AD-A186 282 APPLICATION OF THE ANALYSIS PHASE OF THE INSTRUCTIONAL SYSTEM DEVELOPMENT..(U) NAVAL POSTGRADUATE SCHOOL MONTEREY CA D S BROUGHTON SEP 87 1/1

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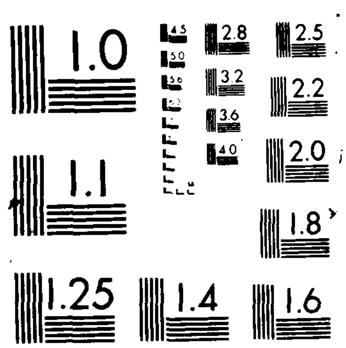
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NAVAL POSTGRADUATE SCHOOL

Monterey, California

THESIS

APPLICATION OF THE ANALYSIS PHASE OF THE
INSTRUCTIONAL SYSTEM DEVELOPMENT TO THE
MK-105 MAGNETIC MINESWEEPING MISSION
OF THE MH-53E HELICOPTER

by

David S. Broughton

September 1987

Thesis Co-Advisors: D.E. Neil
T. Mitchell

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE

REPORT DOCUMENTATION PAGE

1a REPORT SECURITY CLASSIFICATION UNCLASSIFIED	1b RESTRICTIVE MARKINGS
2a SECURITY CLASSIFICATION AUTHORITY	3 DISTRIBUTION/AVAILABILITY OF REPORT Approved for public release; distribution is unlimited
2b DECLASSIFICATION/DOWNGRADING SCHEDULE	
4 PERFORMING ORGANIZATION REPORT NUMBER(S)	5 MONITORING ORGANIZATION REPORT NUMBER(S)
6a NAME OF PERFORMING ORGANIZATION Naval Postgraduate School 6b OFFICE SYMBOL (If applicable) Code 55	7a NAME OF MONITORING ORGANIZATION Naval Postgraduate School
6c ADDRESS (City, State, and ZIP Code) Monterey, California 93943-5000	7b ADDRESS (City, State, and ZIP Code) Monterey, California 93943-5000
8a NAME OF FUNDING/SPONSORING ORGANIZATION 8b OFFICE SYMBOL (If applicable)	9 PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER
8c ADDRESS (City, State, and ZIP Code)	10 SOURCE OF FUNDING NUMBERS PROGRAM ELEMENT NO / PROJECT NO / TASK NO / WORK UNIT ACCESSION NO

11 TITLE (Include Security Classification)

Application of the Analysis Phase of the Instructional System Development to the MK-105 Magnetic Minesweeping Mission of the MH-53E Helicopter

12 PERSONAL AUTHOR(S)
Broughton, David S.

13a TYPE OF REPORT	13b TIME COVERED	14 DATE OF REPORT (Year, Month, Day)	15 PAGE COUNT
Master's Thesis	FROM ______ TO ______	1987, September	95

16 SUPPLEMENTARY NOTATION

17 COSATI CODES			18 SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
FIELD	GROUP	SUB-GROUP	MOAT; ISD; Mission Operability Assessment Technique; Instructional Systems Development; Conjoint Measurement; Task Analysis

19 ABSTRACT (Continue on reverse if necessary and identify by block number)

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20 DISTRIBUTION/AVAILABILITY OF ABSTRACT ☒ UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT ☐ DTIC USERS	21 ABSTRACT SECURITY CLASSIFICATION Unclassified
22a NAME OF RESPONSIBLE INDIVIDUAL Prof. Douglas E. Neil	22b TELEPHONE (Include Area Code) (408) 646-2419 22c OFFICE SYMBOL Code 55Ni

DD FORM 1473, 84 MAR

83 APR edition may be used until exhausted
All other editions are obsolete

SECURITY CLASSIFICATION OF THIS PAGE
UNCLASSIFIED

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#19 - ABSTRACT - (CONTINUED)

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Submitted in partial fulfillment of the
requirements for the degree of

MASTER OF SCIENCE IN OPERATIONS RESEARCH

from the

NAVAL POSTGRADUATE SCHOOL
September 1987

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ABSTRACT

With the introduction of the MH-53E helicopter as a platform for airborne mine countermeasures, a new cockpit flight simulator has been proposed. This simulator, device 2F141, will provide the U.S. Navy with the capability to simulate the flight environment of an airborne mine countermeasures mission. The methodology of the Instructional System Development (ISD) model was applied as a framework for development of a training program. This study concentrated on the analysis phase of the ISD process. Through the application of a task analysis and quantification methodology of the Mission Operability Assessment Technique a rank ordering of subtasks and major flight segments for the ship-based MK-105 magnetic minesweeping mission was determined. This study found that the major flight segments of landing, takeoff and prepare for tow, and transit to the minefield required the most improvement to increase the mission operability and effectiveness score. Therefore, a training program should be designed and developed that will effect these improvements by utilizing the cockpit flight simulator.

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I. INTRODUCTION

Airborne mine countermeasures (AMCM) has been accomplished by use of the RH-53D helicopter since the early 1970's. Since then, this platform and its minesweeping and minehunting systems have been successfully deployed to counter the mine threat. Training of pilots for the AMCM mission primarily consisted of classroom and actual flight time. An RH-53D cockpit simulator with the capability to simulate the AMCM environment has not existed in the Navy. With the forecast introduction of the MH-53E helicopter as the next generation AMCM platform, device 2F141 has been proposed to fill this training void and provide the AMCM community with a state-of-the-art aircraft simulator.

When developing new systems for training, a thorough understanding of the skills required to successfully accomplish the task are necessary. This information can then be utilized to identify crucial skills and build a training program with the objective of training those skills. A model that can be used when building a training program is the Instructional Systems Development (ISD) model.

A. INSTRUCTIONAL SYSTEMS DEVELOPMENT

The methodology of the ISD model can be traced back 30 years to the late 1950's when systematic procedures were first applied to the design of training programs in the military services. These early efforts were, in general, influenced by operational analysis concepts of WW II and the recognition of a need for requirements analysis. This called for an empirical determination and clear understanding of job requirements and the specification of training objectives. These procedures were more clearly organized during the 1960's and early 1970's. The models developed during these later years added steps for development of instructional content, implementation and control. (Vineberg and Joyner, 1980)

The concept of a systematic approach to learning is utilized by the Army, Navy, Marine Corps and Air Force. Although all differ somewhat in organization and detail they are all models of essentially the same process referred to as Instructional System Development (ISD) (Vineberg and Joyner, 1980).

The ISD model has been defined in Air Force Manual 50-2, Instructional System Development (1970) as a deliberate and orderly process for planning and developing instructional programs which insures that personnel are taught the knowledge, skills, and attitudes essential for successful job performance. The model in use by the Navy guides the user through five steps beginning with analysis of the training problem and finishing with quality control of the implemented training program. This model can be applied to a newly emerging weapons system, or an existing system that may require improvement. The concept of the ISD model has been widely applied in military aviation. In particular, the Navy model has been applied in the development of training programs for the F-4, EA-6A and EA-6B, A-6E, F-14, E-2B and E2-C, SH-2F, P-3 and F-18 (Funaro and Mulligan, 1978).

B. PROBLEM STATEMENT

Since the establishment of the AMCM community a need has existed for a safe, effective and realistic environment to train pilots to successfully perform the AMCM mission. This mission can best be described as being conducted in a unique flight environment. This includes ship or shore basing, conducting flights primarily below 150 feet mean sea level with various minesweeping or minehunting devices deployed from the helicopter, and a wide range of weather conditions.

These conditions can create high demands on total crew coordination. For the pilot and copilot, the flight profile requires each to be visually in and out of the cockpit as well as monitoring as many as three communication channels at a time. In the past, the training of pilots for the AMCM mission primarily consisted of classroom and actual flight time. With the delivery of the proposed cockpit trainer, device 2F141, an additional training tool will become available for training pilots for the MH-53E AMCM mission.

The purpose of this study was to utilize the ISD model to suggest critical areas of the AMCM mission that may require emphasis in the training of pilots for this mission. The identification of these critical areas will provide the first step toward developing an effective training program. This effort will concentrate on the analysis of the training problem, the first step of the ISD model. In addition, this analysis will be confined to the magnetic mine countermeasures mission utilizing the MK-105 hydrofoil sled.

II. THE ISD MODEL

The ISD model has evolved over the years into a systematic approach to designing and developing training programs with application to a wide array of new and existing weapon systems in the Armed Services. The definition of the ISD model given earlier encompasses four key features. These features provide the foundation for the structure of the ISD model (Campbell et al., 1977). The four features are:

- Job performance.
- Deliberate and orderly approach.
- Process.
- Teaching essentials.

A. FEATURES

The ISD process is based on the precept of training the skills needed to perform the job. Therefore, it is essential to understand the performance requirements of the job being trained. For existing systems this requires an analysis of the performance criteria for the given job. When the system is under development, job analysis is performed, as much as possible, on related occupational areas. This approach identifies the critical training areas and ensures that the training program concentrates only on these areas.

The systematic approach of the ISD process emphasizes development of a training program that is deliberate and orderly. This feature describes how each step of the process is logically derived or related to the preceding step. It is highlighted by the results of the job analysis in which the important skills for job performance are identified. This ensures that an orderly, logical development of the training program occurs, teaching only the skills necessary for the job (Campbell et al., 1977).

As a process the ISD model provides feedback on the preceding phase of the model. This feedback allows updating, modification, evaluation or verification of the results of the preceding phase. In addition, this feature provides guidelines to the training program development while precisely identifying what needs to be learned, the level of competence for the job to be attained through training, and what acceptable alternatives are available to provide the desired training (e.g., flight simulator, desk top trainer, lectures, etc.).

The last feature of the ISD model, teaching essentials, embodies the concept of clearly identifying all the skills and knowledges needed to be taught to satisfactorily perform the job or task. Although it is impossible to train all the skills that may be required to perform a job, the ISD model provides early identification of tasks for which skills and knowledges are already in the repertoire of the individual beginning training. This repertoire may exist due to prior training or because the skills are so common, training is not required. In addition, the model also identifies those tasks that may only require partial training. All other tasks that do not fit into these categories will require full training (Campbell et al., 1977).

B. COMPONENTS OF ISD

These four features provide the foundation of the ISD model. The structure of the model reflects this foundation and provides a vehicle for implementation. The model in use by the Navy consists of five blocks of related parts or phases (Funaro and Mulligan, 1978). In order, they are:

- Analysis.
- Design.
- Development.
- Implementation.
- Quality control.

The relationship between each phase rests with the fact that output from one phase becomes input for the next phase. The end result of the ISD model is a training program that is ready for implementation.

1. Analysis

The analysis phase is an assessment of the training problem. The basic question asked at this point is, "What skills need to be trained?" In order to answer this question a thorough study of the weapon system under consideration is required. To identify the tasks that must be performed to operate the system a task analysis is performed.

Task analysis is defined in the Air Force Task Analysis Handbook as the process of breaking down a task into its component subtasks and then determining precisely what skills and knowledges a trainee needs to acquire in order to accomplish each subtask. As discussed earlier, not all tasks can be trained. However, by breaking down the tasks into subtasks, a hierarchy of tasks or objectives can be developed to assist in identification of essential behaviors. In this way the training program will concentrate on teaching only what is necessary (Funaro and Mulligan, 1978).

2. Design

The identified tasks and associated behaviors from the analysis phase provide input to the design phase. The goal of this phase is to select or design potential methods of instruction that will best meet the objectives. To meet this goal, efforts concentrate on media selection, course organization, determination of training support requirements, and lesson format. The output from this phase represents an outline for the training program (Funaro and Mulligan, 1978).

3. Development

The next phase of the ISD model is development. During this phase, detailed development of foundation programs from the previous phase have begun. This includes development of instructional materials and aids for the trainee as well as the instructor, test and evaluation in small scale mock-ups if necessary, and incorporation of any revisions. The output from this phase is a training program that is ready for implementation.

4. Implementation and Quality Control

Implementation and quality control are the last two stages of the ISD process. During the implementation phase, the training programs developed in the previous phase are put into effect. The quality control phase allows collection of data to determine the effectiveness of the training program in meeting the training objective. Quality control indicates areas that may require adjustment, additions or deletions to the training program to meet the objective.

III. THE ANALYSIS PHASE OF ISD

In Chapter II the five phases of the ISD model were introduced. The listing of the analysis phase at the top underscores the overall importance of this phase within the model. The reason for this singular importance is that information is collected and decisions are made that drive the model from this point on. However, prior to a detailed description of the analysis phase, an understanding of the terms skill and task are essential.

A. SKILL VERSUS TASK

These two terms are quite often used interchangeably. However, when developing a training program it is necessary to distinguish between the two. Salvendy and Seymour (1973) review several definitions of skill. In their discussion they concentrate on those definitions that focus on the purpose of skill when it involves complex, integrated and directed activities. In particular, they note the definition of skill by Welford (1968) who describes skill as concerned with all the factors which go to make up a competent, expert, rapid and accurate performance.

This definition, however, defines skill in terms of performance. Therefore, a further clarification between the term skill and performance is required. Salvendy and Seymour (1973) differentiate between skills and performance by noting that skills are higher levels of performance and involve complex learning processes. Performance, however, is used to indicate the use of receptor, effector and decision making processes. Thus, through the learning process, performance itself can be changed in standard, nature and degree.

An understanding of these terms is essential when developing a training program. During program development it is necessary to determine the level of performance required to meet a particular goal (e.g., successful completion of an exercise). The determination of the required performance levels will partially drive the types of skills needed to be trained. Although establishing the performance level cannot be over-emphasized, further discussion of performance is outside the scope of this study.

Where skills can be considered as something that is learned, tasks can be considered as something that is performed. This loose description of a task is stated concisely by Meister and Rabideau (1965) as the specific operator behaviors which direct systems operations. When taken as a whole, the operator behaviors are a string of one or more actions that complete a routine or list of objectives. Therefore, by completion of the objectives the operator's behavior directs system operations. Thus, in order to identify a task it must have an immediate purpose with output to accomplish a specified system objective.

In addition, tasks may have several levels of complexity. This type of task may require a combination of subtasks to be completed before completion of the overall task. Ultimately, a subtask can be described that consists of single actions taken toward accomplishing limited short-term or routine objectives. (Meister and Rabideau, 1965).

B. ANALYSIS PHASE

The analysis phase was described earlier as an assessment of the training problem. To perform this assessment Funaro and Mulligan (1978) suggest that the analysis phase should consist of the following components:

- Problem Analysis.
- Task listing.
- Task list validation.
- Selection of task.
- Objectives hierarchies.

1. Problem Analysis

The initial entry into the ISD model occurs with problem analysis. This part of the analysis is concerned with the identification of areas of a training program that need to be developed or revised to achieve an effective program.

In the case of existing training programs, all aspects of the program are examined or evaluated. This may include, but is not limited to course syllabi, instructional materials for students, instructor training, and training devices. Indicators that can be used to identify discrepancies in a training program or changing job requirements can include high accident rates, reports of inadequate performance, and discrepancies between course syllabi and actual duties performed (Vineberg and Joyner, 1980). In the case of an emerging weapon system the analysis is concerned with determining the tasks required to operate the system, the materials required for instruction, and any devices that will optimize training.

2. Task Listing

After the identification of a problem area the analysis phase is concerned with the type of tasks that must be performed to accomplish the overall task. This is achieved through task analysis of which task listing is a part. As mentioned earlier in the definition of task analysis, it is a process of breaking down a task into its component subtasks.

In order to perform a task analysis, a structure of the overall task must be outlined. However, before proceeding, a clarification of the use of the term "overall task" is necessary. Meister and Rabideau (1965) refer to the overall task by use of the term "mission" while the Air Force Task Analysis Handbook uses the term "job." However, the point is clear that the overall task is the end result of combining all related component subtasks. For clarity, the term job will be used to refer to the "overall task" and mission will refer to the first level of subtasks.

The first step in developing a structure of the job requires the identification of the major sequential activities or responsibilities which make up the job. These major activities represent the missions. When subdividing the job into missions, the environments, performance constraints and requirements under which the system will be operating should be considered (Meister and Rabideau, 1965). The structure increases in detail with each successive subdivision of the mission and its subtasks. This process continues until a sufficient level of detail is reached that is required by the analyst.

In addition to the considerations listed above for dividing a job into its missions, the Air force Task Analysis Handbook provides guidelines for identifying and dividing tasks into subtasks. They include:

- A task is a specific action.
- A task has a definite beginning and end.
- A task is performed for a relatively short period of time.
- A task is observable and measurable; that is, an individual can observe the performance of the task or examine a product and be able to determine that the task has been performed properly.
- Each task is independent of other actions.

At each level of the structure these guidelines can be applied to further divide a subtask into its components.

As the structure develops, these guidelines assist in examining the anticipated stimulus inputs and required outputs from each task or subtask. This information results in a task description that is associated with each subdivision of a task or subtask. The task descriptions should include, where applicable, critical time requirements, performance criteria and any pertinent conditions that make up that task component.

The emphasis on task identification and description is based on the psychological principle that the more accurately a behavior can be specified, the more efficiently it may be trained (Funaro and Mulligan, 1978). To underscore the importance of this point, Salvendy and Seymour (1973) state that unless the skills and knowledge employed by the experienced, skilled performer have been analyzed and underscored, the training specialist will not have an adequate conception of where the training must lead the trainees.

The combination of the structure and the task description result in an accurate model of the behavior required to perform a job. Funaro and Mulligan (1978) defines the task list and the task description collectively as the task listing.

3. <u>Task List Validation</u>

The process of validation begins after completion of the initial task listing. The purpose of validation is to ensure that the task listing is accurate in structure, task description, and includes all tasks necessary to define the job to the required level of detail.

Validation is accomplished by the use of subject matter experts (SME). A SME can be defined as an experienced individual in the job being analyzed. Similarly, Funaro and Mulligan (1978) defines a SME for the Navy as personnel experienced in the operation of the weapon system under consideration. The subject matter experts consist of one or more individuals that are an independent entity from those that have developed the task listing.

The validation process reduces the possibility of producing an inaccurate task listing caused by developers of the task listing being unfamiliar in the use and operation of the system under consideration. In addition, the process reduces any bias due to the developers being familiar with the system. The result of this stage of the analysis may require revisions to include, delete or clarify tasks suggested by the subject matter experts. This process could be iterative in nature and may continue until a final task listing is agreed on.

4. Task Selection

This step in the analysis phase is the process of identifying for training one or more tasks from the task list. The process of selection is necessary due to the realization that it may be cost prohibitive to attempt training for all tasks. In addition, the entry level skills of the trainees may eliminate the need to train a particular skill.

In order to begin the selection process it is necessary to have completed the task listing and validation steps. Without first completing these steps the selection of tasks will provide erroneous information that will result in a training program that does not meet the true training requirements. In addition, information about the tasks for establishing their importance, priority and need for training are required.

Selection starts with systematic examination of each task in the task listing to determine if training will or will not be provided. The cost and entry level skills of the trainees are the primary decision rule at this point. The tasks that are selected make up the basis of the training program. Although costs are an important consideration and can not be over-emphasized in the development of any weapon or training system, a detailed discussion of cost considerations is outside the scope of this study.

After identifying which tasks are necessary and desirable to train, a decision is made concerning the degree of training to be administered. This is achieved by comparing the entry level skills of the trainees and the standards of acceptable performance for each task. This comparison leads to development of different levels of training that permit trainees to be classified based on their initial skill level. The basic premise is to assign each task to just that level of training which is necessary to assure that its performance will at least meet the operational standard. The task selection process enables the developers of a training program to concentrate their efforts on developing a training program that efficiently utilizes training resources and emphasizes the essential skills for competent performance.

5. Objective Hierarchy

The previous four stages of the analysis phase have primarily been concerned with (a) task analysis of a particular job, (b) its mission, and (c) subtasks. This effort results in a validated task listing and the selection of one or more tasks for training. In order to train personnel in these tasks the training program must be developed around the selected tasks. To this end, the objective hierarchy stage of the analysis phase serves as a bridge to the next phase of the ISD process, the design phase.

In order to develop the objective hierarchy it is important to understand the role of task analysis. Funaro and Mulligan (1978) suggests that task analysis addresses the question of what must be done by an operator to operate a system. However, the development of objective hierarchies forms a bridge between the analysis and design phase. These objectives serve as a guide to determine what the training program must achieve to produce a competent level of performance for the task.

Development of behavioral objectives is accomplished through behavioral analysis. Salvendy and Seymour (1973) describes behavioral analysis as being concerned with the knowledge and skills that are associated with successful job performance. The emphasis is to understand the psychological processes involved in the performance of a task. Behavioral analysis seeks to determine the major indicators required by an experienced person that initiates a response at a desired performance level. Application of behavioral analysis to task analysis yields behavioral objectives for each level of subtask. Once these behavioral objectives have been defined they become the goals for training.

However, as mentioned earlier, it may not be possible to train for all tasks. Therefore, behavioral objectives should be developed for each task following the task selection process. (Vineberg and Joyner, 1980) Similar to breaking down a job into components in task analysis, the development of behavioral objectives results in a progressively more detailed analysis of behavior. Funaro and Mulligan (1978) suggest the relationships between the various levels of behavioral objectives can best be described using a pyramid model.

The top of the pyramid would represent the first level of behavioral objectives. Each subsequent level is an essential prerequisite to performing the behaviors listed at higher levels in the pyramid. This process can be continued until a suitable level of detail is reached.

Although this will provide a list of behaviors to be trained, a further clarification of what actually should be trained can be determined by comparing the existing level of training of entering trainees to the behavior objectives at a given level. In this way, training will be maximized by devoting training resources where they can best be utilized.

The development of a hierarchy of objectives is fundamental to the ISD methodology. It represents a shift in focus from analyzing what actions make up a task to analyzing what skills and knowledges are required to be learned to perform the task to a specified level of performance. In addition, this step reduces the possibility of overlooking lower levels of behavior that may lead to a weak training program. Throughout the remaining phases of the ISD model these objectives provide the focal point for the design and development of the training program.

IV. METHODOLOGY

Over the past two decades several techniques have been developed to determine the optimum design of equipment to improve the man-machine interface. In aviation three such techniques that have been developed are: Human Operator Simulation (HOS), Performance Assessment and Appraisal System (PAAS), and Mission Operability Assessment Technique (MOAT). The remaining sections of this chapter will present a summary of HOS and PAAS followed by a detailed discussion of MOAT.

A. HUMAN OPERATOR SIMULATION

The Human Operator Simulation (HOS) is a computer program designed to assist system engineers in determining man-machine design specifications for a developing system. The HOS program requires information concerning the operating parameters of the equipment to be tested. This information includes a description of how the equipment operates, the equipment utilization and tactics used to attain desired goals.

The HOS program is then used to simulate the actions of an operator of the equipment being tested. Therefore, by selecting specific tactical environments, the analyst can collect data concerning the man-machine performance. With this information critical design changes can be implemented in the early stages of development. Thus, application of the HOS program is therefore suitable in the early stages of system development. (Strieb and Wherry, 1979)

B. PERFORMANCE ASSESSMENT AND APPRAISAL SYSTEM

The Performance Assessment and Appraisal System (PAAS) is a computer-based training aid developed for use in conjunction with the Navy's Tactical Aircrew Combat Training System (Breidenbach, 1983). The PAAS program provides the user with a fast and efficient capability to make cumulative assessment and diagnostic evaluations of aircrew training performance. The system provides feedback to the user in the form of statistically summarized displays which are based upon a wide range of air combat training performance measures.

The information can be used for quality control feedback to assist training program administrators in evaluating the effectiveness of the training program. In addition, the aircrews receive precise feedback on their performance in the given air combat engagement. Thus, information presented in PAAS is oriented towards training instead of system development.

C. MISSION OPERABILITY ASSESSMENT TECHNIQUE

The Mission Operability Assessment Technique (MOAT) was designed to fill the gap between techniques that provide a method for indicating alternatives related to either the design or the training phase. Implementation of MOAT provides quantitative information about the operability of an entire system, the operability of a specific subsystem or the operability of each task performed during a mission phase. This information can then be used to select one or more tasks for improvement. In general, to obtain the desired improvements, changes may be made at the design level or the training level of weapon system development. In this study the results from application of MOAT will be used as inputs for the design phase of the ISD process.

1. Components of MOAT

The Mission Operability Assessment Technique approaches system evaluation through the application of three disciplines. The disciplines include: (1) task analysis, (2) multi-attribute utility theory (MAU), and (3) scaling theory. Through a combination of these disciplines a single measure of a system or subsystem can be obtained. This measure is referred to as the operability score. Figure 1 depicts the relationship of the three disciplines to systems evaluation (Helm and Donnell, 1979).

a. Task Analysis

Task analysis has previously been discussed in great detail. Although Helm and Donnell (1979) refer to task analysis as a process of developing a task hierarchy, the method and procedure for application are identical to task analysis discussed earlier.

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TASK ANALYSIS
===============>
                                                     SYSTEM
MAU                     MOAT                       EVALUATION
===============>                   =====>

SCALING THEORY
===============>
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Figure 1. MOAT Component Relationship

b. Multi-Attribute Utility Theory

The Mission Operability Assessment Technique utilizes multi-attribute utility theory (MAU) as a way to model the decision making process of a decision maker. Chatfield et al., (1978) describes MAU theory as a technique to investigate and explain the relationship between the utilities of the separate attributes of an alternative as well as the overall utility of the alternatives. In the application of MAU, the decision maker seeks to derive a global evaluation of a set of alternatives from the estimated utilities of their separate attributes.

Winterfeldt and Fischer (1973) discuss two major approaches to MAU assessment. Both provide for the existence of a utility function over multi-attributed alternatives which decompose into single attribute utility functions. The first approach was designed for decisions under risk. The utility function obtained with this approach preserves the decision maker's "riskless" preference order and may also be used in expected utility computations to select among risky alternatives. The second approach is the theory of conjoint measurement. Conjoint measurement simultaneously constructs the overall and single attribute utility functions and preserves the decision maker's preference ordering for riskless decisions. This approach cannot be applied to decisions under risk, where alternatives are not only multi-attributed but also uncertain. For the assessment of the two attribute MAU model Helm and Donnell (1979) utilizes conjoint measurement. Similarly, conjoint measurement was utilized in this study to assess the two attribute MAU model.

c. Conjoint Measurement

Conjoint measurement is a method that attempts to convert data on an ordinal scale into data on an interval scale. This is accomplished by first determining an algebraic rule that best fits the ordinal data. An appropriate algorithm is then utilized to convert this scale to a scale with interval properties. (Greene, 1983)

The algebraic rules for conjoint measurement can be broadly categorized into additive and multiplicative. The basic difference is the number of attributes included in the MAU model. When there are three or more attributes the multiplicative method may be more appropriate. However, the additive conjoint measurement method is best suited for a MAU model made up of two attributes. In addition, Chatfield et al., (1978) state that additive models are good approximations while McClelland (1978) states they are fairly robust and provide alternatives not perceptively different from more complex models.

For additive conjoint measurement, Luce and Tukey (1964) established four axioms that would be sufficient conditions for a two factor model. The four axioms cover: (a) weak order relationships, (b) solvability, (c) cancellation and (d) the Archimedian axiom. With these axioms, Luce and Tukey (1964) were able to prove the fundamental theorem of additive conjoint measurement.

Thus, with the four axioms that require only ordinal properties in the data and the theorem which guarantees the existence of a set of functions, numerical scale values can be assigned in such a way that: (1) the order among objects is preserved, (2) the levels of the factors on which the stimuli vary combine in an independent and additive fashion, and (3) the numerical scales have interval properties.

There are several computer packages that make use of additive conjoint measurement theory. These packages are suitable when working with large data bases. Selected packages are discussed by Greene (1983) and Nygren (1982). However, additive conjoint measurement theory can be implemented by hand. This method is called the delta scaling method and is suitable when working with small data bases. A detailed discussion and application of this method can be found in Appendix C of Helm and Donnell's (1979) paper on MOAT. Due to the small data base used in this study, the delta method will be used.

2. Application of MOAT

To keep this effort manageable, the analysis phase will concentrate on only one of the many missions that could be performed with the MH-53E. As mentioned earlier, the focus of the analysis will be on the pilot performing the magnetic mine countermeasures mission utilizing the MK-105 hydrofoil sled. However, to obtain an operability score for the MH-53E as a complete system, MOAT must be applied to all missions that can be identified.

a. Problem Analysis

The initial entry point into the ISD process begins with problem analysis. For the purposes of this report the MH-53E airborne minesweeping helicopter will be considered an emerging weapon system. Although technology for the MH-53E is based on previous versions of this model (e.g., CH-53D, RH-53D, etc.), there are significant differences in structural design and subsystems (i.e., engines, hydraulic system, etc.) that support the view that this helicopter can be considered an emerging weapon system. As of this writing, MH-53E helicopters are not employed for use in training or fleet operations. However, there currently exists a training program for the Navy's CH-53E that may be modified for training MH-53E pilots. In addition, there is a proposal for an MH-53E flight simulator, device 2F141. With this information it will be assumed that a suitable need analysis was performed.

b. Task Listing

The next step of the analysis phase required the development of a task listing. For weapon systems that exist the task listing can be easily performed on those tasks. However, for weapon systems that do not yet exist, task listing is somewhat more difficult. A suitable substitute is to use similar jobs that currently exist as a template. This refers to developing a task listing that is partially based on analysis of jobs or tasks that are similar. This procedure can provide a certain degree of guidance in performing the task listing. However, this procedure also requires the determination of when the similarities end and when an estimate of the tasks to be performed must be made.

One source of information for the listing, description and performance requirement of a task to be performed by a naval aviator in a given aircraft is the Naval Aviation Training and Operating Procedures (NATOPS) manual for that aircraft. This manual provides a detailed listing and description of certain maneuvers or missions to be performed by the pilot that are peculiar to that aircraft. As of this writing a NATOPS manual for the MH-53E has not been published.

Therefore, to perform the task listing the alternate method was utilized. Since the MK-105 is currently used with the RH-53D minesweeping helicopter, the NATOPS manual for this aircraft was used extensively as a template for the task listing. A key assumption being made is that the flight parameters of the MH-53E with the MK-105 will be essentially the same as the RH-53D with the MK-105.

After selecting the MK-105 mission an operational scenario had to be determined. To arrive at this scenario a hierarchical task structure was used. First, two scenarios were found to be applicable: land-based or ship-based operations. Choosing the ship-based category, a further dichotomy was required to determine on what type of ship the minesweeping operation will be based. This resulted in the listing of the following three classes of ships: LHA, LPD and LPH. The remaining subject matter expert's (SME) verified task listing is contained in Appendix B. This listing was based on selecting an LPH class ship and was conducted to the switchology level of detail (i.e., manipulation of switches on various instruments).

c. Task Verification

The next stage of the analysis required verification of the task analysis. The subject matter experts that were utilized were drawn from pilots of one of the two operational airborne minesweeping squadrons. Since the pilots in a squadron have various levels of experience measured by flight time and qualifications, a SME was defined as being an airborne mine countermeasures helicopter aircraft commander (AHAC). This qualification level requires the pilot to have demonstrated knowledge of the various airborne mine countermeasure systems in order to perform as mission commander of an airborne mine countermeasure mission.

The SME population consisted of five RH-53D pilots. Their qualifications are summarized by the following categorization of flight hour averages shown in Table I.

TABLE I

FLIGHT TIME (HOUR) SUMMARY OF SME

	Flight Time	Range
Mean Total Flight Time	1040	433-2100
Mean Total AMCM Mission Commander Time	315	0-1400
Mean Total Tow Time	91	30-160
Mean Total MK-105 Tow Time	24	4-40

d. Data Collection

Following the verification of the task listing the process of data collection may begin. It is essential that a task listing be verified prior to data collection. This ensures that numerical analysis will be performed on data that accurately represents the task, mission or job being studied. The result of performing analysis based on an unverified task listing will be faulty conclusions that result in a training program that does not meet the training goals as well as waste valuable resources.

The numerical analysis is based on a method of assigning weights to each task in the task listing. Helm and Donnell (1979) calls this the bottom up weighting (BUW) method. Bottom up weighting requires data collection on only those tasks at the bottom of the task listing. Since all higher level tasks are based on subtasks, an operability score can be calculated for each task level. The result of this method is a single operability score for the mission.

The weighting of the mean operability score is accomplished by use of the criticality ratings. Although this is an ordinal scale no attempt was made to convert criticality to an interval scale. Helm and Donnell (1979) recognized that operators' skills might vary, however, there should be only one standard for the criticality of a subtask as it relates to mission accomplishment. This single measure of criticality was taken to be the mean of the criticality ratings. This weighting scheme was shown to provide useful information for task selection in the F/A-18 and A-7E MOAT study.

In addition to collecting data on the bottom level tasks, data concerning the pilot's order preferences for various combinations of technical effectiveness and workload, the two factors in the MAU model, are required. Conjoint measurement was employed to transform this ordinal data into interval data. The transformed data were used to calculate the operability and effectiveness score.

e. Task Selection

The next step of the analysis phase involves selecting one or more tasks for training. This selection can be accomplished in three ways. This requires an analysis of the criticality, mean operability, and effectiveness score for each task.

The criticality of a task would at first appear to be a suitable indicator for task selection. In this case, the decision rule would be to select the task when criticality is high. However, using criticality as the sole criterion for task selection may result in a training program that over-emphasizes the criticality at the expense of the workload and equipment effectiveness. The mean operability score could also be used for task selection. In this case, tasks would be selected that had a low score.

However, relying on this score for task selection may ignore the criticality.

In order to reduce the risk of selecting a task without consideration of both criticality and operability, a measure including both of these scores should be used. This is accomplished by multiplying the mean operability and the normalized mean criticality to obtain an effectiveness score (Helm and Donnell, 1979). In addition, an overall effectiveness score for the system can also be calculated.

For a system to have an overall effectiveness score of 100 is to say the system has a perfect score. In short, no further improvement can be made in the technical effectiveness or workload-compensation-interference factors used in the MAU model. However, there exists room for improvement if the overall effectiveness score is less than 100.

When improvement is indicated, a deficit score can be calculated. The deficit of a task is used to assist in identifying those tasks that are in greatest need of improvement. With improvement of any or all of these tasks the overall effectiveness score and the operability for the mission will increase.

Thus far, the selection process described does not completely address the problem of task selection. Although tasks have been identified, the question still remains, how many tasks to select for training? This can best be answered by analyzing the percentage of contribution of the task to the overall deficit. Therefore, if a requirement exists to increase the overall effectiveness, say 10 percent, the number of task to select can be determined by summing the percentage of contribution until the 10 percent requirement is met.

Through the application of MOAT an attempt is made to provide the decision maker with a systematic procedure for the numerical analysis of a job, mission or task. The result of the analysis permits the decision maker to select a mission or set of tasks for training. However, it is important to note that the actual tasks and the number of tasks that are selected is subjective in nature. As mentioned earlier, these decisions may be strongly influenced by cost considerations and the availability of manpower and materials.

V. PRESENTATION OF DATA

The development of a task listing is a crucial step towards understanding the job and tasks being performed. However, to develop a training program it is important to know what skills and tasks need to be trained. This chapter will concentrate on task selection utilizing the Mission Operability Assessment Technique (MOAT).

A. QUESTIONNAIRE

In order to utilize MOAT, two questionnaires, Ranking Matrix and the Pilot Task Inventory (PTI), were required to collect the data. The data were collected from a population that consisted of 18 RH-53D pilots. However, data from eight pilots were deleted due to incomplete responses on the PTI or Ranking matrix. The qualifications of the ten pilots are summarized in Table II.

TABLE II

FLIGHT TIME (HOUR) SUMMARY OF SUBJECTS

	Flight Time	Range
Mean Total Flight Time	727	403-2100
Mean Total AMCM Mission Commander Time	102	0-800
Mean Total Tow Time	71	0-265
Mean Total KM-105 Tow Time	16	3-50

1. <u>The Ranking Matrix</u>

The Ranking Matrix asked each pilot to rank combinations of the various degrees of Workload-Compensation-Interference (WCI) and Technical Effectiveness (TE). The WCI consisted of four levels of workload imposed on the pilot. A value of one indicates an extreme workload, while a four indicates a very low workload. Similarly, TE consisted of four levels of equipment performance in successfully and safely attaining mission goals. The value of one indicates extremely poor equipment performance, while a four indicates superior equipment performance. A blank Ranking Matrix with instructions is contained in Appendix C. These combinations or cells of the matrix were ranked from best to worst on a scale of one to sixteen for a "typical" task. It was assumed that the rank order for the matrix across all pilots would not vary from task to task (Helm and Donnell, 1979).

The rankings were then aggregated across all pilots that completed the Ranking Matrix. For each cell, a mean and standard deviation were calculated. The rank order of the cells across all pilots was determined by the mean of each cell. The Ranking Matrix with this information is shown in Table III.

To determine if this matrix represented agreement among the pilots, a Chi-square test was performed. This tested the hypothesis that there was no agreement among the

TABLE III

MEAN, STANDARD DEVIATION AND RANK ORDER OF RANKING MATRIX CELLS

WORKLOAD/COMPENSATION/INTERFERENCE

TECHNICAL EFFECTIVENESS	(HI) 1	2	3	(LOW) 4
4 (HI)	8.20 3.65 8	10.90 2.47 11	13.80 1.55 14	16.00 0.00 16
3	5.80 3.36 5	8.40 2.07 9	11.50 1.51 13	14.10 0.99 15
2	3.50 2.22 3	6.30 1.64 6	8.90 1.60 10	11.10 2.51 12
1 (LOW)	1.10 .32 1	3.30 1.49 2	5.30 2.54 4	7.80 3.88 7

The first number in each cell is the mean rank order across all pilots. The second number is the standard deviation and the third number is the rank order of each cell based on the mean.

pilots about the rank ordering of the cells of the matrix. The results of the Chi-square test with 15 degrees of freedom and p = .01 was $X^2 = 127.6$. Therefore, the hypothesis was rejected and agreement among pilots was accepted.

To convert this ordinal scale to an interval scale, conjoint measurement and the delta method were employed. The matrix containing the interval scale is shown in Table IV. Table V shows the normalized (0-100) interval scale. The normalized matrix will be used in conjunction with the PTI to calculate the operability score for a rated task. For example, if a pilot rates a given task a four for TE and a three for WCI, then the operability score for that task will be 84.6.

2. The Pilot Task Inventory

The PTI utilized the task listing that was verified by the subject matter experts. The specific tasks that were rated were tasks at the bottom of the task hierarchical structure. These tasks were selected since all other higher level tasks are based on the lowest tasks.

The PTI for the MK-105 mission contained 94 tasks. The pilots were asked to rate each of the tasks for criticality, WCI and TE. The same definitions and rating scale described earlier for WCI and TE were used in the PTI. A rating scale of one (low) to five (high) was utilized for rating each task for criticality. The instruction set

TABLE IV

DELTA METHOD SOLUTION FOR RANKING MATRIX

WORKLOAD/COMPENSATION/INTERFERENCE

TECHNICAL EFFECTIVENESS	(HI) 1	2	3	(LOW) 4	
4 (HI)	59	79	99	117	59 (HI)
3	56	76	96	114	56
2	37	57	77	95	37
1 (LOW)	0	20	40	58	0 (LOW)
	(HI) 0	20	40	(LOW) 58	

TABLE V

NORMALIZED INTERVAL SCALE

WORKLOAD/COMPENSATION/INTERFERENCE

TECHNICAL EFFECTIVENESS	(HI) 1	2	3	(LOW) 4	
4 (HI)	50.4	67.5	84.6	100	50.4 (HI)
3	47.9	65	82.1	97.5	47.9
2	31.6	48.7	65.8	81.2	31.6
1 (LOW)	0	17.1	34.2	49.6	0 (LOW)
	(HI) 0	17.1	34.2	(LOW) 49.6	

suggested by Helm and Donnell (1979) was used without substantial modification. In Appendix D a blank PTI with accompanying instruction is presented.

B. RESULTS

The operability score for the mission was 74.6. This value was computed by use of the PTI and Task Listing. The bottom up weighting technique enables calculation of an operability score at higher level tasks of the task listing. To accomplish this the mean operability for a task is weighted or multiplied by the normalized criticality. Note that this normalized criticality is normalized at the given task level and not over the 94 tasks listed in the PTI. The products are then summed to calculate a mean operability score for the given task level. This score then becomes an input for the calculation of the mean operability score for the next higher task level. This process is repeated at each level until a single overall operability score is obtained. Appendix D contains the results of applying this procedure.

The calculation of the overall operability provides a method for estimating the operability of tasks that cannot be rated. In addition, this procedure allows a comparison of tasks that are on the same level. However, for decisions on task improvement the emphasis will be placed on the effective operability and deficit score.

The overall effectiveness of the mission was computed from the tasks listed in the PTI. The overall effectiveness score was 74.5 with an overall deficit in effective operability of 25.3. The overall effectiveness score was computed by weighting or multiplying the mean operability and the normalized mean criticality for each task. For this calculation the mean criticality was normalized over the 94 tasks in the PTI. The summation of these products were dived by 100 to obtain the overall effectiveness for the mission. The overall deficit in effective operability was computed by multiplying the mean criticality and the deficit for each task. The deficit in effective operability for a task was defined to be 100 minus the mean operability for a task. These products were then summed and divided by 100 to obtain the overall deficit score.

From the deficit calculations the percent of contribution of each task to the overall deficit can be made. Table VI contains the rank ordering of the 94 tasks by percentage of contribution. The rank ordering begins with the highest contribution and includes the sum of the contributions at a given task. This information is used to select tasks for training that will improve the effectiveness score.

TABLE VI

SUBTASK RANK ORDERING

Subtask	Task Label	Weighted Deficit	Contribution Percent	Contribution Sum
II.B.3	Perform Takeoff And Clear Ship	61.2	2.42	2.42
IV.C.2	Receive Radar Control	59.3	2.34	4.76
II.B.7.b	Place MK-105 At 6 o'clock Position	54.0	2.13	6.89
V.C.1	Operate Raydist Navigation Gear	52.8	2.09	8.98
VII.B	Perform Landing	51.3	2.03	11.01
V.C.2	Read Raydist Cockpit Indicator	44.6	1.96	12.97
IV.C.1	Plot Course	48.5	1.92	14.89
VII.A.6.b	Hover Over Deck Spot	47.3	1.87	16.76
VI.C.1	Operate Raydist Navigation Gear	44.9	1.77	18.53
II.B.6.a	Perform Right Hover Turn	43.8	1.73	20.26
IV.C.3	Read Raydist Cockpit Indicator	43.6	1.72	21.98
II.B.6.b	Perform Left Hover Turn	43.1	1.70	23.68
VII.A.1	Establish Inbound Course to Ship	42.4	1.68	25.36
III.D.2. a.i	Increase Tension to Normal Range	42.1	1.66	27.02
VII.A.2.b	Operate FM Radio	41.2	1.63	28.62
II.B.4.a	Establish 75 Foot Hover	40.0	1.58	30.23
II.B.2.b	Hover Over Deck Spot	38.4	1.52	31.75
II.B.7.a	Perform Voice Comm via ICS	37.7	1.49	33.24
V.B.2.a	Read Cockpit Skew Indicator	37.1	1.47	34.71
III.C.2.a	Receive Status of Magnetic Tails	36.9	1.46	36.17
VII.A.6.a	Perform Visual Comm	36.8	1.45	37.62
VII.A.3. c.i	Perform Visual Comm	35.2	1.39	39.01
VI.B.2.a	Read Cockpit Skew Indicator	33.4	1.32	40.33
II.B.5.b	Pass Control to Pilot in Right Seat	32.0	1.26	41.59
V.C..3	Receive Radar Control	31.8	1.26	42.85
II.B.4.b	Engage Radar Altimeter	30.3	1.2	44.05
IV.C.4	Receive Radar Control	30.3	1.20	45.25
I.B	Maintain Mission and Fuel Logs	30.2	1.19	46.44

TABLE VI (CONTINUED)

Subtask	Task Label	Weighted Deficit	Contribution Percent	Sum
VI.C.2	Read Raydist Cockpit Indicator	29.8	1.18	47.62
VII.A.3.b	Perform Landing Checklist	29.6	1.17	48.79
II.B.5.a	Pass Control to Pilot in Left Seat	29.2	1.15	49.94
III.D.1	Perform Voice Comm via ICS	27.1	1.10	51.04
III.D.2.c	Read Radar Altimeter for Altitude	27.5	1.09	52.13
VII.A.5. a.ii	Perform Visual Comm	27.4	1.08	53.21
I.A.2	Perform Visual Comm	27.1	1.07	54.28
III.D.2. a.ii	Read Cockpit Tension Indicator	27.1	1.07	55.35
VII.A.5. a.i.bb	Operate ICS	26.8	1.06	56.41
V.B.1	Read Cockpit Tension Indicator	26.6	1.05	57.46
III.C.2.b	Receive Status of MK-105	26.5	1.05	58.51
VII.A.2.a	Operate UHF Radio	26.3	1.04	59.55
IV.A.1.b	Operate FM Radio	25.5	1.01	60.56
VII.A.4. a.i	Reduce Tension	24.9	.98	61.54
VII.A.4. a.ii	Read Cockpit Tension Indicator	24.9	.98	62.52
VII.A.4. b.i	Read Cockpit Skew Indicator	24.6	.97	63.49
I.A.1.a	Operate UHF Radio	24.4	.96	64.45
VI.B.1	Read Cockpit Tension Indicator	24.3	.96	65.41
IV.B.2.b	Verify Skew Indicator	24.2	.96	66.37
VI.B.2.b	Visually Verify Skew Indicator	23.7	.94	67.31
VII.A.3.a	Perform Post AMCM Checklist	23.6	.93	68.24
IV.B.2.a	Read Cockpit Skew Indicator	23.5	.93	69.17
VI.D	Perform Landing Procedures	23.0	.91	70.08
IV.C.5	Read Heading Indicator	23.0	.91	70.99
IV.A.1.a	Operate UHF Radio	22.9	.90	71.89
III.A	Receive Report from Crewman "Ready to Commence Tow"	22.9	.9	72.79

TABLE VI (CONTINUED)

Subtask	Task Label	Weighted Deficit	Contribution Percent	Sum
III.D.2.b. ii.aa	Adjust Mirrors	22.5	.89	73.68
VI.A.1	Operate UHF Radio	22.2	.88	74.56
VI.C.3	Receive Radar Control	22.1	.87	75.43
III.B	Perform Forward Air Taxi	21.9	.87	76.30
I.C.3	Perform Takeoff Checklist	21.7	.86	77.16
III.D.2. b.ii.bb	Look at Outside Mirrors	21.2	.84	78.00
I.C.1	Perform AMCM Checklist	21.0	.83	78.83
IV.B.3	Read Radar Altimeter	20.8	.82	79.65
V.B.2.b	Visually Verify Skew Indicator	20.8	.82	80.47
I.C.2	Perform Pre-Takeoff Checklist	20.5	.81	81.28
VIII.B.1	Perform Visual Comm	20.4	.81	82.09
III.D.2. b.i	Read Cockpit Skew Indicator	20.2	.8	82.89
V.A.2	Operate ICS Radio	19.7	.78	83.67
III.D.2. b.ii.cc	Look at Cockpit Mirrors	19.5	.77	84.44
VII.A.3. c.ii	Perform Voice Comm on UHF Radio	19.0	.75	85.19
VII.A.4. b.ii	Visually Verify Skew Indicator	18.5	.73	85.92
VI.C.4	Receive Radar Control	18.3	.72	86.64
VI.B2.c	Read Radar Altimeter	18.2	.72	87.36
VII.A.5. a.i.aa	Operate UHF Radio	18.1	.72	88.08
V.C.4	Read Heading Indicator	17.9	.71	88.79
VI.A.2	Operate ICS Radio	17.5	.69	89.48
III.C.1	Operate UHF Radio	17.2	.68	90.16
II.B.2.a	Receive Hover Signal from LSO/LSE	17.2	.68	90.84
V.B.2.c	Read Radar Altimeter	16.2	.64	91.48
I.A.1.c	Operate ICS Radio	16.0	.63	92.11
VII.A.4.c	Read Radar Altimeter	15.4	.61	92.72
II.B.1	Receive Takeoff Signal from LSO/LSE	15.4	.61	93.33
II.A	Thumbs-up to LSO/LSE (ready to takeoff)	15.3	.60	93.93
VIII.A.1	Perform Visual Comm	15.2	.60	94.53
VIII.B.2	Perform MK-105 Refueling Checklist	15.1	.60	95.13
V.A.1	Operate UHF Radio	14.6	.58	95.71

TABLE VI (CONTINUED)

Subtask	Task Label	Weighted Deficit	Contribution Percent	Sum
I.A.1.a	Operate UHF Radio	13.8	.55	96.26
IV.A.2	Operate IFF Transponder	13.5	.53	96.79
VII.A.5.b	Disengage Radar Altimeter Prior to Elevator Deck Edge	13.0	.51	97.30
II.B.2.c	Perform Cockpit Check	12.4	.49	97.79
VIII.A.2	Perform Aircraft Refueling Checklist	12.1	.48	98.27
II.B.6.c	Raise Landing Gear	11.9	.47	98.74
I.A.3	Operate IFF Transponder	11.0	.43	99.17
IV.B.1	Read Cockpit Tension Indicator	10.7	.42	99.59
VIII.C	Perform Postflight Checklist	10.4	.41	100.00

Overall Deficit = 25.3

VI. DISCUSSION AND RECOMMENDATIONS

Through the application of MOAT the selection of tasks where improvement is needed, can be accomplished. This selection represents the output of the analysis phase. The result of the analysis phase now serves as an input for the design phase, the next phase of the ISD process.

The end result of MOAT is a rank ordering of the tasks that require the most improvement and provide the greatest impact on the operability and effectiveness of the system under study. The rank ordering of the 94 rated tasks presented in Table VI suggests that to eliminate approximately 50 percent of the overall deficit would require selection of the 32 highest ranked tasks. This represents 34 percent of the rated tasks.

Helm and Donnell (1979) state that improvements in operability and effectiveness can be achieved through this selection procedure. However, this also implies that each task is improved or trained as a separate unit or element. The implication of this procedure is that it may result in a set of tasks that are trained "out of context." This refers to training of tasks taking place without the interrelationships of other tasks that are directly associated with that task or subtask level.

Selection of tasks based on rank ordering may at times be appropriate. This is particularly true if each task is primarily unrelated or not directly influenced by other tasks. However, if tasks tend to be related or are directly influenced by other tasks then selection by rank ordering of individual tasks would not be appropriate. This later case applies to the MK-105 minesweeping mission as well as other missions of the RH-53D and MH-53E helicopters. What may not be readily apparent from the Task Listing for the MK-105 mission is that the execution of the tasks overlap with other tasks. The result is that several tasks are being performed at once or in very rapid succession. Thus, training by individual tasks will result in the trainee being able to perform the individual task. However, he will find it difficult if not impossible to adequately perform a series of tasks given a simulated or actual operational situation.

In an effort to account for the interrelationships of tasks, the rank ordered tasks could be grouped by similarity of tasks. An example of this would be to group together all the tasks labeled Perform Visual Communication. Although this task is performed several times, the task is performed at different points during the mission. In addition, the same information is not being conveyed during the occurrence of each task. Therefore, what at first appeared to be a reasonable solution still does not account for significant variations in performing the tasks.

An alternative approach would be to analyze the contribution to the deficit by each of the major flight segments. This approach does not contradict the concept of task decomposition utilized in the development of a task listing and maintains the interrelationship among tasks. The deficit contribution could be calculated by adding the contribution of each of the subtasks within that flight segment. The result of this approach is presented in Table VII.

TABLE VII

RANK ORDERING OF MAJOR FLIGHT SEGMENTS

Major Flight Segment	Contribution Percent	Sum
Landing	21.58	21.58
Takeoff and Prepare for Tow	19.03	40.61
Transit to the Minefield	13.66	54.27
Commence Tow	13.18	67.45
Towing Within Minefield	11.36	78.81
Transit to the Ship	10.96	89.77
Pre-launch	7.33	97.10
Post-flight	2.90	100.00

This approach suggests that to eliminate 40 percent of the deficit the top two flight segments from Table VII should be selected. These segments contain 34 tasks and therefore would appear to be less efficient at reducing the overall deficit. However, the advantage is that all tasks that are related to a specific flight segment are selected for training as a unit. Recognizing that tasks within flight segments are not of equal importance, those tasks that have a high contribution to the deficit could be emphasized during training. Tasks grouped in this manner maintain the interrelationship among the tasks and will lead to the development of a training program that will better prepare the pilot for the mission.

With the proposal of the MH-53E cockpit flight simulator, device 2F141, a portion of the design phase has been completed. To effectively utilize the capabilities of this device and to provide valuable training for airborne minesweeping pilots for the MK-105 magnetic minesweeping mission, it is recommended that a training program be designed based on the results presented in Table VII. The effort should concentrate on course organization, course sequencing, lesson and format specification.

APPENDIX A

TASK LISTING

Operator: RH53-D pilot.
Mission: MK-105 mission conducted from the number two elevator of an LPH class ship. Aircraft positioned on spot mike with engine and rotors engaged and single-point performance check complete. MK-105 and magtails streamed from number two elevator with tow cable faked out on deck. Initially, MK-105 and aircraft fully fueled.

TASK	CONDITION
I. Prelaunch	
A. Perform communication	Briefed on communication plan; operational radios
1. Perform voice communication	Operational radios; requirement to communicate with controlling agencies, other aircraft, or crew members
a. Operate UHF	Operational UHF
b. Operate FM	Operational FM
c. Operate ICS	Operational ICS
2. Perform visual communication	Presence of flight deck and aircraft maintenance personnel
3. Operate IFF transponder	Operational transponder
B. Maintain mission and fuel logs	Briefed on mission and fuel load

C. Perform checklists	Takeoff required; possession of AMCM and NATOPS PCL
1. Perform AMCM checklist	Aircraft configured for mission and possession of AMCM PCL
2. Perform pre-takeoff checklist	Possession of NATOPS PCL
3. Perform takeoff checklist	Possession of NATOPS PCL
D. Perform takeoff procedures	Aircraft ready for flight: MK-105 ready, AMCM and NATOPS PCL complete
II. Takeoff and prepare for tow	
A. Perform visual communication	Give thumbs-up signal when ready for takeoff; check lights on pri-fly
B. Perform takeoff and clear ship	Aircraft operating within limits of power, weather, and weight restrictions
1. Perform visual communication	LSO/LSE are giving takeoff signal
2. Perform hover	Takeoff complete
a. Perform visual communication	LSO/LSE are giving hover signal
b. Perform hover over deck spot	Aircraft 10 to 15 feet above deck level
c. Perform cockpit check	Aircraft in a hover; operational engine, transmission, hydraulic, fuel flow, and performance instruments

3. Perform hover taxi rearward	Aircraft in a hover; LSO/LSE giving rearward taxi signal; tow cable clear of deck edge and obstructions.
4. Perform hover over water	Aircraft is clear of ship
a. Establish 75 foot hover	Radar and barometric altimeters operational
b. Engage radar altimeter	AFCS and radar altimeter operational
5. Pass physical control of aircraft to other pilot	Aircraft in a hover and a left or right turn required to parallel ship into wind; use of ship as visual reference
a. Pass control to pilot in left seat	Pilot in right seat has control; right turn required to parallel ship into wind
b. Pass control to pilot in right seat	Pilot in left seat has control; left turn required to parallel ship into wind
6. Perform hover turn	Aircraft in a hover and wind from left or right relative to aircraft heading
a. Perform right hover turn about the tail to parallel ship into the wind	Wind from right side of aircraft; MK-105 in position for aircraft to turn right
b. Perform left hover turn about the tail to parallel ship into the wind	Wind from left side of aircraft; MK-105 position for aircraft to turn left

c. Raise landing gear	Operational landing gear
7. Perform sideward hover	MK-105 not at six o'clock position relative to aircraft
a. Perform voice communication via ICS	Briefed on communication plan; operational ICS
b. Place MK-105 at six o'clock position relative to helicopter	MK-105 not at six o'clock position
III. Commence tow	
A. Perform voice communication via ICS	Receive report from crewman "ready to commence tow operations"
B. Perform forward air taxi	Normal power available; engine and performance instruments within limits; MK-105 in six o'clock position relative to aircraft heading
C. Perform voice communication	Operational radios; communicate with controlling agencies, other aircraft or crew members
1. Operate UHF	Operational UHF
2. Operate ICS	Operational ICS
a. Receive status of magnetic tails	Magnetic tails are trailing properly
b. Receive status of MK-105	MK-105 configured for the mission

D. Perform tow procedures	MK-105 in six o'clock position relative to aircraft heading and configured for mission
1. Perform voice communication via ICS	Briefed on communication plan; operational ICS
2. Maintain tow parameters	Briefed on mission configuration; operational tow indicator system
a. Attain desired tension	Briefed on mission configuration; possession of AMCM PCL
i. Increase tension to normal range	MK-105 system functioning properly and in six o'clock position; aircrew ready to commence tow; possession of AMCM PCL
ii. Read cockpit tension indicator	Operational tow system and tension indicator
b. Maintain normal skew	Possession of AMCM PCL
i. Read cockpit skew indicator	Operational tow system and skew indicator
ii. Verify skew indicator	Briefed on mission
aa. Adjust mirrors	Operational mirrors
bb. Look at outside mirrors	Mirror adjusted
cc. Look at cockpit mirrors	Mirror adjusted

c. Read radar altimeter for altitude	Operational AFCS and radar altimeter
IV. Transit to the minefield	
A. Perform communication	Briefed on communication plan; operational radios
1. Perform voice communication	Requirement to communicate with controlling agencies, and other aircraft
a. Operate UHF	Operational UHF
b. Operate FM	Operate FM
2. Operate IFF transponder	Operational transponder
B. Maintain tow Parameters	Briefed on mission configuration; operational tow indicator system
1. Read cockpit tension indicator	Briefed on mission configuration; possession of AMCM PCL; operational tow system and tension indicator
2. Maintain normal skew	Possession of AMCM PCL
a. Read cockpit skew indicator	Operational tow system and skew indicator
b. Verify skew indicator	Mirrors operational and properly adjusted
3. Read radar altimeter	Briefed on mission; possession of AMCM PCL; operational AFCS and radar altimeter

C. Perform navigation	Briefed on mission; possession of oceanographic charts; Raydist navigation system operational
1. Plot course	Know position and destination; possession of oceanographic charts
2. Operate Raydist navigation gear	Briefed on minefield coordinates and assignment; operational Raydist navigation system
3. Read Raydist cockpit indicator	Operational AFCS hover indicator
4. Receive radar control	Radar coverage available; operational UHF
5. Read heading indicator	Heading to fly; operational BDHI and magnetic compass
V. Towing within the minefield	Briefed on mission operating area
A. Perform voice communication	Operational radios; requirement to communicate with controlling agencies, other aircraft or other crew members
1. Operate UHF	Operational UHF
2. Operate ICS	Operational ICS
B. Maintain tow parameters	Briefed on mission configuration; operational tow indicator system

	1. Read cockpit tension indicator	Briefed on mission configuration; possession of AMCM PCL; operational tow system and tension indicator
	2. Maintain normal skew	Possession of AMCM PCL
	a. Read cockpit skew indicator	Operational tow system and skew indicator
	b. Visually verify skew indicator	Operational mirrors
	c. Read radar altimeter for altitude	Briefed on mission; possession of AMCM PCL; operational AFCS and radar altimeter
C.	Perform navigation	Briefed on mission; possession of oceanographic charts; Raydist navigation system operational
	1. Operate Raydist navigation gear	Briefed on minefield coordinates and minefield assignment; operational Raydist navigation system
	2. Read Raydist cockpit indicator	Operational AFCS hover indicator
	3. Receive radar control	Radar coverage available; operational UHF
	4. Read heading indicator	Heading to fly; operational BDHI and magnetic compass

VI. Transit to the ship	Briefed on mission
A. Perform voice communication	Operational radios; requirement to communicate with controlling agencies, other aircraft, or crew members
1. Operate UHF	Operational UHF
2. Operate ICS	Operational ICS
B. Maintain tow parameters	Briefed on mission configuration; operational tow indicator system
1. Read cockpit tension indicator	Briefed on mission configuration; possession of AMCM PCL; operational tow system and tension indicator
2. Maintain normal skew	Possession of AMCM PCL
a. Read cockpit skew indicator	Operational tow system and skew indicator
b. Visually verify skew indicator	Operational mirrors
c. Read radar altimeter for altitude	Briefed on mission; possession of AMCM PCL; operational AFCS and radar altimeter
C. Perform navigation	Briefed on mission; possession of oceanographic charts; Raydist navigation system operational
1. Operate Raydist navigation gear	Operational Raydist navigation system
2. Read Raydist cockpit indicator	Operational AFCS hover indicator

3. Receive radar control	Radar coverage available and operational UHF
4. Read heading indicator	Heading to fly; operational BDHI and magnetic compass
D. Perform landing procedures	Transit to ship is complete; clearance received to proceed for landing
VII. Landing	
A. Perform approach	Briefed on mission, course rules of operating area, course rules of LPH
1. Establish inbound course perpendicular to ship's number two elevator	Briefed on mission; clearance received to proceed with approach
2. Perform voice communication	Requirement to communicate with controlling agencies and other aircraft
a. Operate UHF	Operational UHF
b. Operate FM	Operational FM
3. Perform checklists	Landing required; possession of AMCM PCL and NATOPS PCL
a. Perform post AMCM checklist	Possession of AMCM PCL
b. Perform landing checklist	Possession of NATOPS PCL
c. Perform communication	Briefed on communication plan; operational radios
i. Perform visual communication	LSO/LSE are giving signal to continue

ii. Perform voice communication on UHF	Requirement to communicate with controlling agency or other aircraft; operational UHF
4. Maintain tow parameters	Briefed on mission configuration; operational tow indicator system
a. Monitor tension	Possession of AMCM PCL
i. Reduce Tension	Possession of AMCM PCL
ii. Read cockpit tension indicator	Operational tow system and tension indicator
b. Maintain normal skew	Possession of AMCM PCL
i. Read cockpit skew indicator	Operational tow system and skew indicator
ii. Visually verify skew indicator	Operational mirrors
c. Read radar altimeter for altitude	Briefed on mission; possession of AMCM PCL; operational AFCS and radar altimeter
5. Perform forward air taxi	Aircraft in hover; normal power available; engine and performance instruments within limits; MK-105 in recovery position
a. Perform communication	Briefed on communication plan; operational radios

i. Perform voice communication	Operational radios; requirement to communicate with controlling agencies, crew members, and other aircraft
aa. Operate UHF	Operational UHF
bb. Operate ICS	Operational ICS
ii. Perform visual communication	LSO/LSE are giving signal to continue
b. Disengage Radar altimeter prior to elevator deck edge	Operational AFCS and radar altimeter; possession of AMCM PCL
6. Perform hover over deck spot	Aircraft operating limits within weight and weather restrictions
a. Perform visual communication	LSO/LSE are giving hover signal
b. Hover over deck spot	Aircraft 10 to 15 feet above deck level
B. Perform landing	Clearance to land; LSO/LSE are giving signal to land; post AMCM and landing checklist complete
VIII. Postflight	Mission complete
A. Perform refueling of aircraft and/or MK-105	Aircraft and MK-105 require refueling
1. Perform visual communication	LSO/LSE present to receive refuel signal
2. Perform aircraft refueling checklist	Possession of NATOPS PCL
B. Perform MK-105 refueling checklist	Aircraft requires refueling
1. Perform visual communication	LSO/LSE present to receive refuel signal

2. Perform aircraft refueling checklist	Possession of NATOPS PCL
3. Perform MK-105 refueling checklist	Possession of AMCM PCL
C. Perform postflight checklist	Possession of NATOPS PCL

APPENDIX B

WCI/TE RANKING MATRIX

1. INTRODUCTION

The WCI/TE rating matrix shown on the following page represents the relationship of workload-compensation-interference (WCI) and technical effectiveness (TE) in successfully and safely attaining mission goals. The WCI scale reflects the workload imposed upon the operator--the value of 1 indicates an extreme workload, while the value of 4 indicates a very low workload. The TE scale reflects the role of equipment in successfully and safely attaining mission goals--the value of 1 indicates extremely poor equipment performance, while the value of 4 indicates superior equipment performance.

For example, cell position (1,1), the lower left corner, represents a combination of low technical effectiveness and extreme workload-compensation-interference. In contrast, cell position (4,4), the upper right corner, reflects a combination of high technical effectiveness and low workload-compensation-interference.

2. INSTRUCTIONS

Rank each of the sixteen cells in the order of importance where a one (1) represents the least important and a sixteen (16) represents the most important. When you have completed this task, each cell should contain a number between one and sixteen, and no two cells should contain the same number. This subjective ordering will be combined with the rank orderings provided by other RH-53D pilots and used to analyze pilot rating responses to the task analysis of the MK-105 minesweeping mission.

WCI/TE RANKING MATRIX

TECHNICAL EFFECTIVENESS

	1	2	3	4	
Multiple Tasks Integrated					4
Design Enhances Specific Task Accomplishment					3
Adequate Performance Achievable: Design Sufficient to Specific Task					2
Inadequate Performance Due to Technical Design					1
	Workload Extreme; Compensation Extreme; Interference Extreme	Workload High; Compensation High; Interference High	Workload Moderate; Compensation Moderate; Interference Moderate	Workload Low; Compensation Low; Interference Low	

WORKLOAD/COMPENSATION/INTERFERENCE
(Mental and Physical)

APPENDIX C

PILOT TASK INVENTORY

Instructions for Rating The MK-105 Task Analysis

1. CRITICALITY

Definition: How important is it that the pilot be able to perform the given task in order to successfully and safely complete the MK-105 minesweeping mission?

Scale Values:

One (1) indicates a very small importance. Ability to perform this task as compared to other tasks in this duty is unimportant, or almost unimportant, in order to successfully complete the MK-105 minesweeping mission.

Two (2) indicates a small importance. The task within this duty is less important than most tasks required to successfully and safely complete the MK-105 minesweeping mission.

Three indicates (3) a moderate importance. The task within this duty is about as important as most tasks required to successfully and safely complete the MK-105 minesweeping mission.

Four indicates (4) a substantial importance. The task within this duty is more important than most tasks required to successfully and safely complete the MK-105 minesweeping mission.

Five indicates (5) a very substantial importance. The task within this duty is extremely important in order to successfully and safely complete the MK-105 minesweeping mission.

2. WORKLOAD/COMPENSATION/INTERFERENCE (MENTAL & PHYSICAL)

Definition: How great is the workload, how much effort or compensation is required to maintain satisfactory performance, and how much does the workload interfere with the successful and safe completion of the task?

Scale Values:

One (1) indicates Workload extreme, compensation extreme, interference extreme.

Two (2) indicates Workload high, compensation high, interference high.

Three (3) indicates Workload moderate, compensation moderate, interference moderate.

Four (4) indicates Workload low, compensation low, interference low.

3. TECHNICAL EFFECTIVENESS

Definition: What is the contribution of equipment performance in the successful and safe completion of the task?

Scale Values:

One (1) indicates inadequate performance due to technical design.

Two (2) indicates adequate performance achievable; design sufficient to specific task.

Three (3) indicates design enhances specific task accomplishment.

Four (4) indicates multiple tasks are integrated.

MK-105 Task Analysis

Operator: RH53-D pilot.

Mission: MK-105 mission conducted from the number two elevator of an LPH class ship. Aircraft positioned on spot mike with engine and rotors engaged and single-point performance check complete. MK-105 and magtails streamed from number two elevator with tow cable faked out on deck. Initially, MK-105 and aircraft fully fueled.

TASK	C (1-5) (LO-HI)	WCI (1-4) (HI-LO)	TE (1-4) (LO-HI)
I. Prelaunch			
A. Perform communication			
1. Perform voice communication			
a. Operate UHF	____	____	____
b. Operate FM	____	____	____
c. Operate ICS	____	____	____
2. Perform visual communication	____	____	____
3. Operate IFF transponder	____	____	____
B. Maintain mission and fuel logs	____	____	____
C. Perform checklists			
1. Perform AMCM checklist	____	____	____
2. Perform pre-takeoff checklist	____	____	____
3. Perform takeoff checklist	____	____	____

II. Takeoff and prepare for tow

A. Thumbs-up to LSO/LSE ____ ____ ____

B. Perform takeoff and clear ship

1. Receive take-off signal from LSO/LSE ____ ____ ____

2. Perform hover

a. Receive hover signal from LSO/LSE ____ ____ ____

b. Perform hover over deck spot ____ ____ ____

c. Perform cockpit check ____ ____ ____

3. Perform hover taxi rearward ____ ____ ____

4. Perform hover over water

a. Establish 75 foot hover ____ ____ ____

b. Engage radar altimeter ____ ____ ____

5. Pass physical control of aircraft to other pilot

a. Pass control to pilot in left seat ____ ____ ____

b. Pass control to pilot in right seat ____ ____ ____

6. Perform hover turn

a. Perform right hover turn about the tail to parallel ship into the wind ____ ____ ____

b. Perform left hover turn about the tail to parallel ship into the wind ____ ____ ____

c. Raise landing gear ____ ____ ____

7. Perform sideward hover

a. Perform voice communication via ICS ____ ____ ____

b. Place MK-105 at six o'clock position relative to helicopter ____ ____ ____

III. Commence tow

A. Receive report from crewman "ready to commence tow operations" ____ ____ ____

B. Perform forward air taxi ____ ____ ____

C. Perform voice communication

1. Operate UHF ____ ____ ____

2. Operate ICS ____ ____ ____

a. Receive status of magnetic tails ____ ____ ____

b. Receive status of MK-105 ____ ____ ____

D. Perform tow procedures

1. Perform voice communication via ICS ____ ____ ____

2. Maintain tow parameters

a. Attain desired tension

i. Increase tension to normal range ____ ____ ____

ii. Read cockpit tension indicator ____ ____ ____

b. Maintain normal skew

i. Read cockpit skew indicator ____ ____ ____

ii. Verify skew indicator

aa. Adjust mirrors ____ ____ ____

bb. Look at outside mirrors ____ ____ ____

cc. Look at cockpit mirrors ____ ____ ____

c. Read radar altimeter for altitude ____ ____ ____

IV. Transit to the minefield

A. Perform communication

1. Perform voice communication ____ ____ ____

a. Operate UHF

b. Operate FM ____ ____ ____

2. Operate IFF transponder ____ ____ ____

B. Maintain tow Parameters

1. Read cockpit tension indicator ____ ____ ____

2. Maintain normal skew

a. Read cockpit skew indicator ____ ____ ____

b. Verify skew indicator ____ ____ ____

3. Read radar altimeter ____ ____ ____

C. Perform navigation

1. Plot course ____ ____ ____

2. Operate Raydist navigation gear ____ ____ ____

3. Read Raydist cockpit indicator ____ ____ ____

4. Receive radar control ____ ____ ____

5. Read heading indicator ____ ____ ____

V. Towing within the minefield

A. Perform voice communication

1. Operate UHF ____ ____ ____

2. Operate ICS ____ ____ ____

B. Maintain tow parameters

1. Read cockpit tension indicator ____ ____ ____

2. Maintain normal skew

a. Read cockpit skew indicator ____ ____ ____

b. Visually verify skew indicator ____ ____ ____

c. Read radar altimeter for altitude ____ ____ ____

C. Perform navigation

1. Operate Raydist navigation gear ____ ____ ____

2. Read Raydist cockpit indicator ____ ____ ____

3. Receive radar control ____ ____ ____

4. Read heading indicator ____ ____ ____

VI. Transit to the ship

A. Perform voice communication

1. Operate UHF ____ ____ ____

2. Operate ICS ____ ____ ____

B. Maintain tow parameters

1. Read cockpit tension indicator ____ ____ ____

2. Maintain normal skew

a. Read cockpit skew indicator ____ ____ ____

b. Visually verify skew indicator ____ ____ ____

c. Read radar altimeter for altitude ____ ____ ____

C. Perform navigation

1. Operate Raydist navigation gear ____ ____ ____

2. Read Raydist cockpit indicator ____ ____ ____

3. Receive radar control ____ ____ ____

4. Read heading indicator ____ ____ ____

D. Perform landing procedures ____ ____ ____

VII. Landing

A. Perform approach

1. Establish inbound course perpendicular to ship's number two elevator ____ ____ ____

2. Perform voice communication

a. Operate UHF ____ ____ ____

b. Operate FM ____ ____ ____

3. Perform checklists

a. Perform post AMCM checklist ____ ____ ____

b. Perform landing checklist ____ ____ ____

c. Perform communication

i. Perform visual communication ____ ____ ____

ii. Perform voice communication on UHF ____ ____ ____

4. Maintain tow parameters

   a. Monitor tension

      i. Reduce Tension ____ ____ ____

      ii. Read cockpit tension indicator ____ ____ ____

   b. Maintain normal skew

      i. Read cockpit skew indicator ____ ____ ____

      ii. Visually verify skew indicator ____ ____ ____

   c. Read radar altimeter for altitude ____ ____ ____

5. Perform forward air taxi

   a. Perform communication

      i. Perform voice communication

         aa. Operate UHF ____ ____ ____

         bb. Operate ICS ____ ____ ____

      ii. Perform visual communication ____ ____ ____

b. Disengage Radar altimeter prior to elevator deck edge ____ ____ ____

6. Perform hover over deck spot

a. Perform visual communication ____ ____ ____

b. Hover over deck spot ____ ____ ____

B. Perform landing ____ ____ ____

VIII. Postflight

A. Perform refueling of aircraft

1. Perform visual communication ____ ____ ____

2. Perform aircraft refueling checklist ____ ____ ____

B. Perform refueling of MK-105

1. Perform visual communication ____ ____ ____

2. Perform MK-105 refueling checklist ____ ____ ____

C. Perform postflight checklist ____ ____ ____

APPENDIX D

MK-105 MISSION OPERABILITY

Subtask	Task Label	N.C.[1]	M.O.[2]	W.M.O.[3]
I	Prelaunch	.08	79.1	6.3
II	Takeoff and Prepare for Tow	.16	68.3	10.9
III	Commence Tow	.14	76.2	10.7
IV	Transit to Minefield	.12	71.6	8.6
V	Towing Within the Minefield	.11	72.4	8.0
VI	Transit to the Ship	.12	76.6	9.2
VII	Landing	.22	75.7	16.7
VIII	Postflight	.05	83.5	4.2
MK-105 Mission Operability				74.6
I	Prelaunch			
A	Perform Communication	.52	80.0	41.6
B	Maintain Mission and Fuel Logs	.08	59.2	4.7
C	Perform Checklists	.40	82.1	32.8
Total				79.1
I.A	Prelaunch			
1	Perform Voice Comm	.74	84.3	62.4
2	Perform Visual Comm	.18	67.3	12.1
3	Operate IFF Transponder	.08	68.7	5.5
Total				80.0
I.A.1	Perform Voice Comm			
a	Operate UHF Radio	.31	87.0	27.0
b	Operate FM Radio	.31	77.0	23.9
c	Operate ICS Radio	.38	87.8	33.4
Total				84.3
I.C	Perform Checklist			
1	Perform AMCM Checklist	.33	82.2	27.1
2	Perform Pre-Takeoff Checklist	.33	82.2	27.1
3	Perform Takeoff Checklist	.34	82.2	27.9
Total				82.1

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[1]N.C. = Normalized Criticality.

[2]M.O. = Mean Operability.

[3]W.M.O. = Weighted Mean Operability.

Subtask	Task Label	N.C.	M.O.	W.M.O.
II	Takeoff and Prepare for Tow			
A	Thumbs-up to LSO/LSE	.05	82.2	4.1
B	Perform Takeoff and Clear Ship	.95	67.6	64.2
Total				68.3
II.B	Perform Takeoff and Clear Ship			
1	Receive Takeoff Signal from LSO/LSE	.06	82.1	4.9
2	Perform Hover	.20	75.2	15.0
3	Perform Hover Taxi Rearward	.10	57.5	5.6
4	Establish Hover Over Water	.16	69.9	11.2
5	Pass Physical Control of Aircraft to Other Pilot	.12	64.5	7.7
6	Perform Hover Turn	.19	65.7	12.5
7	Perform Sideward Hover	.17	63.1	10.7
Total				67.6
II.B.2	Perform Hover			
a	Receive Hover Signal from LSO/LSE	.29	82.1	23.8
b	Perform Hover Over Deck Spot	.36	67.5	24.3
c	Perform Cockpit Check	.35	77.4	27.1
Total				75.2
II.B.4	Perform Hover Water			
a	Establish 75 Foot Hover	.53	68.0	36.0
b	Engage Radar Altimeter	.47	72.2	33.9
Total				69.9
II.B.5	Pass Physical Control of Aircraft to Other Pilot			
a	Pass Control to Pilot in Left Seat	.50	66.1	33.1
b	Pass Control to Pilot in Right Seat	.50	62.8	31.4
Total				64.5

Subtask	Task Label	N.C.	M.O.	W.M.O.
II.B.6	Perform Hover Turn			
a	Perform Right Hover Turn	.39	60.9	23.8
b	Perform Left Hover Turn	.40	62.5	25.0
c	Raise Landing Gear	.21	80.5	16.9
Total				65.7
II.B.7	Perform Sideward Hover			
a	Perform Voice Comm via ICS	.46	67.2	30.9
b	Place MK-105 at 6 o'clock Position	.54	59.7	32.2
Total				63.1
III	Commence Tow			
A	Receive Report from Crewman "Ready to Commence Tow"	.08	80.6	6.5
B	Perform Forward Air Taxi	.07	77.2	5.4
C	Perform Voice Comm	.25	77.1	19.3
D	Perform Tow Procedures	.60	75.0	45.0
Total				76.2
III.C	Perform Voice Comm			
1	Operate UHF Radio	.26	80.9	21.0
2	Operate ICS Radio	.74	75.8	56.1
Total				77.1
III.C.2	Operate ICS Radio			
a	Receive Status of Magnetic Tails	.50	70.5	35.4
b	Receive Status of MK-105	.50	78.8	39.4
Total				75.8
III.D	Perform Tow Procedures			
1	Perform Voice Comm vis ICS	.14	75.7	10.6
2	Maintain Tow Parameters	.86	74.9	64.4
Total				75.0

Subtask	Task Label	N.C.	M.O.	W.M.O.
III.D.2	Maintain Tow Parameters			
a	Attain Desired Tension	.34	71.7	24.4
b	Maintain Normal Skew	.51	77.2	39.4
c	Read Radar Altimeter for Altitude	.15	74.1	11.1
Total				74.9
III.D.2.a	Attain Desired Tension			
i	Increase Tension to Normal Range	.53	67.9	36.0
ii	Read Cockpit Tension Indicator	.47	75.9	35.7
Total				71.7
III.D.2.b	Maintain Normal Skew			
i	Read Cockpit Skew Indicator	.33	82.9	27.4
ii	Verify Skew Indicator	.67	74.4	49.8
Total				77.2
III.D.2. b.ii	Verify Skew Indicator			
aa	Adjust Mirrors	.35	73.9	25.9
bb	Look at Outside Mirrors	.35	75.4	26.4
cc	Look at Cockpit Mirrors	.30	73.6	22.1
Total				74.4
IV	Transit to Minefield			
A	Perform Comm	.18	71.9	12.9
B	Maintain to Parameters	.36	81.9	29.5
C	Perform Navigation	.46	63.4	29.2
Total				71.6
IV.A	Perform Comm			
1	Perform Voice Comm	.74	70.3	52.0
2	Operate IFF Transponder	.26	76.7	19.9
Total				71.9
IV.A.1	Perform Voice Comm			
a	Operate UHF Radio	.53	73.4	38.9
b	Operate FM Radio	.47	66.9	31.4
Total				70.4

Subtask	Task Label	N.C.	M.O.	W.M.O.
IV.B	Maintain Tow Parameters			
1	Read Cockpit Tension Indicator	.27	90.7	24.5
2	Maintain Normal Skew	.50	78.4	39.2
3	Read Radar Altimeter	.23	79.0	18.2
Total				81.9
IV.B.2	Maintain Normal Skew			
a	Read Cockpit Skew Indicator	.55	80.7	44.4
b	Verify Skew Indicator	.45	75.6	34.0
Total				78.4
IV.C	Perform Navigation			
1	Plot Course	.21	57.8	12.1
2	Operate Raydist Navigation Gear	.22	52.6	11.6
3	Read Raydist Cockpit Indicator	.22	64.3	14.2
4	Receive Radar Control	.17	67.4	11.5
5	Read Heading Indicator	.18	77.5	14.0
Total				63.4
V	Towing within the Minefield			
A	Perform Voice Comm	.18	81.9	14.7
B	Maintain Tow Parameters	.41	76.5	31.4
C	Perform Navigation	.41	64.2	26.3
Total				72.4
V.A	Perform Voice Comm			
1	Operate UHF Radio	.42	81.8	34.4
2	Operate ICS Radio	.58	81.9	47.5
Total				81.9
V.B	Maintain Tow Parameters			
1	Read Cockpit Tension Indicator	.28	77.5	21.7
2	Maintain Normal Skew	.72	76.1	54.8
Total				76.5

Subtask	Task Label	N.C.	M.O.	W.M.O.
V.B.2	Maintain Normal Skew			
a	Read Cockpit Skew Indicator	.37	67.7	25.0
b	Verify Skew Indicator	.31	78.3	24.3
c	Read Radar Altimeter for Altitude	.32	83.6	26.8
Total				76.1
V.C	Perform Navigation			
1	Operate Raydist Navigation Gear	.26	52.9	13.8
2	Read Raydist Cockpit Indicator	.28	58.0	16.2
3	Receive Radar Control	.26	70.8	18.4
4	Read Heading Indicator	.20	79.2	15.8
Total				64.2
VI	Transit to the Ship			
A	Perform Voice Comm	.20	83.0	16.6
B	Maintain tow Parameters	.36	76.3	27.5
C	Perform Navigation	.33	71.0	23.4
D	Perform Landing Procedures	.11	82.8	9.1
Total				76.6
VI.A	Perform Voice Comm			
1	Operate UHF Radio	.49	80.7	39.5
2	Operate ICS Radio	.51	85.2	43.5
Total				83.0
VI.B	Maintain Tow Parameters			
1	Read Cockpit Tension Indicator	.27	78.9	21.3
2	Maintain Normal Skew	.73	75.4	55.0
Total				76.3
VI.B.2	Maintain Normal Skew			
a	Read Cockpit Skew Indicator	.38	71.0	27.0
b	Verify Skew Indicator	.31	75.3	23.3
c	Read Radar Altimeter for Altitude	.31	81.0	25.1
Total				74.4

Subtask	Task Label	N.C.	M.O.	W.M.O.
VI.C	Perform Navigation			
1	Operate Raydist Navigation Gear	.27	57.6	15.6
2	Read Raydist Cockpit Indicator	.24	69.0	16.6
3	Receive Radar Control	.23	76.2	17.5
4	Read Heading Indicator	.26	82.1	21.3
Total				71.0
VII	Landing			
A	Perform Approach	.93	76.6	71.2
B	Perform Landing	.07	64.4	4.5
Total				75.7
VII.A	Perform Approach			
1	Establish Inbound Course to Ship	.06	67.6	4.1
2	Perform Voice Comm	.11	69.9	7.7
3	Perform Checklist	.23	77.3	17.8
4	Maintain tow Parameters	.26	80.3	20.9
5	Perform Forward Air Taxi	.22	81.7	18.0
6	Perform Hover Over Deck Spot	.12	67.2	8.1
Total				76.6
VII.A.2	Perform Voice Comm			
1	Operate UHF Radio	.49	75.9	37.2
2	Operate FM Radio	.51	64.2	32.7
Total				76.6
VII.A.3	Perform Checklists			
a	Perform Post AMCM Checklist	.24	78.9	18.9
b	Perform Landing Checklist	.28	77.4	21.7
c	Perform Communication	.48	76.4	36.7
Total				77.3
VII.A.3.c	Perform Comm			
i	Perform Visual Comm	.49	68.6	33.6
ii	Perform Voice Comm on UHF Radio	.51	83.9	42.8
Total				76.4

Subtask	Task Label	N.C.	M.O.	W.M.O.
VII.A.4	Maintain Tow Parameters			
a	Monitor Tension	.43	80.1	34.4
b	Maintain Normal Skew	.36	77.5	27.9
c	Read Radar Altimeter for Altitude	.21	85.9	18.0
Total				80.3
VII.A.4.a	Monitor Tension			
i	Reduce Tension	.54	80.1	43.3
ii	Read Cockpit Tension Indicator	.46	80.1	36.8
Total				80.1
VII.A.4.b	Maintain Normal Skew			
i	Read Cockpit Skew Indicator	.55	76.8	42.2
ii	Visually Verify Skew Indicator	.45	78.5	35.3
Total				77.5
VII.A.5	Perform Forward Air Taxi			
a	Perform Comm	.72	78.5	56.5
b	Disengage Radar Altimeter Prior to Elevator Deck Edge	.28	90.1	25.2
Total				81.7
VII.A.5.a	Perform Comm			
i	Perform Voice Comm	.67	80.0	53.6
ii	Perform Visual Comm	.33	75.5	24.9
Total				78.5
VII.A.5. a.i	Perform Voice comm			
aa	Operate UHF Radio	.46	82.3	37.9
bb	Operate ICS Radio	.54	78.0	42.1
Total				80.0
VII.A.6	Perform Hover Over Deck Spot			
a	Perform Visual Comm	.49	70.6	34.6
b	Hover Over Deck Spot	.51	63.9	32.6
Total				67.2

Subtask	Task Label	N.C.	M.O.	W.M.O.
VIII	Postflight			
A	Perform Refueling of Aircraft	.39	34.3	32.9
B	Perform Refueling of MK-105	.40	79.3	31.9
C	Perform Postflight Inspection	.21	39.2	13.7
Total				33.5
VIII.A	Perform Refueling of Aircraft			
1	Perform Visual Comm	.46	81.0	37.3
2	Perform Aircraft Refueling Checklist	.54	87.0	47.0
Total				84.3
VIII.B	Perform Refueling of MK-105			
1	Perform Visual Comm	.51	77.3	39.4
2	Perform MK-105 Refueling Checklist	.49	32.5	40.4
Total				79.3

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