SIMULATION OF THE OCEAN ENVIRONMENT

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INTRODUCTION

When attempting to simulate the ocean environment, we are in effect trying to duplicate a dynamic medium with a range of variables as follows:

(1) Surface temperatures ranging from 80 degrees F in the Gulf Stream to the mid twenties in the Arctic while bottom temperatures are in the mid-thirties throughout.

(2) Depths varying from zero to over 5,000 fathoms in a rather random fashion so that the deepest depths do not occur as would be expected in the middle of the oceans.

(3) Salinities range from low values of three parts per thousand in inland and Arctic waters to more common twenty-six parts per thousand in coastal areas and maximum value about thirty-seven parts per thousand in the open oceans.

(4) Temperature changes with depth can range from an increase of up to 5 degrees F for each ten feet, to decreases of 20 degrees F in ten feet with the added complication that gradient values may change in quantity, and sign with each ten foot increment. Thus a vertical profile of temperature can be very complicated especially in the shallow depths at which no temperature variability is confined. A complete change in gradient arrangement may sometimes be found only ten miles apart in the open and as close as one mile apart in selected areas, such as along the mouth wall of a strong thermal current, namely the interface surface between cold and warm water near the origin of the Gulf Stream. There is also an always present complicated microthermal structure to be considered.

(5) Added to the already complicated medium, a mixing factor caused by variable surface waves which range from zero to 30 or 40 feet high and result in new combinations of variables and new vertical thermal structures constantly being rearranged. Other factors which require inclusion in the simulated medium are: (1) currents, other than major thermal currents, (2) meteorological effects, (3) geographical effects such as water color and turbidity, and (4) biological effects. The amount of change in the ocean variables accompanying these effects would

depend on the original value of the variable, the geographical location of the variable, and the rate of change the variable is presently undergoing.

This medium then, when simulated must be capable of producing realistic effects upon simulated vehicles, viewing systems, operations and electronic devices which duplicate the in-site effect of the real ocean on real operational equipment. A way to accomplish simulation of the ocean environment is possible by simulating parts of the environment for their effect on various types of equipment. A breakdown of environmental parts for simulation could be, but is not limited to: (1) physical ocean effects on equipment, (2) underwater viewing conditions, and (3) dynamic ocean processes.

SIMULATION OF OCEAN PHYSICAL EFFECTS

The ocean's physical effect influences all Navy sea operations, from the landing of an aircraft on a carrier deck to accurate fire control, or to the tracking and classification of an underwater target. Simulators for training in the above-mentioned operations must consider the physical effect of the ocean plus the operational problems encountered with change from one ocean condition to another. Most large training devices today are sophisticated to the point of including a computer. Into a computer can be programmed models capable of simulating ocean effects on the device operation.

A device such as the Ship Docking trainer is one which requires the effect of ship motion and drift resulting from wave height or sea state. Mathematical relations have been developed describing motions of various hull shapes to varying amounts of wave height. Motion studies are carried out at David Taylor Model Basin using scale models of Navy ships in a large wave tank. With the determined equations of motions due to wave height for individual hull shapes in the computer, the trainee can experience typical reactions for that type of hull in encountering the stated wave heights.

In the case of sonar, a physical effect of the environment is to either limit its range capability to almost nil or enhance the range greatly. Here again, mathematical models are used in the simulator to produce the environmental effects; these models, however, are rather theoretical. First attempts to model the environment for sonar, required assumptions which proved to be invalid and resulted in models which were representative of a too general ocean rather than a real ocean. These models provided tracking experience in the simulator, but in nonoperational conditions, thus newly trained sonar operators have encountered difficulty when tracking in the real world environment after training. The environmental parameters having the greatest effect on sonar is water temperature and temperature gradient with depth. One attempt to make the models more representative is to consider only small geographical areas of the ocean and develop models for its characteristics. This will result in more software packages accompanying the simulator; however, the resulting increase in efficiency for training should more than compensate for the added cost and handling problems. A future simulator installation located on the west coast then could contain math models of the environment typical of the Eastern North Pacific and not concern itself with conditions typical of the North Atlantic. Thus, the simulated environment will represent the ambient conditions with which the trainee will have to contend, and therefore result in more realistic training.

The simulation of depths or pressure effects is usually accomplished by mechanical means. Some items used in this simulation are decompression chambers, pools, tanks and even old 16" gun barrels as used by the NRL Sound Reference Laboratory here in Orlando. This type of simulation is used to test and calibrate underwater equipment, also to acquaint divers with uncomfortableness and hazards of underwater work. The simulation of this portion of the environment is already a highly developed art.

SIMULATION OF OCEAN BOTTOM VIEWING

The simulation of ocean bottom viewing for shallow depths has been accomplished very capably with color motion pictures and color wide angle still photography. These films are used for diver instruction orientation and in periscope viewing simulation. Simulated viewing of the ocean bottom from near the surface to 6,000 foot depths, which is the operating depth of Alvin type vehicles, is being developed in conjunction with our Underwater Terrain Navigation and Reconnaissance Simulator being constructed by Amecom, a Division of Litton Industries.

The foremost problem in simulating a view of the deep ocean is to consider what is available for viewing at depth and what are the viewing conditions. Aside from the shadow of the submersible's tender and a fish or two near the surface, generally no views of interest are available to a submersible operator during descent until the bottom is approached. Reasons why no view is available during descent is the lack of a visual reference point in empty water, plus the fact that natural light fades to dark below depths of more than 200 feet, and artificial lights designed for viewing are usually not operated until near the bottom in order to conserve battery power. As the submersible cruises from ten to thirty feet above the ocean bottom one must consider the viewing conditions. In order to see at great depths artificial light must be provided. However, the brightest lights available are not the answer as suspended particles in the water will cause some light to be scattered back toward the viewer thus reducing the visibility. This is partly alleviated by using blue green light. Water of unusual clarity will provide a viewing distance of approximately 200 feet. Generally the turbidity from any of a number of causes can further reduce the depth of field from an expected 60 feet or so to a condition where the porthole appears to be painted black. Bottom features, usually sharp at shallow depths, become less sharp in the deep ocean and result in a loss of contrast.

Simulation of this condition will be handled in the following amnner. Within a 15'x15' water tank there will be placed a 10'x10' rearrangeable terrain model, in full color, containing varied bathymetric features, all reduced to a 60 to 1 scale. The submersible simulator's trainee cab will be mounted on support structures above the water tank. The tank when filled will provide up to three feet of water. One optical head pickup is suspended mechanically from the trainee cab into the water and will present a view of the terrain model. The image will be relayed to the trainee cab by an optical train and will be presented to a simulated porthole. The system will allow the scene presented to the pick-up head to be viewed by the trainee operator as if it were directly outside the viewing port of the submersible. Under good viewing conditions a scale depth of field of about 60 feet is available, which is the approximate depth of field for good conditions in the ocean. By means of reducing light, adding dyes to the water, introducing small plastic particles to the water and causing chemical reactions, degrees of scattering and turbidity typical of those encountered for the type of bottom can be controlled.

Two other viewing systems will be provided the simulator. These systems are a closed circuit television and a mounted still camera. The TV system will be tied in with optical system for porthole viewing. The operator will have the same controls as in the real world situation. Television resolution and contrast will be commensurate with that of operation systems under varying conditions of turbidity and scattering. The TV picture will be black and white as very little will be gained for the increased cost of color; also TV systems in most submersibles are black and white.

The 35mm still camera with automatic film advance will be incorporated into the direct viewing optical system, and will permit the trainee to view and photograph sections of the model terrain when desired. An interrupter mirror will divert the image rays from the eyepiece to the camera lens during the short interval the camera shutter is open. In some operational craft the photographs do not match the porthole views because the cameras are mounted at an angle to the porthole. It is common practice for an operator to take pictures through the porthole for reference and better orientation. A hand held polaroid camera will be provided in the simulator for the taking of pictures through the porthole.

A unique part of the submersible simulator is the fact that it is completely up to the trainee operator. This unprogrammed feature presented a problem on obstacle avoidance sonar which requires a terrain feature display according to the heading and depth of the vehicle. An optical device is used to simulate the sonar display. A smaller scale terrain model, but exact duplicate as to location of features, is placed in a light tight box. A TV camera is mounted over the model in the same manner as the student cab above the large model to provide the camera the same motions as the cab. Positive drive control is provided so that the student cab and the sonar simulator TV camera are always exactly over the same point on their individual models. A light source rotating through 360° is located directly below the TV camera. Translation and attitude of the student cab is provided for the light source so that the portion of the model illuminated will be equivalent to the sonar beam in the live situation. The scan rate of the light source is proportional to the scan rate of a live sonar. Control will be provided the trainee operator for manual or automatic scan. A high contract ratio is used in the TV system so that areas not directly illuminated will be black. The TV image then is transferred to a simulated PPI display using a P7 phosphor as in real sonar CRTs so that the optical spectrum and phosphor decay rate will be proportional to those of the real sonar. The operational obstacle avoidance sonar has the capability of three range settings. This feature will be simulated by equipping the TV camera with three lenses of different focal lengths for simulated maximum ranges of 50, 100 and 200 feet.

SIMULATION OF OCEAN PROCESSES

The study of ocean effects on ships and offshore installations can be enhanced by simulation of the dynamic ocean processes and measurement of their scaled effects on ships or offshore installation models. The most obvious ocean dynamic property is waves. They are simulated in large wave tanks at various locales such as those at David Taylor Model Basin and at Florida University at Gainesville. These huge wave tanks are suitable for the study of the effect of waves on sonar beams, erosion of beaches and breakwaters, or as already mentioned, the development of hull motion equations due to wave parameters. An ideal simulator has been developed by NAVTRADEVCEN for wave studies on a smaller scale, called the Model Ocean Wave and Current Generator. With an overall length of only sixteen feet, this Wave Tank can be accomodated within most laboratory buildings. Although small in size the generator is capable of producing waves equivalent to sea state 7. Mixing processes due to wave action can be studied by the addition of dyes or small plastic particles to make the mixing action visible. Thermal current diffusion and mixing may be studied since provision has been made to inject dyes with heated water at any desired depth. Wind shearing studies on waves can be accomplished using a calibrated blower across known wave heights. Waves, currents and eddies caused by underwater obstructions and topography may be studied by placing models of the obstructions in the tank. The Model Ocean Wave and Current Generator is a device capable of simulating simultaneously several dynamic ocean processes to aid in the study of their interactions and interrelationships.

CONCLUSION

The oceans of the world can be described as a vast and complex medium constantly in a state of change for which simulation is a most difficult task. Partial simulation can be accomplished, and in most cases is highly effective. Environmental effects can be programmed into training devices as described for the ship docking trainer. Terrain models in a water environment can duplicate bottom features, which, together with dyes and chemicals in the water, will simulate the physical aspects and characteristics of any geographical location. In the same manner electro-optical or electro-mechanical techniques can be utilized to provide many of the ocean's dynamic parameters either singly or in combinations. It is when we attempt to simulate in one package all the ocean's parameters and effects, over all geographical locations that chaos can result.

PROVISIONING AND ITS RELATIONSHIP TO THE END ITEM

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Within the NMC (Naval Material Command) establishment, the "Provisioning Process" can be considered as a cycle which starts when the need for the equipment is generated and it is closed when the new equipment reaches the field with its supporting repair parts and support equipment (tools and test equipment).

Provisioning is one of the most unique of all logistic support areas because its elements cross many functional and organizational lines of both the contractor and Government activities. Of the many support elements, repair parts and support equipment are among the most significant. Provisioning serves one major purpose -- providing adequate initial material support for the end item.

Department of Defense Instruction 3232.4 states that: -- The principal objective of provisioning in the Department of Defense is to assure that initial spares and repair parts (including tools and test equipment) required to support and maintain end items of material being introduced into service will be available in the appropriate Military Supply System(s) and at maintenance echelons when needed. Our objective is to complete the provisioning cycle sufficiently in advance of device delivery, to permit item identification, source coding, cataloging, parts and support equipment selections and procurement of items to insure concurrent delivery, of required material, with each new training device.

The following brief description of the life cycle of a typical training device should lead to a better understanding of the relationship between provisioning and the end item program.

(1) Project Establishment. This phase is concerned with identifying, reviewing, coordinating and approving the military need for development of new training devices. During this phase, TDP (Technical Development Plan), (MC) Military Characteristics, specifications, maintenance plans and material requirements are prepared. A feasibility study, if required, may be conducted during this period.

(2) Development/Production. This phase covers the entire spectrum of development and design efforts, resulting in training equipments (prototype, preproduction models and/or production models).

(3) Deployment and In-Service Use - After completion of tests, delivery is made in accordance with deployment requirements for the training device program.

(4) Disposal. A training device whose service life is complete is classified as obsolete and disposed of as required by Navy regulations.

This brings up the question -- Where do the activities of provisioning fit into the life cycle of a training device? Historically, formal provisioning has been viewed as starting with the award of the contract; however, NAVTRADEVCEN through its Training Device Integrated Logistic Support Program begins the provisioning process long before contract award. In many cases, personnel who are engaged in the project establishment phase are the same individuals who participate in provisioning. Also it is important to understand the close relationship between maintenance and provisioning. Certain actions performed in the maintenance engineering program have a direct relationship to provisioning, for example - design and development, preparation of maintenance support plans, and accomplishment of maintenance evaluations. Although it is generally agreed that provisioning should be initiated as early in the program as possible, often times in the past, the projection of provisioning requirements, actions and time frames have been somewhat inadequate. In programs with a high degree of design change activity, early participation carries certain calculated risks. However, the penalties of early participation must be weighed against the inherent long-range savings in time and thereby timely support, all of which emphasizes the critical need for careful and deliberate provisioning planning. Personnel responsible for planning must, as soon as possible, become familiar with the overall program timing to identify significant milestones, which determine when provisioning events can be initiated and when they must be completed.

There are two basic time elements to be considered in discussing the actual provisioning cycle: Establishment of the program time frame parameters in which the provisioning program processes must be performed, and programming the occurrence of specific provisioning events within this time frame. These elements will be discussed later in greater detail. The period in which provisioning must be accomplished varies with the type of program. Types of training device end item programs existing today range from those consisting of complex research and development, test and production, to those involving commercial items. The length of the phases within a program vary; therefore provisioning planning, the early identification, scheduling, communication and control of all provisioning tasks and objectives, provide for the development of a program tailored to each training device acquisition.

Planning has been said to involve "choosing between alternatives." Frequently it tends to become stereotyped or to be governed by the requirements and time periods of existing specifications and procedures. It is highly unrealistic to consider a series of procedures which establish a set of "boiler plate" requirements and time periods unrelated to an actual training device program schedule as a substitute for planning. Training Device projects vary in many ways, e.g., number of line items, complexity, production leadtime, or drawing release schedule. Because the programs vary greatly, planning obviously cannot be static. A plan used on one program should not be applied to another without first examining it thoroughly for suitability. Planners should recognize that each program is unique and that tasks and schedules must be developed specifically for each program.

The Naval Training Device Center approach to provisioning is a "tailored provisioning" concept, using the philosophy contained in the Integrated Logistic Support For Training Devices (NAVTRADEVCEN Bulletin 40-1A). Under this approach, provisioning requirements, methods and schedules are tailored -- through careful analysis within a framework of policy and regulation - to fit each individual program. This precludes the wholesale use and application of "boiler plate" requirements for all programs. Each training device requiring provisioning is examined in the light of its equipment and program characteristics in an effort to identify those significant provisioning requirements, methods and schedules that will achieve the desired support in the most timely and efficient manner.

One of the important phases of provisioning planning is the establishment of contractual requirements. Provisioning Technical Documentation as well as other contractual requirements are specified in the PRS (Provisioning Requirements Statement), NAVSUP Form 1319 and made a part of the TPR (Technical Proposal Requirement) and the contract. Military Specification MIL-P-21873 (NAVY) provides the instructions for preparation of PTD (Provisioning Technical Documentation) requirements. In some programs, because of the device or program complexity and peculiarities training device contractors will be required to:

(1) Provide interim support for a specified period of time as set forth in NAVTRADEVCEN Bulletin 40-1A.

(2) Perform Provisioning Screening in accordance with MIL-P-84000A.

(3) Apply "Phased Provisioning" in accordance with DODINST 4140.19 and MIL-P-38785. Phased provisioning is a management refinement to the provisioning process whereby procurement of all or a part of the total computed quantity of selected items is deferred until the later stages of production, thereby enhancing the ability of the provisioning activities to more reliably predict requirement.

(4) Recommend and enter SM&R (Source, Maintenance and Recoverability) codes on MEARS (Maintenance Engineering Analysis Records) and/or the PPL (Provisioning Parts List) for each item. SM&R Codes are listed and identified in NAVSUP Instruction 4423.14.

(5) Recommend procurement action codes in accordance with NAVMAT Instruction 4200.34B, DOD Hi-Dollar Spare Parts Breakout Program.

(6) Submit each PPL in increments, provided that such increments comprise no less than a complete component. Where design stabilization or production scheduling is by components, training device contractors should not withhold submission of provisioning technical documentation for one component until completion of subsequent components, equipments or the complete system unless such added increments are required for clarity of evaluation. Partial PTD submissions must be made at the earliest date consistent with the requirement and intent of the PRS and training device contract. In the event that a training device contractor cannot comply with the PTD incremental submission (progres-

sive provisioning) routine established by NAVTRADEVCEN, the contractor should notify NAVTRADEVCEN to permit renegotiation of the time schedule for adequate and complete processing of PTD to allow delivery of material concurrent with the end item (training device).

The second and the most important phase of provisioning is "Provisioning Scheduling." The objective of provisioning scheduling is the development of a detailed time schedule of both Government and training device contractor actions needed to achieve the desired types of initial support equipment and parts delivery to the device user. This can and must be accomplished by programming specific provisioning events within the program time frame in which the provisioning process must occur. Six important training device program milestones must be identified in establishing parameters for the provisioning cycle:

(1) Award of Contract
(2) Drawing (data) release schedule
(3) Production parts release
(4) Initial parts support delivery
(5) Training Device Delivery
(6) Training Device Deployment

The relationship to the overall end item (training device) and provisioning program is that, finally, the individually scheduled functions must be joined to form an overall provisioning schedule which must be coordinated within the overall training device program schedule. Provisioning, being one of the most unique logistic support areas, must, therefore, be given the same priority, scheduling and intensified management by the contractor as is applied to the end item (device) being fabricated to meet a specified Navy RFT (Ready for Training Date). Only by applying the six milestones will provisioning serve the one major purpose -- providing adequate initial material support for the training device concurrent with delivery of the end item.

A discussion of provisioning and its relationship to the end item is not complete without mention of budgeting, since the fund requirements are directly related to the total end item (device) cost. Even though the sources of provisioning funds vary, the basic process of determining "how much" remains the same. Because of the uncertainties involved in provisioning, restraints must be placed on the amount of material that may be procured. The support equipment and repair parts procured during initial provisioning will be limited to those few maintenance significant items required for all categories of maintenance. Repair parts procured concurrently with the end item are normally limited to those required to full initial allowance, pipeline and replacement requirements until normal Navy replenishment procedures can provide required support. This allows time to obtain knowledge on new repair parts requirements for new items before beginning quantity procurements of the parts which will sustain the training device through its normal operating life cycle to the disposal phase.

Perhaps the best way to summarize the relationship of the provisioning process to the end item is -- the start and completion of the provisioning process will vary from one item to another and from one training device to another. The constant variety coupled with the requirement that the provisioning cycle be completed sufficiently in advance of device delivery to insure concurrent delivery of required material with each new training device -- makes provisioning the challenge it is today.