{array}{l}\text{Number of runs on which the torpedo}\\ \text{attacked the target to hit or to turnaway}\end{array}\right)}{\left(\begin{array}{l}\text{Number of runs valid for overall attack,}\\ \text{excluding those runs which experienced}\\ \text{type A or B malfunctions and those runs}\\ \text{on which the torpedo did not acquire the}\\ \text{target}\end{array}\right)}$$

(NOTE: A type B malfunction is a destructive malfunction occurring before an attack, but after at least one acquisition, at a time when attack was still considered possible. $(MOE)_4$ is a measure of torpedo attack performance, given prior acquisition, in the absence of destructive malfunctions.)

REFERENCE: Final Report on Project C/C1
"Concurrent Evaluation of the Torpedo Mk 46 Mod 1"
17 Oct. 1966, CONF.

09 - Magnetic Influence Bottom Mine

DESCRIPTION: This is an aircraft-planted, magnetic influence bottom mine intended primarily to interdict indigeneous small craft carrying war material on inland waterways. It can also be dropped on land for use as an anti-vehicle and anti-personnel mine.

(1) SPECIFIC OBJECTIVE: Determine the response of the device to small craft.

$(MOE)_1$ = Probability that the device will actuate when a small-boat target passes directly over

$$= \frac{\left(\text{Number of times device actuated in response to a small-boat target}\right)}{\text{Number of valid runs}}$$

$(MOE)_2$ = Probability that the device will actuate within moderate damage range in response to a boat target

$$= \frac{\left(\text{Number of times device actuated within moderate damage range in response to a boat target}\right)}{\text{Number of valid runs}}$$

$(MOE)_3$ = Probability of actuation versus lateral range for given boat target

(2) SPECIFIC OBJECTIVE: Determine the response of the device to vehicles crossing a bridge.

MOE = Probability that the device will actuate and do at least moderate damage to a vehicle passing over a bridge when planted in a swamp close to the bridge

$$= \frac{\left(\text{Number of times device actuated within moderate damage range in response to a vehicle passing over a bridge}\right)}{\text{Number of valid runs}}$$

(3) SPECIFIC OBJECTIVE: Determine the response of the device to vehicles on land.

MOE = Probability that the device will actuate within moderate damage range in response to a vehicle when planted on land

$$= \frac{\left(\text{Number of times device actuated within moderate damage range in response to a vehicle}\right)}{\text{Number of valid runs}}$$

REFERENCE: Final Report on Project C/V14
"Concurrent Evaluation of the Destructor Mk 30 Mod 0"
12 Feb. 1968, SECRET

TABLE B-2 Operational Test & Evaluation
MOE Data Base (Continued)

Area: Submarines (S)

CODE	ITEM
S1	Submarine
S1-1	(Submarine in Fixed Barrier Mission)
S1-2	(Submarine in Area Search Mission)
S1-3	(Submarine in Surveillance Aided Intercept Mission)

SUBMARINES (S)

S1 - Submarine

S1-1 (Submarine in Fixed Barrier Mission)

DESCRIPTION: The Fixed Barrier Role is one in which an SSK is assigned a patrol area and the responsibility to detect and kill any enemy submarines that may be encountered in the area.

(1) SPECIFIC OBJECTIVE: Detect and kill any enemy submarine encountered.

MOE = SSK versus Transitor effectiveness (STE)

$$= P_D \, P_C \, P_{A1} \, P_{A2} \, P_K$$

where

P_D = probability that the SSK detects a transiting submarine without first being killed, given a detection opportunity

$$= \frac{D}{O} = \frac{\text{Number of detections of a transitor by the SSK}}{\text{Number of valid detection opportunities for the SSK}}$$

P_C = probability that the SSK correctly classifies a transiting submarine without being killed between the time of detection and time of classification, given that the transitor has been detected

$$= \frac{C}{D} = \frac{\left(\text{Number of correct classifications of the transitor by the SSK}\right)}{\left(\text{Number of detections of the transitor by the SSK that are valid opportunities for classification}\right)}$$

P_{A1} = probability that the SSK makes an attack against a transiting submarine without being killed between the time of classification and attack given that the transitor has been correctly classified

$$= \frac{A1}{C} = \frac{\left(\text{Number of attacks made by the SSK against the transitor}\right)}{\left(\text{Number of correct classifications of the transitor by the SSK that are valid approach opportunities}\right)}$$

P_{A2} = probability that the SSK conducts an accurate attack (i.e., accurate placement of the weapon as evaluated when the weapon approaches the target and not at time of fire) against a transiting submarine without being killed between the time of attack and the time the launched weapon no longer requires control by the firing ship for successful culmination of the attack, given that an attack is made

$$= \frac{A2}{A1} = \frac{\left(\text{Number of accurately placed attacks by the SSK against the transitor}\right)}{\left(\text{Number of attacks made by the SSK against the transitor that are valid for evaluating attack accuracy}\right)}$$

P_K = probability that a transiting submarine is destroyed, given that an accurate attack is made

$$= \frac{K}{A2} = \frac{\text{Number of transitors killed by the SSK}}{\left(\text{Number of accurately placed attacks by the SSK against the transitor}\right)}$$

LOWER LEVEL EVALUATION:

P_{A2} = probability of accurate attack

$= (P_F P'_{AP} + Q_F P''_{AP}) P_S$

where

P_F = probability of an accurate fire control solution at time of fire, given that an attack is made

Q_F = $1 - P_F$

P'_{AP} = probability of an accurate placement, given satisfactory torpedo performance through the placement point and an accurate fire control solution at TOF

P''_{AP} = probability of an accurate placement, given satisfactory torpedo performance through the placement point and an inaccurate fire control solution at TOF

P_S = probability of satisfactory shipboard system performance, given that an attack is made

ASSUMPTIONS:

(1) A valid detection opportunity is defined as a transiting enemy submarine entering the SSK patrol area. Accordingly, when all transitors pass through the SSK patrol area, all transits are detection opportunities.

(2) A detection is defined as occurring when the SSK gains contact on the transitor.

(3) Correct classification of the transitor occurs when the SSK correctly identifies a sonar contact as an enemy submarine.

(4) An attack is defined as occurring with the simulated or actual launch of one of more weapons.

(5) An accurate attack or accurately placed attack for actual torpedo firings is defined as one during which the target passes through the acquisition cone of the torpedo as it approaches the target; for simulated firings, one for which a torpedo would have reached theoretical acquisition range by following the programmed run, including wire guidance commands.

(6) A kill is defined as occurring when an attack would have resulted in an actual kill had a warshot weapon been used.

DATA REQUIREMENTS SUMMARY:

DATA ITEM	DATA SOURCE
D	Determined by comparing the bearing of sonar contacts contained in the SSK's Sonar Contact Logs and the Commanding Officer's Narrative with the bearing of the transitor on the reconstructed track.
C	Obtained from analysis of the Sonar Contact Log and/or Commanding Officer's Narrative.
A1	Obtained from the Commanding Officer's Narrative and/or the submitted attack records.
A2, K	Determined during reconstruction.

(NOTE: In this development, all of the data may come from a set of transits such that D in the numerator of P_D is the same as the D in the denominator of P_C, etc. However, this is not a necessary condition for use of this model; i.e., the data sample used for one phase can be different from the data sample used in the succeeding phase. An example of how this is likely to occur is as follows: An exercise transitor is detected, classified, and tracked. During the SSK's approach the exercise transitor experiences a casualty and goes out of action for several hours. The interaction is valid for detection and classification, but invalid for approach and attack. Hence, in this case, the C in the denominator of P_{A1} is one less than the C in the numerator of P_C.)

REFERENCE: "Submarine Analysis Notebook"
Commander, Submarine Development Group Two
Sept. 1973, CONF.

S1-2 (Submarine in Area Search Mission)

DESCRIPTION: Ownship is assigned the task of seeking out and destroying an enemy submarine in a designated ocean area, given the target location is unknown. There is a considerable range of tactical options available to the searcher, e.g., choice of search pattern, mode of sonar operation. The searcher may sweep through the search area overtly, i.e., radiating sufficient noise to lure a target into an attack position. Alternately, the searcher may use a covert search, attempting to detect and kill a target while remaining undetected. This latter type of search is more prevalent at present.

(1) SPECIFIC OBJECTIVE: Detect and kill the target submarine.

MOE = Area Search Effectiveness (ASE)
= Probability that own ship will detect and kill a target submarine at or before time t, given that a detection opportunity begins at time 0 and continues without interruption through time t
= $P_S(t)\ P_C\ P_{A1}\ P_{A2}\ P_K$

where

$P_S(t)$ = probability that a target is detected and is killed at or before time t, given that a target is killed

$$= \frac{n_t}{n} - \frac{1}{n} e^{(-t/\bar{t})} \sum_{i=1}^{n_t} e^{(S_i/\bar{t})}$$

P_C = probability that own ship correctly classifies the target without being successfully counterattacked between time of detection and classification, given a detection

$$= \frac{C}{D} = \frac{\text{Number of correct classifications by own ship}}{\left(\begin{array}{l}\text{Number of detections by own ship that are}\\ \text{valid opportunities for classification}\end{array}\right)}$$

P_{A1} = probability that own ship makes an attack without being successfully counterattacked between time of classification and attack, given correct classification

$$= \frac{A1}{C} = \frac{\text{Number of attacks made by own ship}}{\left(\begin{array}{l}\text{Number of correct classifications by}\\ \text{own ship that are valid approach}\\ \text{opportunities}\end{array}\right)}$$

P_{A2} = probability that own ship conducts an accurate attack (i.e., accurate placement of the weapon as evaluated when the weapon approaches the target and not at time of fire) against a target submarine without being successfully counterattacked between the time of attack and the time the launched weapon no longer requires control by the firing ship for successful culmination of the attack, given that an attack is made

$$= \frac{A2}{A1} = \frac{\text{Number of accurately placed attacks by own ship}}{\left(\begin{array}{l}\text{Number of attacks made by own ship that are}\\ \text{valid for evaluating attack accuracy}\end{array}\right)}$$

P_K = probability of a kill, given that an accurate attack is made

$$= \frac{K}{A2} = \frac{\text{Number of kills by own ship}}{\left(\begin{array}{l}\text{Number of accurately placed attacks}\\ \text{by own ship}\end{array}\right)}$$

t = time for which ASE is being estimated

n = number of complete runs

$\bar{t}$ = exercise mean time-to-detection

$= \frac{\text{Sum of search times}}{\text{Total number of detections}}$

S_i = length of the time interval between detection and kill on a complete i^{th} run; ordered such that $S_{i-1} \leq S_i \leq S_{i+1}$

n_t = number of complete runs on which the interval between detection and kill was less than t, i.e., n_t is such that $S_{n_t} \leq t < S_{n_t} + 1$

ASSUMPTIONS:

(1) A detection opportunity exists whenever both the searcher and target are in the designated search area.

(2) A detection is defined as occurring when the searcher gains contact on a target.

(3) Correct classification of the target occurs when the searcher correctly identifies a sonar contact as an enemy submarine.

(4) An attack is defined as occurring with the simulated or actual launch of one or more weapons.

(5) An accurate attack or accurately placed attack for actual torpedo firings is defined as one during which the target passes through the acquisition cone of the torpedo as it approaches the target; for simulated firings, one for which a torpedo would have reached theoretical acquisition range by following the programmed run, including wire guidance commands.

(6) A kill is defined as occurring when an attack would have resulted in an actual kill had a warshot weapon been used.

DATA REQUIREMENTS SUMMARY:

DATA ITEM	DATA SOURCE
D	Determined by comparing the bearing of sonar contacts contained in the Sonar Contact Logs and the Commanding Officer's Narrative with the bearing of the target on the reconstructed track.
C	Obtained from analysis of the Sonar Contact Log and/or Commanding Officer's Narrative.
A1	Obtained from the Commanding Officer's Narrative and/or the submitted attack records.
A2, K	Determined during reconstruction.
t_i	Determined during reconstruction. If detection is gained on the i^{th} run before the searcher enters the search area, then $t_i = 0$.
S_i	Determined during reconstruction as the interval between detection and the predicted or actual impact of a simulated weapon or real weapon, respectively.

(NOTE: In this development, all of the data may come from a single exercise such that C in the numerator of P_C is the same as the C in the denominator of P_{A1}, etc. However, this is not a necessary condition for use of this model; i.e., the data sample used for one phase can be different from the data sample used in the succeeding phase. An example of how this is likely to occur is as follows: A target is detected, classified, and tracked. During own ship's approach the target experiences a casualty and goes out of action for several hours. The interaction is valid for detection and classification, but invalid for approach and attack. Hence, in this case, the C in the denominator of P_{A1} is one less than the C in the numerator of P_C. However, some complete runs are needed in order to determine the times S_i..)

REFERENCE: "Submarine Analysis Notebook"
Commander, Submarine Development Group Two
Sept. 1973, CONF.

S1-3 (Submarine in Surveillance Aided Intercept Mission)

DESCRIPTION: A search area of sufficient magnitude is such that own ship, using its own detection capability, would have difficulty in detecting an on-station or transiting target in a timely manner. Intelligence about the motion of the target, gained by an outside surveillance system, is transmitted to the submarine, which then attempts to intercept (close, detect, and classify) the target. Intercept is considered successful if the submarine attains a position relative to the target which is suitable for its ultimate objective (kill, general or close surveillance, etc.). The success of own ship depends directly on the effectiveness of target localization, and the command and control efficiency of the surveillance system.

(1) SPECIFIC OBJECTIVE: Close, detect and classify a submarine target with the aid of a surveillance system.

MOE = Surveillance Aided Intercept Effectiveness (SAIE)
= Probability that the submarine will covertly detect, classify and close a target detected by a surveillance system, and designated for intercept, utilizing localization information from the surveillance system in real time

$$= P_L \left| P_T \left[P_R \cdot P_P \cdot P_{D1} + (1-P_R) P_{D2}\right] + \left[(1-P_T) P_{D3}\right] \right| P_C \cdot P_A$$

where

P_L = probability that the surveillance system localizes the target at least once, given an opportunity

$$= \frac{N_L}{N_0}$$

P_T = probability that the current surveillance localization is effective, given that at least one localization occurs. (Effective localization is not defined in an absolute sense; rather, the analyst evaluates each run. Localization is considered to be non-effective if it is evaluated as insufficient to effect an intercept by the submarine.)

$$= \frac{N_T}{N_L}$$

P_R = probability that own ship utilizes the current localization, given that an effective localization was obtained

$$= \frac{N_R}{N_T}$$

P_P = probability that own ship attains search position, given that he utilized the current data

$$= \frac{N_P + N_{D1}}{N_R}$$

P_{D1} = probability that own ship detects the target, given that he attained search position

$$= \frac{N_{D1} + N_{D2}}{N_P + N_{D1}}$$

P_{D2} = probability that own ship detects the target, given that he did not utilize the current effective localization

$$= \frac{N_{D3}}{N_T - N_R}$$

P_{D3} = probability that own ship detects the target, given that the localization is non-effective

$$= \frac{N_{D4}}{N_L - N_T}$$

P_C = probability that own ship correctly classifies the target without being successfully counterattacked between time of detection and classification, given a detection

$$= \frac{N_C}{N_{D1} + N_{D2} + N_{D3} + N_{D4}}$$

P_A = probability that own ship makes an undetected approach to a suitable position for kill or for initiating surveillance, given that a correct classification exists

$= \frac{N_A}{N_C}$

N_O = number of opportunities (exercise runs)

N_L = number of exercise runs on which at least one surveillance localization occurs

N_T = number of exercise runs on which the current localization is effective (the target's position is within own ship's search area) when the target is detected, or own ship enters the search area, or the target reaches CPA, and own ship is not in the search area

N_R = the number of exercise runs on which own ship had correctly received and utilized the current effective localization

N_P = the number of exercise runs on which own ship commenced a search of the area based on effective localization prior to detection of the target

N_{D1} = the number of exercise runs on which own ship detects the target while enroute to a search area based on effective localization, and the target is contained in the search area

N_{D2} = the number of exercise runs where own ship detects the target within the search area while conducting a search of the area

N_{D3} = the number of exercise runs on which own ship detected the target while acting on localization data that is either outdated (more recent effective localization has occurred, but has not been received) or that has been garbled in transmission, or has been erroneously evaluated

N_{D4} = the number of exercise runs on which own ship detected the target while acting on localization data that was non-effective

N_C = the number of exercise runs on which own ship correctly classifies the target

N_A = the number of exercise runs on which own ship completes an undetected approach to a position relative to the target from which he may carry out his assigned combat role

ASSUMPTIONS:

(1) An exercise run is that period of time during which the target proceeds along a designated track through an assigned patrol area at such a speed or in such a condition that detection by the surveillance system is likely.

(2) A surveillance localization is said to occur if and when the assisting surveillance system supplies the Submarine Operational Control Authority (OPCON) with an estimate of target position, heading, speed, and a corresponding measure of confidence in each, at any time during an exercise run.

(3) Own ship's assigned search region is generally a square area, centered on the reported target's position, oriented such that one pair of sides are parallel to the course vector, and which moves with time along the target's reported PIM vector. The search region is reset with each updated localization reported by the surveillance system, and the DR restarted from the new localization position and along the new PIM received.

(4) The target is said to be contained within the search region; or, conversely, the surveillance localization is said to be effective if one of the following conditions exists:

(4.a) If own ship detects the target when the target is within the search region.

(4.b) If own ship attains (defined below) the search region and the target is within the search region.

(4.c) If own ship neither detects, nor attains, and the target is within the search region at the time of CPA.

(5) An effective localization is utilized by own ship if the localization information has been:

(5.a) Received without garbles, plotted correctly, and is the basis for subsequent action by own ship.

(5.b) Received garbled, recognized as incorrect, proper correction applied, plotted correctly, and used as above.

(6) Own ship is said to attain a desired position within the search region if either of the following conditions exists:

(6.a) Own ship enters the search region prior to detecting the target.

(6.b) Own ship detects the target while enroute to the search region, and the target is contained within the search region.

REFERENCE: "Submarine Analysis Notebook"
Commander, Submarine Development Group Two
Sept. 1973, CONF.

TABLE B-2 Operational Test & Evaluation MOE Data Base (Continued)

Area: Surface Ships (SS)

CODE	ITEM
SS1	Destroyer
SS1-1	(Destroyer in Close-In Screening Mission)
SS1-2	(Destroyer in Barrier/Search Attack (SAU) Mission)
SS1-3	(Destroyer in Passive Barrier/Cold War Submarine Hold-Down Mission)
SS1-4	(Destroyer Using Jezebel)
SS2	Amphibious Assault Ship (LPH-2, Sea Control Ship)

SURFACE SHIPS (SS)

SS1 - Destroyer

SS1-1 (Destroyer in Close-In Screening Mission)

DESCRIPTION: A close-in destroyer screen attempts to prevent an enemy submarine from penetrating the screen and gaining a position to launch a torpedo attack on a protected high value unit (HVU).

(1) SPECIFIC OBJECTIVE: Prevent a single submarine penetrator from attacking a protected merchant convoy or task force.

MOE = Destroyer Screen Effectiveness

= Probability that a single submarine is prevented from penetrating a close-in destroyer screen and gaining position to launch a torpedo attack on a high value unit (HVU)

$$= P_{D/O}\, P_{E/D}\, P_{AT/E}\, P_{H/AT}\, P_{K/H}$$

where

$P_{D/O}$ = probability of detection given an opportunity

$$= \frac{D_1}{O} = \frac{\left(\text{Number of valid detections by the destroyer screen}\right)}{\left(\text{Number of penetrations attempted, i.e., number of valid screen detection opportunities}\right)}$$

$P_{E/D}$ = probability of engagement given detection

$$= \frac{E_1}{D_2} = \frac{\left(\text{Number of valid submarine detections that are engaged by the destroyer screen}\right)}{\left(\text{Number of valid screen detections that are valid opportunities for engagement}\right)}$$

$P_{AT/E}$ = probability of attack given engagement

$$= \frac{A_1}{E_2} = \frac{\left(\text{Number of "yes" decisions for a screen destroyer to attack the penetrating submarine}\right)}{\left(\text{Number of screen engagements that are valid attack decision opportunities for the destroyer screen}\right)}$$

$P_{H/AT}$ = probability of hit given attack

$$= \frac{H_1}{A_2} = \frac{\begin{pmatrix}\text{Number of valid "yes" decisions to attack} \\ \text{that result in weapon hit}\end{pmatrix}}{\begin{pmatrix}\text{Number of "yes" decisions to attack that} \\ \text{are valid opportunities for weapon hit}\end{pmatrix}}$$

$P_{K/H}$ = probability of kill given a hit

$$= \frac{K}{H_2} = \frac{(\text{Number of kills})}{\begin{pmatrix}\text{Number of valid attacks which} \\ \text{result in weapon hit}\end{pmatrix}}$$

LOWER LEVEL EVALUATION

(a) $P_{E/D}$ = probability of engagement given detection

$$= (1 - P_{LC})\, P_{E/\overline{LC}}$$

where

P_{LC} = probability that the destroyer screen irretrievably loses contact on the penetrating submarine

$$= \frac{L_1}{D_2} = \frac{\begin{pmatrix}\text{Number of submarines that successfully penetrate} \\ \text{because the destroyer screen loses contact} \\ \text{irretrievably}\end{pmatrix}}{\begin{pmatrix}\text{Number of detections that are valid engagement} \\ \text{opportunities for the destroyer screen}\end{pmatrix}}$$

$P_{E/\overline{LC}}$ = probability that a screen destroyer maneuvers to a position such that an attack decision can be made, given that an irretrievable lost contact is not the cause of submarine success

$$= \frac{E_1}{L_2} = \frac{\begin{pmatrix}\text{Number of times a screen destroyer} \\ \text{successfully gains position to attack} \\ \text{a penetrator}\end{pmatrix}}{\begin{pmatrix}\text{Number of valid engagement opportunities} \\ \text{upon which contact is not irretrievably} \\ \text{lost}\end{pmatrix}}$$

(b) $P_{H/AT}$ = probability of hit given attack

$$= P_{TL/AT}\, P_{APT/TL}\, P_{H/APT} + P_{AL/AT}\, P_{APA/AL}\, P_{H/APA}$$

$$+ P_{DATL/AT}\, P_{APATD/DATL}\, P_{H/APATD}$$

$$+ P_{DTL/AT}\, P_{APTD/DTL}\, P_{H/APTD}$$

$$+ P_{DAL/AT}\, P_{APAD/DAL}\, P_{H/APAD}$$

where

$P_{TL/AT}$ = probability of single Surface Vessel Torpedo Tube (SVTT) launch, given an attack

$$= \frac{(TL)_1}{A_2} = \frac{\left(\text{Number of destroyer screen attacks in which a single SVTT launch is made}\right)}{\left(\text{Total number of destroyer screen attacks that are valid opportunities for any ASW weapon launch}\right)}$$

$P_{APT/TL}$ = probability of accurate placement, given single SVTT launch

$$= \frac{(APT)_1}{(TL)_2} = \frac{\left(\text{Number of single SVTT launches which result in accurate placement of weapon}\right)}{\left(\text{Number of single SVTT launches which are valid opportunities for accurate weapon placement}\right)}$$

$P_{H/APT}$ = probability of hit, given accurate placement of single SVTT in a single SVTT launch

$$= \frac{HT}{(APT)_2} = \frac{\left(\text{Number of accurate placements, in single SVTT launches, that result in weapon hit}\right)}{\left(\text{Number of accurate placements, in single SVTT launches, that are valid opportunities for weapon hit}\right)}$$

$P_{AL/AT}$ = probability of single ASROC launch, given an attack

$$= \frac{(AL)_1}{A_2} = \frac{\left(\text{Number of destroyer screen attacks in which a single ASROC is launched}\right)}{\left(\text{Total number of destroyer screen attacks that are valid opportunities for any ASW weapon launch}\right)}$$

$P_{APA/AL}$ = probability of accurate placement, given single ASROC launch

$$= \frac{(APA)_1}{(AL)_2} = \frac{\left(\text{Number of single ASROC launches which result in accurate placement of weapon}\right)}{\left(\text{Number of single ASROC launches which are valid opportunities for accurate weapon placement}\right)}$$

$P_{H/APA}$ = probability of hit, given accurate placement of single ASROC in a single ASROC launch

$$= \frac{HA}{(APA)_2} = \frac{\left(\text{Number of accurate placements, in single ASROC launches, that result in weapon hit}\right)}{\left(\text{Number of single ASROC accurate placements, in single ASROC launches, that are valid opportunities for weapon hit}\right)}$$

$P_{DTL/AT}$ = probability of dual SVTT launch, given an attack

$$= \frac{(DTL)_1}{A_2} = \frac{\text{Number of dual launched SVTT attacks}}{\left(\text{Total number of destroyer screen attacks that are valid opportunities for any ASW weapon launch}\right)}$$

$P_{APTD/DTL}$ = probability of accurate placement of at least one SVTT, given dual SVTT launch

$$= \frac{(APTD)_1}{(DTL)_2} = \frac{\left(\text{Number of dual SVTT launches which result in accurate placement of at least one weapon}\right)}{\left(\text{Number of dual SVTT launches which are valid opportunities for accurate placement}\right)}$$

$P_{H/APTD}$ = probability of one hit, given accurate placement of at least one of two SVTT's in a dual SVTT launch

$$= \frac{HTD}{(APTD)_2} = \frac{\left(\text{Number of times that accurate placement of at least one weapon, in a dual SVTT launch, results in a weapon hit}\right)}{\left(\text{Number of times that accurate placement of at least one weapon, in a dual SVTT launch, is a valid opportunity for a weapon hit}\right)}$$

$P_{DAL/AT}$ = probability of dual ASROC launch, given an attack

$$= \frac{(DAL)_1}{A_2} = \frac{\text{Number of dual launched ASROC attacks}}{\left(\text{Total number of destroyer screen attacks that are valid opportunities for any ASW weapon launch}\right)}$$

$P_{APAD/DAL}$ = probability of accurate placement of at least one of the ASROC's, given dual ASROC launch

$$= \frac{(APAD)_1}{(DAL)_2} = \frac{\left(\text{Number of dual ASROC launches which result in accurate placement of at least one weapon}\right)}{\left(\text{Number of dual ASROC launches which are valid opportunities for accurate placement}\right)}$$

$P_{H/APAD}$ = probability of one hit, given accurate placement of at least one of two ASROC's in a dual ASROC launch

$$= \frac{HAD}{(APAD)_2} = \frac{\left(\text{Number of times that accurate placement of at least one weapon, in a dual ASROC launch, results in a weapon hit}\right)}{\left(\text{Number of times that accurate placement of at least one weapon, in a dual ASROC launch, is a valid opportunity for a weapon hit}\right)}$$

$P_{DATL/AT}$ = probability of dual ASROC/SVTT launch, given an attack

$$= \frac{(DATL)_1}{A_2} = \frac{\text{Number of dual ASROC/SVTT launch attacks}}{\left(\text{Total number of destroyer screen attacks that are valid opportunities for any ASW weapon launch}\right)}$$

$P_{APATD/DATL}$ = probability of accurate placement of at least one of the two weapons (ASROC/SVTT) given dual ASROC/SVTT launch

$$= \frac{(APATD)_1}{(DATL)_2} = \frac{\left(\text{Number of dual ASROC/SVTT launches which result in accurate placement of at least one weapon}\right)}{\left(\text{Number of dual ASROC/SVTT launches which are valid opportunities for accurate weapon launch}\right)}$$

$P_{H/APATD}$ = probability of one hit, given accurate placement of at least one of the two weapons in a dual ASROC/SVTT launch

$$= \frac{HATD}{(APATD)_2} = \frac{\left(\text{Number of times that accurate placement of at least one weapon, in a dual ASROC/SVTT launch, results in a weapon hit}\right)}{\left(\text{Number of times that accurate placement of at least one weapon, in a dual ASROC/SVTT launch, is a valid opportunity for a weapon hit}\right)}$$

ASSUMPTIONS:

(1) A submarine must penetrate the destroyer screen in order to attack an HVU. Submarine attacks on HVU from outside the destroyer screen (i.e., a cruise missile attack) are not considered. This assumption is made because in the SHAREM exercises, which are the major source

of data for estimating the MOE, the submarine is required to penetrate the destroyer screen in order to gain an attack position on an HVU. The attack position is defined in terms of the range to the nearest HVU.

(2) The attacking submarine is said to have successfully penetrated the destroyer screen when (1) it has closed the HVU to an attack position or (2) it has reached a position inside the screen such that an HVU lies along the bearing line from an attacking destroyer to the penetrating submarine.

(3) Data from astern penetrations should not be aggregated with data from ahead penetrations since radiated noise and perturbed water conditions astern the screened body make astern penetrations nonequivalent to ahead penetrations with similar relative speeds.

(4) Submarine evasion of the destroyer screen is not considered (i.e., the submarine either successfully penetrates or is killed). Neither the model nor the present SHAREM exercises are designed to evaluate the effect of forestalling a submarine penetration. To model the effectiveness of forestalling would require a quantitative measure of screen effectiveness as a function of time. The present model may serve as a building block for such a more general, all inclusive model. If future SHAREM exercises include situations where the penetrating submarine evades, such that it is no longer considered a penetration threat, a term could be added to the model presented herein to account for this. Evasion, so defined, is mutually exclusive of both the submarine being killed and the submarine successfully penetrating the screen. Evasion may occur, for example, due to a HVU maneuver based upon screen detection.

(5) Details (e.g., reattacks) of a destroyer/submarine dogfight are not considered. Submarine attacks on destroyers are not considered. In the present SHAREM scenario, the above occurrences are rare.

If any of the above did occur during a penetration run, however, the success or failure of the destroyer screen in attaining a position to attack (and deciding to attack) the penetrating submarine should be included in the data base for evaluating destroyer screen effectiveness.

(6) If the destroyer weapon is not accurately placed, it is assumed that the submarine is not hit. A weapon is said to be accurately placed if the target falls within the nominal acoustic acquisition cone of the enabled weapon.

(7) If a submarine is initially detected and contact is lost and later regained by the same screen destroyer or by another screen destroyer, that submarine is considered to be only <u>one</u> screen detection (i.e., there can be no more than one screen detection per penetration attempt).

(8) The destroyer screen is initially semi-alerted. (i.e., destroyer screen knows the submarine is in the area but does not have a bearing and/or range estimate.)

(9) The probability of screen destroyers prosecuting a non-submarine detection (i.e., a false contact) is not explicitly considered in this evaluative model; rather, false contacts are considered in destroyer performance measures addressed separately. It should be realized, however, that prosecuting false contacts could have a degrading effect on destroyer screen effectiveness. It may, for instance, be the cause of a penetrating submarine not being detected. As such, its degrading effect is implicitly reflected in this measure.

(10) The probability of the destroyer screen correctly classifying a valid submarine detection is implicitly included in this model (i.e., detecting a valid submarine means detecting <u>and</u> classifying it).

(11) Only one destroyer will attempt to engage the submarine given that the penetrating submarine is detected by the destroyer screen (i.e., only one-on-one encounters are considered).

(12) If a submarine is initially detected and contact is lost and later regained by the same screen destroyer or by another screen destroyer, that submarine is considered to be only one valid detection, i.e., there can be only one screen detection per penetration attempt.

(13) If a detection is made and contact is lost and never regained due to evasion or confusion on the part of the submarine such that it fails to close the destroyer screen and pass between screen destroyers, that submarine is considered to have been neither a valid detection opportunity nor a valid detection.

(14) A screen detection is a valid opportunity for engagement if the destroyer is not artificially prevented from attaining an attack position relative to the submarine – for example, a run termination prior to engagement.

(15) A decision to attack is made when the firing order to launch a weapon is given; however, for each engagement only one attack decision is counted.

(16) The measure of effectiveness is regarded as an estimate of the probability of kill given an opportunity, since it is not necessarily equal to the number of kills divided by the number of opportunities. The reason for this is that runs are sometimes truncated, that is, a success in one phase of an encounter may not be a valid opportunity for the next phase due to the exercise run being prematurely terminated by the OTC of the exercise.

(17) If contact is regained by the destroyer screen prior to submarine penetration of the screen, the destroyer screen is not considered to have irretrievably lost contact.

(18) A weapon is considered to be accurately placed if the target falls within the nominal acoustic acquisition cone of the enabled weapon.

(19) If a dual launch is attempted but due to fire control, weapon, or personnel failure only one weapon enters the water, then that launch is treated as a single launch. If due to any failure no weapons enter the water, then that run is assessed as a failure to launch.

(20) The expanded probability of hit given attack allows for only one launch tactic per attack and only one hit per attack.

DATA REQUIREMENTS SUMMARY:[1]

DATA ITEM \ DATA SOURCE	DETECTION EXERCISES[2]	ATTACK EXERCISES[3]	WEAPONS TESTS, LABORATORY TESTS, ETC.
O	X		
D_1, D_2	X		
$\overline{LC}$	X		
E_1, E_2	X		
A_1	X		
A_2		X	
$(TL)_1$, $(AL)_1$, $(DTL)_1$ $(DAL)_1$, $(DATL)_1$		X	
$(TL)_2$, $(AL)_2$, $(DTL)_2$ $(DAL)_2$, $(DATL)_2$		X	
$(APT)_1$, $(APA)_1$, $(APTD)_1$ $(APAD)_1$, $(APATD)_1$		X	
$(APT)_2$, $(APA)_2$, $(APTD)_2$ $(APAD)_2$, $(APATD)_2$		X	
HT, HA, HTD, HAD, HATD		X	
K/H_2			X

(NOTES:

(1) The sample size of data used to estimate each of the conditional probabilities need not be equal. This allows maximum use of data from different type exercises and also from exercise runs which are terminated prior to completion and thus valid for estimating only some terms of the model.

(2) A detection exercise consists of repeated attempts by one submarine to penetrate a destroyer screen that is made up of two or more destroyers on patrol stations protecting a single ship high value unit (HVU). In this type of exercise, the submarine attempts to penetrate the screen to simulate a penetration attempt against a complete destroyer screen. The penetrating submarine neither attempts to evade the screen nor attacks screen destroyers. The submarine mission is to reach an attack position on a high value unit of the screened body. Simulated submarine cruise missile attacks from outside the convoy are not included in these exercises. For the purpose of evaluating destroyer screen success, each non-truncated exercise run results in either a successful screen penetration by the submarine or a destroyer screen decision to attack a detected submarine. The actual exercise run terminates when either the submarine penetrates the screen, the OTC terminates the run, or after a specified period from COMEX, whichever occurs first. Data for the model beyond the decision to attack the submarine in an engagement is obtained from SHAREM attack exercises and other sources.

(3) An attack exercise consists of repeated attempts by one submarine to penetrate a destroyer's patrol area. The main objective of this type of exercise is to evaluate destroyer attack effectiveness. For the purpose of providing data for the evaluative model, attack exercise runs proceed from the destroyer decision to attack, through destroyer weapon launch, to either automatic cutoff (ACO) range (i.e., weapons are not set to hit) or weapon miss. The destroyer weapons include both deck launched torpedoes and ASROC.)

REFERENCE: "Destroyer Analysis Notebook"
COMDESDEVGRU Technical Report 15-73
31 Aug. 1973, CONF.

SS1-2 (Destroyer in Barrier/Search Attack (SAU) Mission)

DESCRIPTION: A coordinated ASW group (including destroyers) attempts to locate, intercept, and destroy enemy submarines that are in transit to and from their bases and operating areas.

(1) SPECIFIC OBJECTIVE: Locate, intercept and destroy enemy submarines.

MOE = Probability of destroying an enemy submarine given an opportunity

$= P_{D/O}\, P_{A/D}\, P_{K/A}$

where

$P_{D/O}$ = probability of detecting an enemy submarine, given an opportunity

$$= \frac{\text{Number of detections}}{\text{Number of opportunities}}$$

$P_{A/D}$ = probability of accurately placed attack, given detection of an enemy submarine

$$= \frac{\text{Number of accurately placed attacks}}{\text{Number of detections}}$$

$P_{K/A}$ = probability of proper weapon functioning, given an accurately placed attack

$$= \frac{\text{Number of weapons which functioned properly}}{\text{Number of accurately placed attacks}}$$

REFERENCE: "Destroyer Analysis Notebook"
COMDESDEVGRU Technical Report 15-73
31 August 1973, CONF.

SS1-3 (Destroyer in Passive Barrier/Cold War Submarine Hold-Down Mission)

DESCRIPTION: Contact is maintained, overtly or covertly, with an enemy submarine while it is in transit or on-station with the ability to be able to localize the submarine with sufficient speed and accuracy when required.

(1) SPECIFIC OBJECTIVE: Maintain contact sufficiently so as to be able to localize when required.

MOE = Probability of intercepting an unalerted transiting enemy submarine

$$= P_{D/O} \, P_{AC/D}$$

where

$P_{D/O}$ = probability of detecting an unalerted transiting enemy submarine using passive sonar (SOSUS or air dropped buoys), given an opportunity

$$= \frac{\text{Number of passive detections}}{\text{Number of opportunities}}$$

$P_{AC/D}$ = probability of converting a passive sonar contact (SOSUS or air dropped buoys) to an active sonar contact

$$= \frac{\text{Number of active contacts}}{\text{Number of passive detections}}$$

REFERENCE: "Destroyer Analysis Notebook"
COMDESDEVGRU Technical Report 15-73
31 August 1973, CONF.

SS1-4 (Destroyer Using Jezebel)

DESCRIPTION: This ship utilizes an airborne platform (in particular, the drone anti-submarine helicopter (Dash)) to drop sonobuoys and to relay the sonic information to the destroyer. This concept provides the destroyer with a long range detection and classification capability against a snorkeling-diesel submarine.

(1) SPECIFIC OBJECTIVE: Evaluate detection capability.

$(MOE)_1$ = Detection success ratio

$$= \frac{\text{Number of detections}}{\text{Number of detection opportunities}}$$

$(MOE)_2$ = Effective sonobuoy detection range

ASSUMPTION: A detection opportunity is that period when the target submarine is snorkeling.

(2) SPECIFIC OBJECTIVE: Evaluate classification capability.

$(MOE)_1$ = Classification success ratio

$$= \frac{\text{Number of targets correctly classified}}{\left(\text{Number of opportunities for target classification}\right)}$$

$(MOE)_2$ = Mean time required to classify a target after initial contact

ASSUMPTION: A target classification opportunity is one where received signature characteristics from one sonobuoy matched the known target signature characteristics.

REFERENCE: Final Report on Project F/0251
"Conduct a Fleet Operational Investigation of the Destroyer Jezebel Concept"
3 June 1970, SECRET

SS2 - Amphibious Ass‹ ılt Ship (LPH-2)

DESCRIPTION: This is a LPH-2 Class ship with AV-8A fixed wing VSTOL aircraft and SH-3H ASW helicopters. The ship operates helicopters in a continuous airborne ASW mission, and VSTOL in a react mode for DLI (Deck Launched Intercept) or DLA (Deck Launched Attack) against air or surface threats.

(1) SPECIFIC OBJECTIVE: Evaluate single DLI/DLA reaction against a single threat in AAW and ASURW missions.

$(MOE)_1$ = Likelihood of interception

$$= \frac{\text{Number of intercepts}}{\text{Number of DLI/DLA attempts}}$$

$(MOE)_2$ = Average reaction time from detection to launch

$(MOE)_3$ = Average reaction time from launch to intercept

(2) SPECIFIC OBJECTIVE: Determine the capability to contrul the laying of sonobuoy patterns utilizing the SH-3 helicopter.

$(MOE)_1$ = Average pattern placement error

$(MOE)_2$ = Median pattern placement error

(3) SPECIFIC OBJECTIVE: Determine system capability for submarine localization and tracking using SH-3 relayed Jezebel information.

$(MOE)_1$ = Likelihood of an estimated position (EP)

$$= \frac{\text{Number of estimated positions obtained}}{\left(\text{Number of opportunities for passive localization, given detection}\right)}$$

$(MOE)_2$ = Mean estimated position error

$(MOE)_3$ = Median estimated position error

(4) SPECIFIC OBJECTIVE: Determine the system capability to lay and maintain a passive sonobuoy barrier at a specified range from the ship while maintaining a fixed speed-of-advance (SOA).

$(MOE)_1$ = Mean barrier kingpin drop error

$(MOE)_2$ = Mean length error (nm) of achieved sonobuoy line from desired line, assuming kingpin drop is accurate

$(MOE)_3$ = Mean end-to-end course error (deg) of achieved sonobuoy line from desired line, assuming kingpin drop is accurate

$(MOE)_4$ = Mean error (nm) in sonobuoy spacing

$(MOE)_5$ = Mean deviation of sonobuoys from desired course (deg)

(5) SPECIFIC OBJECTIVE: Evaluate system response to a torpedo flaming datum or other detection within a specified distance of a task force main body.

$(MOE)_1$ = Average redetection time, which is the average of the elapsed time taken from the time of SH-3H arrival at datum to the time of the first confirmed active redetection or MAD

$(MOE)_2$ = Number of magnetic anomaly detections

$(MOE)_3$ = Average redetection time to MAD, which is defined as the average period of elapsed time from time of redetection to the time of the first MAD

$(MOE)_4$ = Average number of valid attacks, which is defined as the number of attacks evaluated by the exercise submarine as "good" or "excellent" or, in the absence of a submarine evaluation of the attack, those attacks determined by computer reconstruction to be within 1000 yds of the submarine position

$(MOE)_5$ = Average redetection to attack time, which is defined as the average period of elapsed time from the time of redetection to the time of the first valid attack from any participating SH-3H

$(MOE)_6$ = Likelihood of kill, assuming kill given a valid attack is certain

$$= \frac{\text{Number of valid attacks}}{\text{Total number of attack opportunities}}$$

(6) SPECIFIC OBJECTIVE: Determine the accuracy and capability of the system to lay a sonobuoy field using VSTOL aircraft.

$(MOE)_1$ = Average aircraft track error (deg)

$(MOE)_2$ = Average placement error of the first sonobuoy

$(MOE)_3$ = Average placement error of all sonobuoys dropped

$(MOE)_4$ = Average placement error of all sonobuoys dropped, after removal of the kingpin error

(7) SPECIFIC OBJECTIVE: Determine system capability to control the SH-3 helicopter to a specified sonobuoy drop position.

$(MOE)_1$ = Mean buoy drop error in range (nm)

$(MOE)_2$ = Mean buoy drop error in bearing (deg)

REFERENCE: Second Partial Report on Project P/C2
"Conduct an Operational Appraisal of the Interim Sea Control Ship"
14 Aug. 1973, CONF.

TABLE B-3 Platform, System and Equipment Index

TABLE B-3 Platform, System and Equipment Index (Continued)

TABLE B-3 Platform, System and Equipment Index (Continued)

TABLE B-3 Platform, System and Equipment Index (Continued)

TABLE B-4 Project Index

PROJECT	AREA CODE	SUBJECT	PAGE
C/C1	08-3	Mk 46 Mod 1	B-134
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C/S4	08-2	ASROC	B-133
C/S5	DD1	NTDS	B-43
C/S10	EDC16		B-78
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C/S17	06	SUBROC	B-126
C/S18	A4-3	DASH	B-10
C/S19	C5	HICAPCOM	B-38
C/S21	NG1	OMEGA Receiver	B-115
C/S23	M5	Mk 1 Mod 0 (TERNE III)	B-113
C/S24	FC3	Mk 114	B-90
C/S25	ADC4	SCAT	B-25
C/S34	EDC1-1	AN/SPS-49 (XN-1), AN/SPS-50 (XN-1)	B-58
C/S43	EDC15	0-1331(XN-1)/ULQ-6	B-77
C/S44	ADC7	ROTOVAC 6X, ROTOVAC 7X	B-28
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C/S52	EDC18	AM-4530/ULQ-6A	B-81
C/S56	ADC1-1	AN/BQR-16	B-12
C/S59	ADC1-2	AN/BQR-15	B-13
C/S61	ADC1-1	AN/BQR-19	B-12
C/S63	ADC5	NIXIE	B-26
C/S68	DD2	DATACOURTS	B-44
C/S70	EDC16	AN/SLQ-17(V)	B-78
C/S71	ADC8	AN/WLR-9	B-29
C/S72	EDC1-1	AN/SPS-58	B-58
C/S82	EDC2	AN/UPX-24	B-62
C/S85	ADC9	SAWS	B-30
C/S94	EDC5	AN/WLR-8(V)2	B-65
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C/V9	M2	YAGM-45 SHRIKE	B-106
C/V10	ADC4	SCAT	B-25
C/V14	O9	Destructor Mk 30 Mod 0	B-136
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F/096	EDC7	SHADOWGRAPH	B-67
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F/0143	IOD1		B-100

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F/0148	C3		B-36
F/0151	EDC9		B-69
F/0186	M3	AGM-12B Bullpup	B-108
F/0198	FC4-2	F-4 AMCS Aero 1A, F-8 AWG-4	B-92
F/0210	EDC17		B-80
	EDC20	ALT-27	B-83
F/0214	A4-1	SH-3A	B-8
F/0228	DD4	ANEW	B-49
F/0237	FC4-3		B-96
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F/0257	03	A-6A/RABFAC/Paveway	B-123
F/0263	02	Walleye II Mk 5	B-122
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