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Virtual Environment Training for Engineering (VET-E):
Material Readiness Assessment

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13. ABSTRACT *(Maximum 200 words)*

The Virtual Environment Training for Engineering (VET-E) project was conducted for the Chief of Naval Operations (OPNAV, N869). This work was sponsored by the Bureau of Naval Personnel (PERS-OOH). The operational goal was to develop a training environment that would enable engineering officers to adequately assess the material condition of a ship's propulsion plant. The technical goal was to: (1) develop and demonstrate desktop virtual environment (VE) training for the prospective engineering officer, (2) select and demonstrate the instructional strategies necessary for training material assessment in a virtual environment (VE), and (3) demonstrate the effectiveness of VE technology in improving the performance of Engineering Officers. This report documents the technical approach, instructional approach, and evaluation plan for VET-E. The project will be completed by Naval Air Warfare Command, Training Systems Division (NAWCTSD), Orlando, FL, following the Transfer of Function of the Navy Personnel Research and Development Center, Classroom and Afloat Training Division, effective 1 February 1998.

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Forward

The Virtual Environment Training for Engineering (VET-E) project was conducted under Program Element 0603707N for the Chief of Naval Operations (OPNAV, N869). This work was sponsored by the Bureau of Naval Personnel (PERS-OOH). The goal of this effort was to develop a training environment that would enable engineering officers to adequately assess the material condition of a ship's propulsion plant. This report covers the technical approach, instructional approach, and evaluation plan for VET-E. This project will be completed by Naval Air Warfare Command, Training Systems Division (NAWCTSD), Orlando, FL, following the Transfer of Function of the Navy Personnel Research and Development Center, Classroom and Afloat Training Division, effective 1 February 1998.

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Ms. April Moranville, Principal Investigator

Mr. Donald Hewitt, Project Assistant

Dr. Michael Cowen, Principal Investigator

This project also benefited from the expertise, enthusiasm, and support of the subject matter experts from the Department Head School Prospective Engineering Officer Course, Surface Warfare Officer School, Newport, RI, and those Commander Naval Surface Force Pacific personnel who are listed below. These professionals spent countless hours ensuring the fidelity and accuracy of the VET-E instructional materials:

LCDR David Eastwood

LT Michael Samuelson

LT J. A. Jurata

LTJG Loren Smith

References to "the project team" in this report are inclusive of contributions which may have been made by any of the individuals above, the project contractors, or members of the Implementation Planning Group (IPG) chaired by N869T4.

Summary

Background

The inability to train Chief Engineering Officers (CHENGs) to properly assess the material readiness of their propulsion plants was identified as a deficiency by the Chief of Naval Operations (N869) in FY95. Time, costs, and material considerations have limited the ability of the training community to provide extensive hands-on material assessment opportunities to reinforce classroom training conducted in the Department Head, Prospective Engineering Officer (PEO) course, at the Surface Warfare Officer School (SWOS), Newport, RI. This deficiency has been noted in Operational Propulsion Plant Examination (OPPE) results, Department Head Discharge for Cause data, and Engineering Training Group (ETG) training visits. The lack of adequate training has resulted in engineers being "relieved for cause," equipment casualties, lost operating time, and costly repairs. Existing training capabilities have not been sufficient to resolve the problem.

Objective

The objectives are to: (1) develop and demonstrate desktop virtual environment (VE) training for the prospective engineering officer, (2) select and demonstrate the instructional strategies necessary for training material assessment in a virtual environment (VE), and (3) demonstrate the effectiveness of VE technology in improving the performance of Engineering Officers.

Approach

The project team selected a case-based approach to this training by developing training scenarios for use within a virtual engineering space that will provide the student engineering officer with an opportunity to build on prior knowledge and experience to recognize material discrepancies and take appropriate corrective action.

Project Status

The team first obtained and reviewed the terminal and enabling objectives for the PEO course and for the "Hot Plant" course at Naval Training Center, Great Lakes, IL. It was determined that material readiness assessment is not specifically addressed in the existing curriculum, although the tools to conduct such assessments are provided in the curriculum. The team then reviewed recent Propulsion Examination Board (PEB) reports with the assistance of personnel from Instructional Science and Development, Inc. A thorough review of the capabilities and limitations of available virtual environment technologies was then conducted. Immersive environments were rejected in favor of the non-immersive desktop personal computer (PC) environment due to insufficient fidelity and the potential adverse effects of motion sickness in the immersive environment. Navigation through a three-dimensional, modeled engineering space on the PC was adequate in light of the requirement for the engineering officer to navigate and remain oriented in the engineering spaces. Although the fidelity was still less than optimal to meet a requirement to read dials, gauges, tags, stencils, etc., it was still better than that

available in head-mounted displays (HMDs). In addition, the PC had greater ease of use and lower cost.

Research Triangle Institute (RTI) was contracted to develop a three-dimensional modeled environment based on the 3D computer-assisted design (CAD) drawings of the Arleigh Burke class destroyer (DDG51) obtained from a third party contractor. The technology to do this did not exist at the outset of this project. As the state of technology improved over the life of the program, RTI was able to create a second rendering of the environment using 2D digital images taken from a physical DDG51 propulsion plant. Discrepancies could be "painted" into the digital environment. It also became possible to incorporate the content of some 2D drawings into the original modeled environment. Measures of performance (MOP) and measures of effectiveness (MOE) for material assessment training were identified, and two initial training scenarios were created. These incorporated the common discrepancies found in the PEB review. With instructor modeling and guidance, the student will identify and prioritize these discrepancies and propose a plan of action to resolve each one. It is hypothesized that students using the desktop VE to perform material assessment in a case-based setting will perform better than students using either conventional, paper-based visuals alone or conventional, paper-based visuals with a case-based approach to material assessment.

An evaluation plan was developed, and the results will be analyzed both quantitatively and qualitatively. A draft life cycle support plan was also produced. The evaluation plan is ready to be executed. It is anticipated the evaluation can be completed within FY98.

Recommendations

This product should be evaluated and recommendations provided to SWOS, N869, and PERS-00H. The digital imagery technology shows promise for the development of inexpensive training for environments where complex equipment with significant safety and operational requirements precludes use of actual systems. The modeled technology should be further developed as improved visual resolution becomes available for low-cost training delivery systems.

Status to Date

The VET-E project was transferred in its final year to NAWCTSD, Orlando, FL. The transfer is the result of the NPRDC Training Department function being transferred to NAWCTSD as a consequence of BRAC 95. The foregoing materials describe the background and status of the project as of the 5th of December, 1997. The future direction and development of the project will be determined by NAWCTSD, in concert with the membership of the IPG.

Table of Contents

List of Figures

Introduction

Problem

The inability to train Chief Engineering Officers (CHENGs) to properly assess the material readiness of their propulsion plants was identified as a deficiency by the Chief of Naval Operations (N869) in FY95. Time, costs, and material considerations have limited the ability of the training community to provide extensive hands-on material assessment opportunities to reinforce classroom training at the Surface Warfare Officer School (SWOS), Newport, RI. This deficiency has been noted in Operational Propulsion Plant Examination (OPPE) results, Department Head Discharge for Cause data, and Engineering Training Group (ETG) training visits. The lack of adequate training has resulted in engineers being "relieved for cause." equipment casualties, lost operating time, and costly repairs. Existing training capabilities have not been sufficient to resolve the problem.

Objective

The objective was to experimentally evaluate the feasibility of using case-based training methods with a "desktop" virtual environment to conduct material readiness assessment training for Prospective Engineering Officers (PEOs) in the Department Head course at SWOS, Newport, RI.

Background

An N969 requirement, in FY95, directed the development of a training program that provides (1) a simulation of the propulsion plant environment to provide hands-on material assessment capability in the schoolhouse and (2) a training methodology that uses engineering casualty experiences that identify the material readiness condition of the propulsion plant.

Implementation Planning Group

An Implementation Planning Group (IPG) was established by the N869 Project Officer in FY95. The IPG ensures that the research effort remains responsive to a valid requirement and serves as the planning vehicle by which the transition of products developed through the advanced development process reach operational use. IPG responsibilities and membership are outlined by the OP-01 MPT Research and Development Project Officer's Guidebook. The IPG, chaired by N869T4, included Navy Personnel Research and Development Center (NAVPERSRANDCEN Code 131); Bureau of Personnel (PERS-00H); Chief of Naval Education and Training (CNET T23); SWOS, Code 61; Naval Sea Systems Command (NAVSEASYSCOM 042); NAVSEASYSCOM (PMS 400 F32); Commander Naval Surface Force Pacific (COMNAVSURFPAC N813); and Office of Naval Research (ONR 342B).

Material Assessment

To ensure full compliance with their duties, as specified in the Standard Organization and Regulations of the U.S. Navy, and elsewhere, Engineering Department personnel are responsible for identifying and correcting equipment deficiencies in their spaces. Frequently this takes the form of a "walk-through" of the engineering spaces in response to specific problems and to determine the status of work in progress. Examples of material readiness deficiencies include, but are not limited to, gauges reflecting out-of-parameter conditions, excessive pump leak off, blown gaskets, and safety hazards.

Technologies

A case-based instructional strategy combined with a "desktop" virtual environment was selected to deliver material assessment training. The training problem is not limited to the Prospective Engineering Officer's timely assessment of the material condition of the propulsion plant. Retention of what has been learned is also an issue given the limited opportunity to practice under realistically simulated conditions. In work reported by Semb and Ellis (1994), it was found that instructional strategies that actively engage students result in better retention. Case-based learning (CBL) instructional approach, properly designed and delivered in a virtual environment, should *actively engage* the students and result in the needed retention.

Virtual Environments

Time, cost, and material considerations limit the ability of the training community to provide sufficient "hands on" experience with simulated material assessment opportunities to reinforce classroom training. Training delivered in a virtual environment (VE) should provide a solution to the problem of limited availability of training. Also, current training limits the scope of material discrepancies that CHENGs can encounter due to safety concerns. Introducing a fault into an operating turbine engine that could result in catastrophic failure is not a viable training option. Given projections for desktop computer power and display systems to increase in performance while simultaneously decreasing in cost, PC-based "desktop" virtual environment training delivery systems will be efficient solutions in the near to mid term. There are also opportunities for gains in training availability. New laptop PCs are increasing in capability and decreasing in cost, providing an opportunity to make the "desktop" VE training available not only in the schoolhouse, but also while deployed, thereby overcoming a major limitation of current training technologies.

Case-Based Learning

CBL, also known as scenario-based, uses accumulated prior experience to prepare personnel to recognize, understand, and solve new problems. This model proposes that previous situations relevant to the current engineering problem are recalled, compared with the current propulsion plant situation, and through a process of interpretation and generalization lead to a solution for the current problem. The use of a CBL environment would allow PEOs to experience numerous scenarios containing discrepant equipment, thereby building up an extensive set of previous situations for recall. As a training methodology, it provides modeling of the desired behaviors and approaches to learning and problem solving, feedback on performance, and an orientation for decision-making. It was selected for use in this effort since it closely approximates the working (performance) environment of the CHENG aboard ship.

Approach

The approach used in the VET-E project consisted of several phases: The definition of the tasks the CHENG performs; the identification and conversion of an appropriate shipboard propulsion plant into a virtual environment; the review of the existing Prospective Engineering Officer Course and Curriculum; identification of specific areas of performance deficiency; assessment of available VE technologies and applications; identification and assessment of appropriate instructional strategies; integration of the VE technologies with the most appropriate instructional strategy; and design and development of an evaluation plan for assessing the effectiveness of the resultant training program and devices.

Definition of CHENG Tasks

Cognitive task interviews were conducted to define the engineering tasks performed by the CHENG. The interviewees consisted of five personnel from the Propulsion Engineering Board (PEB) who had served an average of 17 months as Chief Engineering Officer (CHENG) and 19.5 months as a Main Propulsion Assistant (MPA); five instructors from the Department Head Prospective Engineering Officer (PEO) course at Naval Training Center (NTC), at Naval Station (NS) Great Lakes, four of whom were Engineering Officer of the Watch (EOOW) qualified and had served an average of 23 months in an Engineering Department billet; three instructors from the Marine Propulsion course at SWOS; two personnel from the Afloat Training Group (ATG) San Diego, one CHENG and one MPA.

The interviewees described the CHENG position as one of high stress and very high workload within a complex work environment requiring good management skills as well as attention to detail. A CHENG must have a well qualified team and must understand the operation of the engineering systems. Working with limited resources, a CHENG must be able to prioritize which deficiencies will receive the Engineering Department's primary attention. CHENGs also have responsibilities not directly related to the Engineering department which require their attention, thereby reducing the amount of time they can spend working on purely engineering duties. It is in this work environment that the task of material assessment must be performed. The preparation, prior experience, and training of the PEO is shown in Figures 1 and 2.

At its most basic level, material assessment is the CHENG's perception of the variables in the engineering environment. These variables may be the operating parameters of a system, the "proper feel" of lube oil, or the "squared away" look of a well maintained engineering space. This recognition process is akin to the first step in what Klein (1989) has called Recognition Primed Decision (RPD) making as well as what Endsley (1995a, 1995b) calls Situation Awareness (SA). However, both RPD and SA go on to include behavior after the recognition (or assessment) of the environment such as what actions to take to reach certain goals. Differentially, Klein generally is describing a process whereas Endsley generally is describing a state.

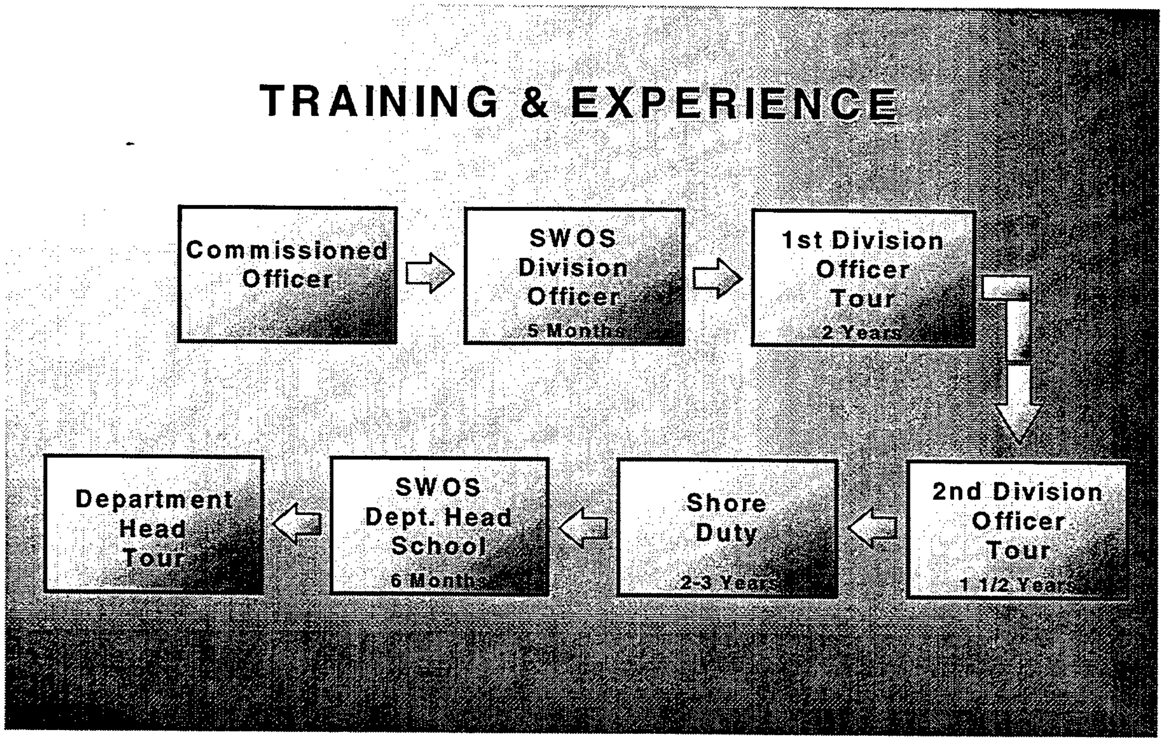

Figure 1. Training and experience for prospective engineering officers.

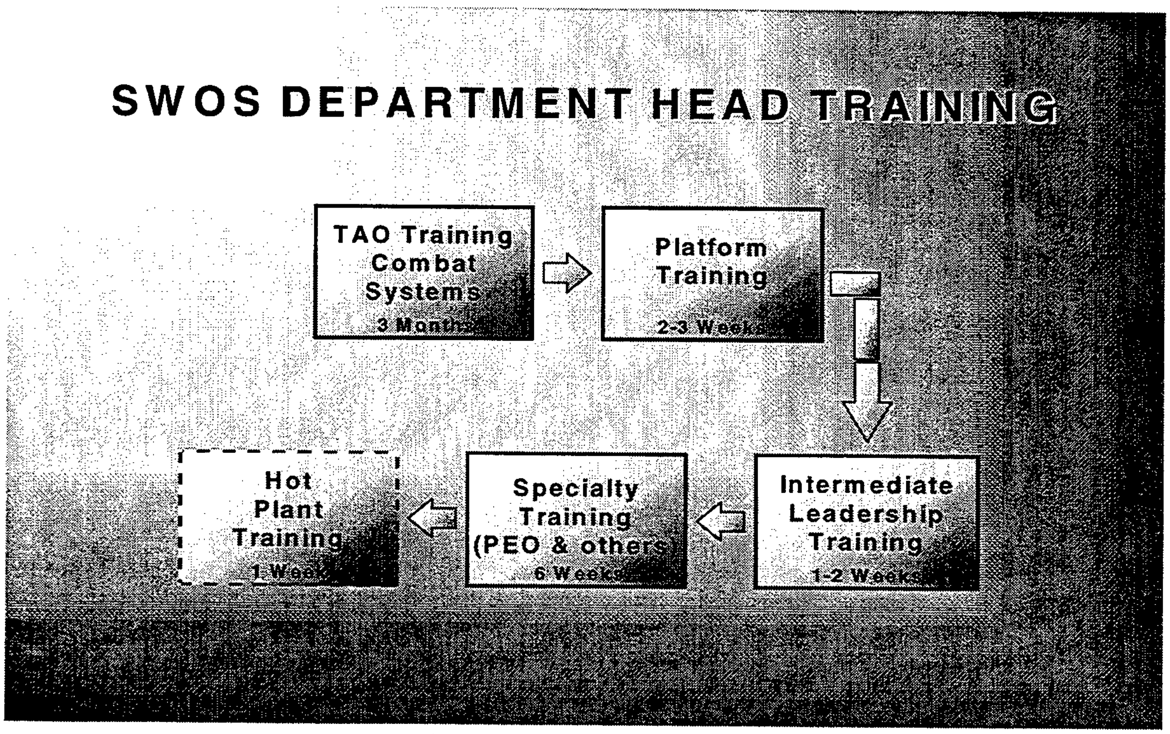

Figure 2. Surface Warfare Officers School Department Head Training.

Generally, interviewees described three primary means of assessing whether or not the various engineering systems are operating within acceptable limits: (1) Visual inspection, augmented by sound and touch. A majority of respondents when asked, "What is material assessment?" responded by describing some form of visual inspection, calling it variously "housekeeping" or space cleanliness, or "just the appearance of the spaces." (2) Equipment logs, which allow trends to be developed over time for particular systems or subsystems. These logs provide both a source of data and a structure to organize that data. Engineering Operating Sequencing System (EOSS) and Engineering Operating Procedures (EOP) are additional sources of "structure" that are used by the CHENG to organize their operational environment and ensure that the engineering plant is functioning properly. (3) Discrepancies discovered through routine maintenance checks such as those performed according to the Planned Maintenance System (PMS). Many of the former CHENGs related having to rely more on the logs and PMS checks because they found it difficult to find the time to conduct frequent walkthroughs of the engineering spaces. They relied on the other members of the engineering team to perform frequent visual inspections. This reliance on other team members underscores the importance of having a well-trained and experienced Engineering Department which is not always the case. Training and experience play a large part in properly performing the maintenance checks. CHENGs reported the logs presented some problems simply due to the sheer number of logs and the amount of data in each log that had to be reviewed.

The two most common responses as to why some CHENGS had difficulty performing material assessment were: (1) Lack of system knowledge, resulting in ignoring perceived minor discrepancies that were in fact symptomatic of major problems and (2) inexperience in managing the various aspects of the PMS so that maintenance was either not performed or performed incorrectly. Several respondents also noted that often a perceived minor discrepancy does not get corrected immediately. The more time passes, the more the discrepancy begins to look like part of the "normal environment" so that after awhile people forget that it actually is a discrepancy. Other factors were also reported to cause equipment to be left in a discrepant state. Only when an inspection team points it out or a significant malfunction occurs because of the existing discrepancy does it become "visible" again. Unwillingness to report needed equipment repairs because the ship may not be able to perform its mission, inadequate funding to effect needed repairs, and an inability to manage people effectively also were reported by one or more of the respondents.

Identification and Conversion of Plant Layout into Virtual Environment

Computer-assisted design (CAD) drawings for the DDG51, Arleigh-Burke class, were obtained. These CAD blueprints were converted into computer graphics files, which were then converted into basic two-dimensional and three-dimensional computer files. The conversion of these basic drawings served as the foundation for "building" or rendering an environment that modeled the DDG51 propulsion plant.

Additionally, the actual DDG51 propulsion plant environment was photographed from multiple locations on the three levels in the ship. At each location, photos were taken around a center point to provide a 360 degree view. These digital photo images were combined or "stitched" together to present a panorama of the locations photographed. Subsequently, it was discovered that material readiness "discrepancies" could be graphically "painted" into these images to create the appearance of a problem in the environment.

Review of Prospective Engineering Officer Course

PEO Course Review

A review of the PEO course was contracted. The training objectives, both terminal and enabling, were identified and reviewed. These objectives focused on locating and identifying components in the propulsion and auxiliary systems as well as describing the interrelationships between various propulsion systems and the engineering plant as a whole. The results of the PEO course review, interviews with the Propulsion Examining Board, and the initial training scenarios are contained in the report prepared by Instructional Science and Development, Inc. (ISD) (March, 1996), provided in Appendix A. The training scenarios subsequently were revised and lengthened. The revised scenarios were reported by ISD in December, 1996, and are provided in Appendix B. The final scenarios, drawn from the earlier efforts with a script incorporating a case-based approach to instruction, are found in Appendix C.

At SWOS, students are provided classroom instruction on what to look for in material readiness assessment. After completing their training, optionally, some students proceed to NTC Great Lakes enroute to their shipboard assignment. At NTC Great Lakes, they undergo one to two weeks of training on the "hot plant," an operating propulsion plant used for familiarization and demonstration purposes. There they are encouraged to identify material deficiencies. Instructors at the hot plant, however, are unable to introduce realistic fault conditions into the equipment due to safety and cost considerations. Thus, it is difficult to realistically simulate material deficiencies to reinforce their earlier classroom lectures. In general, the two week course was found to be informal; a "gentleman's course" was one instructor's comment. When instructors were asked how they knew who was performing adequately and who needed help they gave anecdotal evidence: "You can tell who needs help and who doesn't by the questions they ask," one instructor noted when asked about student performance. These findings suggest the need to incorporate specific training objectives and instruction into the course work presented at SWOS and at the hot plant.

Interviews with Propulsion Examination Board (PEB) Members

In addition to the curriculum objectives required for training, interviews were conducted with subject matter experts to identify the skills and knowledge needed for Chief Engineering Officers to be successful in assessing the material condition of their propulsion plants. The results of these interviews identified three primary areas of expertise. The first and most basic is (1) *pattern recognition*. Pattern recognition is the ability to identify an object as a member of a class (Watanabe, 1985). For example, an experienced CHENG can identify whether or not a flange shield is in the class of "discrepant flange shields." This skill is built up over time through experience with similar equipment and problems in the engineering spaces. (2) *System knowledge* is the second area of importance identified. A CHENG may not be able to tell if something is discrepant unless he understands what role that object plays in the larger engineering system. A lack of understanding of the interrelationships that exist in the complex engineering systems was seen as a common problem. This knowledge base is built up through formal schooling and experience. (3) *Management skill* is the third area of necessary expertise for a CHENG. A CHENG must be able to organize the ship's engineering resources to properly monitor and maintain the engineering equipment. This includes using his time efficiently since a CHENG has many duties other than engineering responsibilities. This expertise is also built up through formal schooling and job experience.

Identify Specific Areas of Deficiency

To determine the most common readiness assessment problems that occurred for CHENGs, an assessment was made of the Operational Propulsion Plant Examination (OPPE) reports. These reports are prepared by inspectors whose jobs it is to identify problem areas aboard ship, or by Subject Matter Experts (SMEs). The results of this analysis are contained in the report prepared by Instructional Science and Development, Inc. (ISD) (March, 1996), found in Appendix A.

To construct cases or scenarios that would be relevant to Fleet engineering officers the material readiness sections of OPPE reports were used to determine what equipment was most problematic aboard ship. The areas of interest were Main Engine Room #1 and Main Engine Room #2. Some 61 OPPE reports from both Commander Naval Surface Force Pacific (COMNAVSURFPAC) and Commander Naval Surface Force Atlantic (COMNAVSURFLANT) were reviewed. An example of a list of equipment from a frigate (FFG) and a cruiser (CG) noted to have material deficiencies is shown in Figure 3. An "X" under the ship class indicates an occurrence of the equipment as deficient in an OPPE report.

Main Engine Room	FFG	CG
HP Air Reducing Valve	X	X
Lube Oil Unloader Pressure		X
Start Air Reducing Valve Leak	X	X

Figure 3. Examples of equipment deficiencies.

The list of equipment developed from the OPPE reports was given to a SME to construct a "walkthrough" scenario that would focus on the equipment that was noted frequently in the OPPE reports. Initially, two scenarios were developed and given to PEB members and to NTC Great Lakes instructors for feedback and revisions. Subsequently, it was decided that the project testbed would be at SWOS in the PEO course. As a result, these scenarios were also reviewed and revised by SWOS participants. The revised scenarios, found in Appendix C, will be used as the basis for the case-based instructional scripts and the evaluation of the present project.

Assess Existing VE Technologies and Applications

The NPRDC research team visited a number of sites, both commercial and academic, to gain a better understanding of the current state of VE development. This was done prior to awarding a contract for development of the software environment. Sites visited included:

University of New Mexico	Armstrong Lab, Brooks AFB
Sandia National Laboratories	General Dynamics, Electric Boat Division
Lockheed Martin	Naval Research Lab (NRL)
Southwest Research Institute	Naval Surface Warfare Center, White Oak
Research Triangle Institute	Kaiser Electro-Optics, Inc.

The developmental options included whether to use a head mounted display (HMD) and an audio format to localize engine room sounds. An HMD was not used because of insufficient resolution for displaying the material readiness deficiencies and, secondarily, potential simulator sickness. As HMD resolution improves, this decision should be revisited. Audio effects were obtained for 64 different engine room sounds. But, time and cost considerations did not allow incorporating them into the engine room environments for the feasibility demonstration.

Two versions of the desktop VE were developed: A 3-D modeled environment and a digital imagery environment. The modeled environment was constructed using the original DDG51 CAD files which provided the structural aspects of the ship. These were translated into a GAF graphics format and then to a DXF format, which was then imported into 3D Studio. The structural or "wire frame" view is shown in Figure 4. The equipment in the modeled engine room environment was built using 3D Studio, Release 4. A Microsoft Visual C++ application provided the navigational capability within the environment and Sense8's WorldToolKit 3-D provides the rendering API. WorldToolKit is "the software of choice for PC-based VR applications because of its support for nearly all the VR peripherals on the market today" (Phillips, 1995, p. 3). The PC-based pentium equipment required to support the two environments are found in Appendix D.

Main Engine Room #2, Platforms 1, 2, and the Hold, were constructed using 3-D models. Originally, both Main Engine Rooms #1 and #2 were to be fully modeled in 3-D for the desktop VE, but resource constraints did not allow it. Figure 5 shows a view from the modeled environment which was built up from the wire frame model.

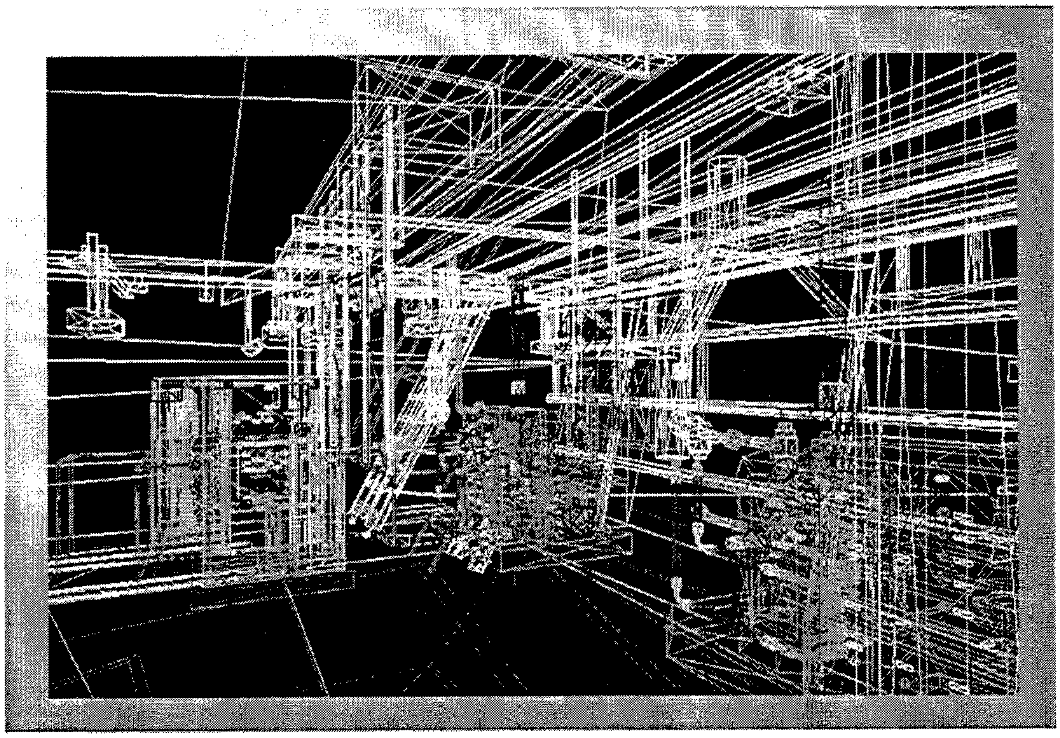

Figure 4. "Wire Frame" view from the DDG51 modeled environment.

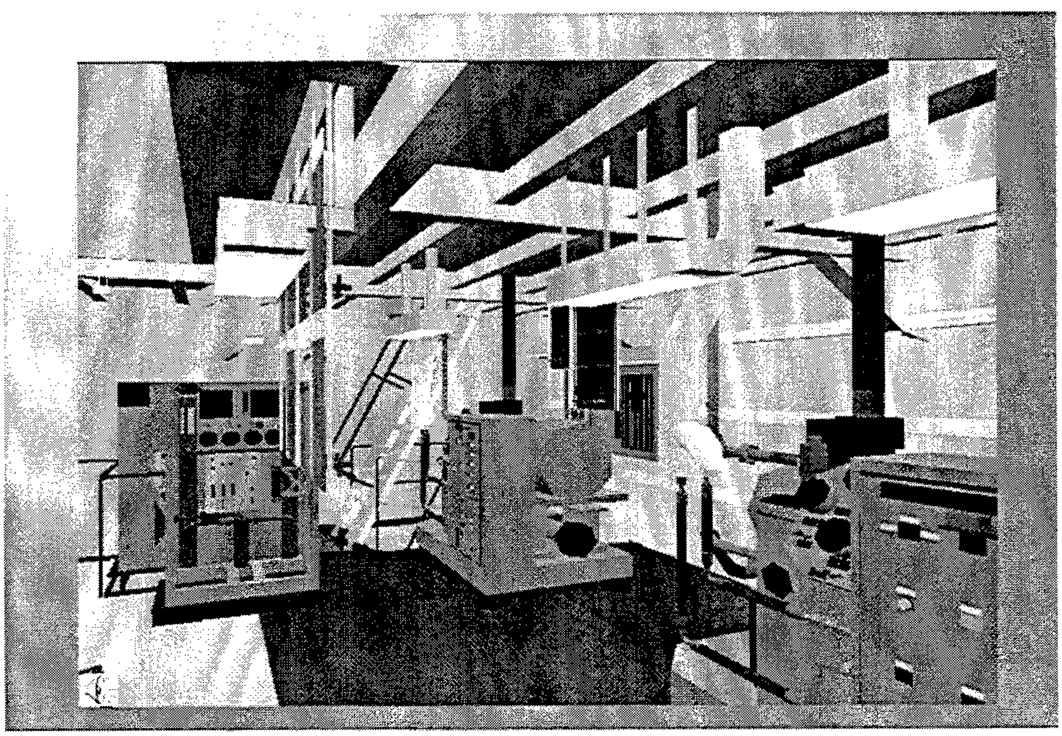

Figure 5. View of the modeled DDG51 engine room.

The digital image environment was constructed from a series of individual digital photographs of the engineering spaces aboard a DDG51 Class ship. These individual digital photographs were "stitched" together using Apple's QuickTime VR stitcher to provide 360° panoramas. Each panorama is referred to as a node. Both engine rooms exist in the digital image environment as described above. An example of the view from a node is shown in Figure 6.

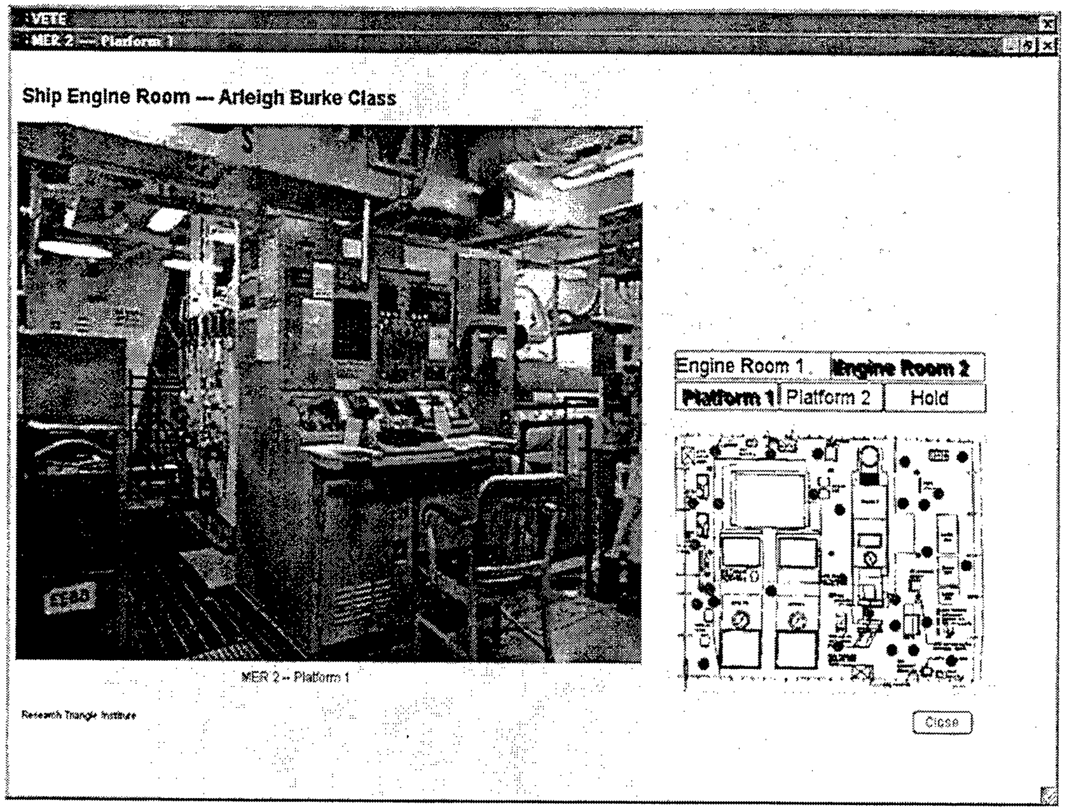

Figure 6. Digital image environment view of DDG51 engine room with schematic.

The panoramas from each node are embedded into a MacroMedia Director application. The floor plan to the right of the scene allows the user to navigate in the digital engineering space. Each large black dot represents a node. In the actual system the unoccupied node dots appear blue while the occupied or viewpoint node appears red. Midway through the effort it was decided to use the digital VE version as opposed to the modeled version. It had become clear that the resolution necessary to display the more subtle engineering discrepancies could not be achieved with the technology available. The necessary resolution should be available in the future, however, and the next generation system should revisit this decision.

Identify and Assess Appropriate Instructional Strategies

The three areas of expertise necessary to perform material readiness assessment (pattern recognition, system knowledge, and management skills) are enhanced through practice involving problem solving, critical thinking, and reasoned judgment. These skills can be taught or reinforced through the case-based learning approach. Learning results from the process of resolving a problem embedded within a case. The cases or scenarios in this project use the instructor as a model for the assessment process. The cases have specific objectives and a restricted field of student options for exploration within the problem environment.

The presentations for this project identify material conditions in Main Engine Room 2 of an Arleigh Burke class ship. The specific discrepancies, however, are generic discrepancies based on the results of the OPPE reports and interviews with SMEs (see Appendices A and B). The scenarios replicate performance of a routine task in a dangerous, complex environment.

Integrate the VE Technologies With the Most Appropriate Instructional Strategy

The intent of the VET-E project is to produce a high fidelity desktop virtual environment in which a case-based learning opportunity is present. A case-based instructional strategy was selected as it most closely replicated the working or performance environment for the CHENG. The cases, as used here, are notional or composite cases built from discrepancies identified by the PEB, SWOS instructors, and casualty reports. They are not historical cases, although the addition of selected historical cases would be appropriate following the feasibility demonstration and as the students gain experience.

Design and Develop an Evaluation Plan for VET-E

The objective of the evaluation is to demonstrate the effectiveness of the desktop virtual environment (VE) training program to train material readiness assessment. The training program is presented in the form of a scenario made up of a number of discrepancies in the engineering spaces aboard a DDG51 class ship.

Evaluation Plan for Virtual Environment for Engineering

Objective

The objective of the evaluation is to demonstrate the effectiveness of the virtual environment training program to train material readiness assessment.

Training Program

The VE training program is presented as a scenario made up of a number of discrepancies in the engineering spaces aboard ship. The training contains two elements: (1) an image-based interactive computer graphics program portraying the engineering spaces and equipment aboard ship; and (2) a case-based approach (Williams, 1992) to teaching material assessment which includes instructor modeling of the material assessment process, instructor coaching of the students, student practice with the computer program, and feedback.

Elements (1) and (2) together are an appropriate integrated approach to the subject and constitute the experimental approach. Those receiving the training described above are the experimental group, Group C.

To test the value of the experimental approach, two control groups will be set up for comparison with the experimental group. The two control groups are:

Group A. Photographs of the engineering spaces and equipment will be provided with a paper scenario. The engineering spaces are divided into nodes or locations where photos were taken. They are based on the same digital images used in the computer graphic process. Eight contiguous photos are presented per node. A total of 34 nodes will be used, half for each scenario. The subjects will be told to find the discrepancies in the scenario using the photographs.

Group B. This group will be given the same materials as Group A, but will also be trained using the same case-based approach as the experimental group, Group C.

The case-based approach includes:

1. Mini-cases. A mini-case is a segment drawn from a larger case (Spiro & Jehng, 1990). Each of the discrepancies is an instance of a problem that could occur aboard ship. It is a concrete incident of what could be found while doing an inspection of the engineering spaces. A scenario consists of a series of mini-cases or discrepancies.

2. Instructor modeling of the material assessment process. Modeling consists of a demonstration by the instructor of how he performs material assessment. While the instructor models the process, s/he explains her/his reasoning to the students. Included in the discussion are the identity of the discrepancy, the corrective action to be taken, the urgency of the problem, and an assessment of the situation as affected by this particular event, including system interactions.

3. Instructor coaching of the students. After the modeling process is complete, coaching takes place. Coaching involves the instructor observing students as they try to complete tasks and providing hints and helps when needed.

4. Student practice with the computer application. Following a period of coaching, the student looks for discrepancies without the aid of the instructor.

5. Feedback. When the student completes his/her assessment s/he returns to the instructor to get feedback on the results.

The first two or three steps of the case-based instruction could be completed with a group of two to three students with an instructor. The instruction is delivered from a script to ensure uniformity of the instruction across groups. (See Appendix C.)

For each scenario, testing scenario and evaluation scenario, the discrepancies were selected from a pool of discrepancies so that the difficulty of each scenario would be about equal. The discrepancies were rated on a scale of 1 to 3 for criticality. The following criteria were used to select the discrepancies for each of the scenarios:

1. One discrepancy of high criticality (1), two discrepancies of intermediate criticality (2), and two discrepancies of lowest criticality (3) were used for each scenario.

2. Discrepancies were evenly distributed across the three platforms of the ship (Platform 1, Platform 2, Hold).
3. More than one discrepancy was present at some nodes (areas) so that the student would practice a complete assessment of the spaces.
4. Some nodes have no discrepancies.
5. Each scenario includes documented problems that have occurred on ships.
6. Discrepancies include (1) system knowledge, (2) management issues, (3) and visual recognition components.
7. A time limit of 45 minutes was initially set for each scenario. However, after pilot testing, the time was increased to one hour.

Subjects

Prospective Engineering Officers (PEOs) attending the Department Head course at Surface Warfare Officer's School (SWOS) will be used for the experimental training and evaluation. Courses convene six times a year, and each class contains approximately 20 PEOs, 10-15 of whom are gas turbine specialists. At least 10 subjects will be run in each of the three groups, more if available. Subjects will be obtained approximately one week before the conclusion of each class, starting with the February 1998 class, and continuing with the May and July classes.

Instructors

For the two group that are receiving the case-based instruction (Groups B and C), two or three instructors will be used. The same instructors should be used for both groups to ensure the equality of the instruction. It is recommended that the instructors be from SWOS to ensure familiarity with the subject matter. The instructors will practice the script with other test subjects to ensure they are equally proficient with both groups receiving the instruction.

Design

The testing phase will be carried out using a scenario different from that used during the training. All groups will have completed the Prospective Engineering Officer course and will have had the standard SWOS training in the subject matter. All groups will spend approximately the same time with the training scenario. Group A will be given no additional instruction beyond that received in the classroom. Group B will be trained using the case-based approach. Group C will be trained in the case-based approach with the benefit of the interactive computer graphics program enabling them to move around in the virtual engineering spaces. Two subject can be trained together, but they should practice and be tested individually. Table 1 shows the design of the evaluation.

Table 1

VET-E Evaluation Plan

Group A	Group B	Group C
Scenario 1 Training Photo Visuals	Scenario 1 Training Photos and Case Instruction (CI)	Scenario 1 Training Virtual Environment and CI
Scenario 2 Test (Photos)	Scenario 2 Test (Photos)	Scenario 2 Test (Computer)

In addition to the training, each group will be given a short demographic questionnaire. Groups B and C will be given a questionnaire on the case-based approach. Group C will be given a questionnaire on the usability of the desktop VE program. The student questionnaire is found in Appendix E. Instructors will be given a questionnaire on the case-based approach and the usability of the desktop VE program. The instructor questionnaire is found in Appendix F.

Since the virtual environment will not be completed until February 1998, Control Group B will be tested for the January class, Group C for the May class, and Group A for the July class. Ideally, some subjects would be tested from each group for each class. However, since that is not possible due to the virtual environment completion schedule, demographics for each subject will be examined to determine that the groups are comparable in experience, education, and training. If they are not, the differences will be controlled statistically.

Familiarization

While the training program will be conducted using the image-based system, it would still be desirable to perform some evaluation of the model-based system. The model-based system could be used for familiarization of the engineering spaces and it could be evaluated to determine if this added to any effect of the image-based system. This evaluation could take place if there are a sufficient number of subjects, perhaps an additional 10, to add this component.

For the group trained with the virtual environment on the computer, a familiarization session using a model-based computer environment simulation of the engineering spaces could be used. Group D could be formed and trained in the same way as Group C with the addition of a familiarization session with the model-based system to be administered to the image-based training. This training would allow the student to move about in the engineering spaces and locate a list of equipment. Group C and Group D would be compared to determine if this familiarization session increases achievement in the final evaluation.

For the familiarization training, the instructor will show the student how to move about in the spaces following a layout. Then the instructor will demonstrate how to find several items on a list. The instructor will watch the student and assist as necessary for a few items. After that, students will be on their own to explore the spaces and find the equipment on the list.

If sufficient subjects are not available to include Group D, the model-based system could be used with other groups of subjects who are now required to pass a test on the layout of a ship. Groups could be tested with and without the aid of the model-based program and the results of the test could be compared for each group. While this would show a possible additional application of this program, it is not part of the objective of the present research effort.

Hypotheses

1. Group C will perform better than Groups A or B. It is expected that the experimental treatment with both the computer graphics and the case-based approach will be superior.

2. Group B will perform better than Group A. Group B should benefit from the case-based approach, but will not have the interactive computer program of Group C.

3. Group A's performance will be inferior to both Group B and Group C. Group A will have neither of the two elements of Group C, nor the one element of Group B.

Evaluation

For each of discrepancies found, the subject will be asked the following questions.

a. Identify the discrepancy
b. Specify what action to take.
c. Prioritize each action on a scale of 1 to 5 indicating when the action should be taken:
    1. Security breach or CAS REP.
    2. Fix immediately.
    3. Put on the 8 o'clock report—fix this week.
    4. Place discrepancy on the CSMP or order repair parts.
    5. Conduct repairs after completing higher priorities.
d. Assess the situation. What are the implications of this problem for the situation as a whole.

In addition to the quantitative measures, questionnaires will be administered to each subject to collect demographic data on background, education, training, and experience. In addition, a usability questionnaire will be administered to determine the subjective experience of each subject and instructor in the use of the virtual environment, the visual pictures, and the case-based approach to instruction. The student and instructor questionnaires are found in Appendices D and E, respectively.

Analysis

For each of the three groups, the following scores will be collected from the test data.

1. Identification of discrepancy (DISCR). This is a measure of pattern recognition. There are a total of 17 discrepancies to be identified, so the total possible DISCR score is 17. There are an additional six nodes to be examined that do not contain any discrepancies. A half-point will be deducted from the total score for every incorrect discrepancy identified, giving a DISCRA score, or adjusted discrepancy score.

2. Corrective action (CORRA). This is a measure of management skill. The answers to this question will be rated as either 1 for acceptable or 2 for good insight or 0 for incorrect. Since this score is dependent on the number of correct discrepancies identified, it will be adjusted for the DISCR score obtained. The CORRA score is the total corrective action score divided by DISCR multiplied by 100 (to remove the decimal).

3. Priority (PRIOR). This is another measure of management skill. The answers to this question will be rated as either 1 for acceptable or 2 for the best answer or 0 for incorrect. Since this measure is also dependent on the DISCR score, it will be adjusted accordingly. The PRIOR score is the total priority score divided by DISCR multiplied by 100.

4. Relation to other systems (SYSTM). This is a measure of system knowledge. The answer to this question will be rated as either 1 for acceptable or 2 for the best answer or 0 for incorrect. Again this measure is dependent on the DISCR score and will be adjusted accordingly. The SYSTM score is the total system score divided by DISCR multiplied by 100.

Final course test scores (FINAL) will be obtained for each participant in the study to determine if the interventions had any effect on course performance.

A multivariate analysis of variance (MANOVA) with three independent groups (A, B, C) and five dependent variable (DISCR, CORRA, PRIOR, SYSTM, FINAL) will be used. Covariates such as years of experience and past experience can be controlled in this design. The Wilks' Test is recommended because it is a likelihood ratio test and has good properties (Johnson, 1996).

Pilot Study

First, the script and photos were tested for Group B on a Navy Lieutenant and a Senior Chief to ensure the instructions were clear, to determine how long the instruction and testing would take, and to determine if the discrepancies could be detected in the photos. Both had engineering and damage control experience but neither was considered an expert. Since they were not subject matter experts, we did not suggest changes to be made on the basis of their input. We did, however, make changes to the script on the basis of their testing.

Second, two Lieutenants who were engineers were tested; one officer had served as a Division Officer on a DDG51 and the other had 18 years experience in various engineering capacities. We tested the script on both officers, and then had one of them complete Scenario 1 and the other Scenario 2. After they completed the task, we examined the answer sheets to determine if they had failed to detect any of the discrepancies. One engineer found all of the discrepancies and the other missed a few. In some cases, the discrepancies that were missed were seen when pointed out, and in others the discrepancies were considered to be problematic. The problematic discrepancies were listed and recommended for adjustments by NAWCTSD after other experts are consulted, probably the instructors at SWOS.

Status to Date

The VET-E project was transferred in its final year to NAWCTSD, Orlando, FL. The transfer is the result of the NPRDC Training Department function being transferred to NAWCTSD as a consequence of BRAC 95. The foregoing materials describe the background and status of the project as of the 5th of December, 1997. The future direction and development of the project will be determined by NAWCTSD, in concert with the membership of the IPG.

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Appendix A

Shipboard Material Inspection Analysis and Initial Training Scenario Design for the Virtual Marine Propulsion Plant

Training Scenario Design Plan for the Virtual Marine Propulsion Plant

Contract N66001-91-D-9502
Order 7J21
Item A012

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(Final)

Prepared for

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Introduction

The Navy Personnel Research and Development Center (NPRDC) has been directed to develop a training environment that will assist in enabling Naval Engineering Officers to adequately assess the material condition of their engineering plants. Instructional Science and Development Inc. (ISD) has done extensive work in shipboard main propulsion engineering environments and is familiar with the unique training problems that arise in environments that are both complex and hostile. ISD has been tasked to provide NPRDC with two detailed descriptions of material assessment scenarios, to be modeled in a virtual environment (VE) resembling a DDG51 class ships main engine room (MER).

ISD has been tasked to (1) evaluate and analyze shipboard material inspection data and training course curriculum materials from the PEO Course, and (2) to provide NPRDC with two detailed descriptions of material assessment scenarios. These scenarios will be developed and demonstrated in a virtual environment (VE) for potential inclusion in the PEO course curriculum.

From a training standpoint there are two major factors that determine whether discrepancies can be properly identified by the student, they are: (1) Does the student have the appropriate program knowledge to recognize that a discrepancy exists and to identify it? (2) Is the student familiar enough with the surrounds to be able to focus attention and recognize, objects that have discrepancies without being distracted by environmental considerations? If the student has acquired the prerequisite program knowledge needed to identify the discrepancies, then the VE scenario exercises will be instrumental in familiarizing them with the environment. In addition, this environment provides the student with a chance visually to identify discrepancies in a more realistic setting.

Methodology

The data analysis was conducted in two phases. First the Operational Propulsion Plant Examination (OPPE) inspection data was analyzed. Second the PEO course curriculum and class schedule data was reviewed. Using the findings from the analysis, specific deficiencies were identified for inclusion in the scenarios. The deficiencies were further broken down into subgroups as described below. Shipboard walk-throughs were conducted to orchestrate the inclusion of the deficiencies into the training scenarios. These walk-throughs provided a sequence for displaying equipment, piping, and machinery the students need to see during the VE experience. Consideration was also given to the sensory perceptions used in the actual engineering plant environment, as well as comments and recommendations on their usage in the virtual environment.

OPPE Inspection Results

The comprehensive data analysis included OPPE inspection reports from over 31 different ships and across the three major engineering platforms: steam, gas turbine, and diesel propulsion. Specific material deficiencies were reviewed and deficiencies that were general and found throughout the three engineering platforms were collected. Data found to occur with a high degree of frequency across the three platforms were further divided into six subgroups. Items for inclusion in the scenarios were identified from these subgroups. The subgroups and their individual items are listed below.

- Piping and Valves
  1. Missing and improper valve labeling
  2. Poor valve maintenance
  3. Improper pipe stenciling
  4. Lagging missing and/or torn
  5. Flange leaks
  6. Short studded valves and flanges

- Damage Control Equipment
  1. AFFF stations
  2. PKP bottles tags
  3. Halon stations

- General Outfitting
  1. Deck plates
  2. Unsafe ladders
  3. Improper tag out procedures
  4. Lock wire missing, broken etc.

- Instrumentation
  1. Gauges out of calibration and improperly installed
  2. Thermometers broken

- Flammable Liquid Systems
  1. Lube oil strainers
  2. Mechanical seals leaking
  3. Flange shields soaked and/or missing
  4. Lube oil sample racks
  5. Pooled lube oil or fuel oil on foundations

- Machinery
  1. Gas Turbine Module
  2. Fuel oil service pumps
  3. Fuel oil and lube oil purifiers
  4. Lube oil service pumps

Most of the machinery listed as out of commission (OOC) during the time of the OPPE inspections was removed from consideration. This machinery varied across the three engineering platforms and would serve no purpose by being illustrated in the virtual environment. However, one piece of machinery, should appear tagged out in the scenario to illustrate improper tag out procedures.

PEO Course Curriculum Review

The training objectives and the curriculum schedule from the Prospective Engineering Officer (PEO) course were reviewed. Of the 72 class periods reflected over the two week course schedule, 31 of these periods contain some sort of material assessment activities. These material assessment activities include assessing safety, damage control equipment, cold checks, and hot checks. By matching the results from the data analysis of shipboard inspections with the topics taught in the PEO course, specific areas could be identified.

A significant number of material assessment lessons came from the Engineering Operational Sequencing System (EOSS) procedure Master Light Off Checklist (MLOC), a Prelightoff Checklist. Items addressed in the MLOC procedure to be included in the scenarios are listed below as they appear in the EOSS procedure. It should be noted that extensive knowledge of a number of engineering programs, both in material and maintenance areas, is needed to comply with some of the listed items.

MLOC Items

- Ensure bilge, drip pans, and decks are free of oil.
- Ensure all flange shields and strainer spray covers are in place and properly attached.
- Ensure all damage control equipment is in place and ready for use (weight, seals, charged, etc.)
- Ensure all valve hand wheels are installed, properly attached, and remote operators are connected and operational.
- Ensure all gauges are in place, properly mounted and not overdue for calibration.
- Ensure all security locks, lock wire seals, and locking devices are in place and no indication of being tampered with.
- Inspect for and remove all fire hazards from engineering spaces. Stow all equipment not in use (missile hazards).

Shipboard Environment Observations and Findings

A visit was made to the USS John Paul Jones DDG-53. The #2 main engine room was toured and evaluated for the development of the two scenarios. The engine room has three levels: 1st platform, 2nd platform, and hold level. A walk through of each level was conducted and various deficiency items were identified. Special attention was paid to the noise levels, temperature changes in various areas, and the visual accessibility of frequently noted discrepancies listed above.

In general, the actual engineering environment overloads the senses. Visually there are objects in close proximity to one's body from overhead, under foot and on either side. This causes the space personnel to constantly watch the overhead for possible objects hanging down that could cause injury to their heads. The deck surface varies from deck grating, which is open so that the lower level can be seen from above, to deck plating, which is closed. This variance in deck surface causes the space personnel to always be conscious of their footing. Numerous objects have to be avoided while walking around the space. Personnel have to maneuver around the space rather than simply walking through.

The surfaces of various machinery, equipment and piping vary greatly in surface temperature, which causes the space temperature to fluctuate. Walking under a vent causes personnel to feel cool air blowing on them, while walking close to an operating air compressor or similar piece of equipment gives off radiant heat that can be felt. Usual odorant inputs include fuel oil, lube oil, and fire. The decibel (Db) levels often exceed the recommended ranges and hearing protection is required when entering a space. The sounds consist of equipment operating sounds, various communications over the loud speaker systems, and other metallic noises.

These combinations of sensory inputs hamper personnel in identification of various discrepancies. The senses of the student should be exercised as much as possible during the virtual experience. The virtual environment should aid in familiarizing the student with the environment in which they will be operating. Some general observations are listed below concerning sensory inputs the students will need to experience during the scenarios..

Sound

Engine room sounds need to be represented in the virtual environment and the student should wear ear plug like devices that cause the same uncomfortable feeling as ear plugs do. Disposable ear plugs are required for all personnel going into a noise hazard area such as the main engine room. The noise should be as realistic as possible and noise levels should vary based upon the proximity of the student to the machinery or source. The specific Db levels of the actual environment should be met. The physical discomfort of the noise coupled with the discomfort of the ear plugs will add to the realism of the sensory inputs.

Visual Effects

Most of the material deficiencies in the two scenarios fall within the field of vision ranging between five and seven feet in height. As the student walks through the engine room the discrepancies are either at eye level, slightly above or slightly below, but most can be seen without bending down. For looking at pump foundations and other discrepancies where bending down is required, a zooming feature should be provided. This will enable the student to take a closer look at various equipment and provide a way of reading information on various tags, labels, and gauges. Some tags and labels will need to be finely detailed so that the student can walk up to a gauge and read not only the graduations on the gauge but also the small lettering on the calibration sticker affixed to the face of the gauge. The student should also be able to view the environment with the normal range of sight, ranging from far left to far right, or approximately 180 degrees. Generally the closeness of the environment should be duplicated. The height of overhead objects should be duplicated giving the effect of hanging close to the student,s head. Similarly the deck grating placement and surrounding machinery should be placed so the student sees the objects in the same proportion as onboard ship. On the hold level of the engine room the student is required to step up and down a few steps. The student should see the effects of stepping up or stepping down as the case may be. Finally during the time the students are in the virtual environment their vision should be restricted to the virtual environment. No outside stimulus should be present.

Maneuverability

For the students to maneuver throughout the space and between the levels they will need a device that gives them freedom of movement. They should, however, be required to maneuver around all machinery and other objects in their way. The students should be given some negative indication when they bump into an object thereby forcing them to constantly pay attention to where they are going. This can be accomplished using a joystick, mouse or some similar device. The students should be able to move ahead, backward, and make a 360 degrees rotation from either side, without needing to move ahead.

Scenario Scoring

The scenarios need to be scored to monitor the students' progress through the course. There should be a device that enables the students to mark the discrepancies they find during the scenario. Once an object is marked it should indicate to the student that it has been previously marked. This can be accomplished by indicating it visually or by producing a sound that tells the student that it already has been marked.

Scenario #1

The starting point of the scenario places the student standing on the 1st platform of #2 main engine room. The down ladder is directly behind them and the student is facing the AFFF hose reel which is slightly to the right.

AFFF Station #1 The following discrepancies exist: (1) The hose is tangled and not properly wound around the reel. (2) The AFFF inlet valve has safety wire hanging and not connected to valve properly.

After inspection of the AFFF station, the student then moves to the down ladder between #2 GTG and #2A GTM, and goes to the 2nd platform. On the 2nd platform the student turns to the left and passes between the GTM module and the ladder.

2A GTM Module The module door is closed and the lock is missing from the door. Details of the door and the lock hinge have to be shown, including any warning signs that are present.

After walking pass the module, the student moves to the area directly behind #2 GTG. As the student looks straight ahead he/she sees the rear of the GTG, the fire station to the left and the halon cylinders to the right. As the student stands looking at the stator of the GTG, the following discrepancies can be seen. The student should be able to move close to each of the three objects for inspection.

#2 GTG (rear) The stator oil piping has two flange shields missing, and lube oil is pooled on the foundation.

Fire Station #1 The fire station has obvious standing water in its hose coming from the valve to the first hose loop. This is indicated by the hose being swollen at this point.

Halon Cylinders #1 The pressure gauges on the halon bottles indicate zero.

Moving to the right the student is allowed to walk past the halon cylinders. Making a left turn and moving straight ahead the student moves down the side of the GTG to the module door.

GTG #2 Module The module door is closed and the lock is missing from the door. Details of the door and the lock hinge have to be shown, including any warning signs that are present.

The student can move forward pass the GTG module door to the fire station, but no further.

Fire Station #2 The nozzle has small drips of saltwater coming from the tip, causing the deck directly below it to have salt caked on it.

The student is then allowed to walk back down the path just taken, allowed to move to the right between the dry air system dehydrator #4 and SSAS air dehydrator #2 or to the left past the halon cylinders and the start air reducing station. No further discrepancies can be noted if the student moves back towards the area s/he came from, or if s/he decide to turn left and go past the halon cylinders. If the student decides to turn right, once in front of #2 LPAC, the student walks down past the air compressors and dehydrators. The noise levels in this area should increase, as appropriate, with #3 LPAC operating. The student can then continue to walk past #2 HPAC with #2 HP dehydrator on the opposite side.

#2 HP Air Dehydrator There are three gauges on this dehydrator. The calibration stickers should be missing and the red line pointers on the gauges should be pointing to zero.

Heat Stress Thermometer Place a heat stress thermometer in the overhead hanging from the electrical cables. The thermometer glass column should appear to be broken.

The scenario should end when all discrepancies are found and identified or after 30 minutes of operation.

Scenario #2

The starting point of this scenario places the student standing on the hold platform of #2 main engine room at the foot of the down ladder. With the ladder directly behind, the student walks straight ahead as he/she is facing the lube oil service pumps. The fuel oil service filter/separators are positioned to the right.

Fuel Service Filter/ Senaration 2A &2B	The gauges on the gauge board for the filter/separators havecalibration stickers missing, and half of the red line pointers are at zero. The other half are at the proper locations.
Fire station #2	The fire station has no discrepancies.
PKP Bottle#1	The PKP bottle via the AFFF station to the right of the student has a tag torn and oil soaked.
AFFF Station #2	The following discrepancies exist on the AFFF station to the student's right: (1) The hose is tangled and not properly wound around the reel. (2) The AFFF inlet valve is missing the required safety wire that should be connected to valve.

After inspection of the AFFF station, the student then moves to the lube oil service pumps. While standing in front of 2B lube oil service pump and looking at the two vertical discharge valves, he/she sees the following discrepancies:

2B Lube Oil Service Pump	The flange shields on the lower valve are oil soaked and there is pooled oil on the flange. The handwheel is missing a proper valve label and there is lube oil pooled on the foundation of the service pump.

Walking past both of the lube oil service pumps and moving along straight ahead, on the student's left is a duplex lube oil strainer.

Duplex Lube Oil Strainer	The strainer has pooled lube oil standing on the foundation and an oily rag is balled up in the drip pan.
Heat Stress Thermometer	Place a heat stress thermometer in the overhead hanging from a pipe directly above the service pump. The thermometer should show the mercury at the top of the glass column.

The student walks to the duplex saltwater strainer and makes a right turn. The student now faces the port shaft. He/she sees the shaft turning (the shaft is painted with barber pole stripes). At this point there is a single step going down that allows personnel to step under the shaft and a single step going up on the other side of the shaft. The student should be able to see the steps and be able to walk forward and see the effects of stepping down and stepping up while passing under the shaft. Once the student has passed under the shaft and stepped up on the other side, he/she is allowed to go to the fire station and no further.

Fluorescent Light #1 A fluorescent light in the overhead in front of the fire station is flickering, indicating a tube getting ready to go out.

Fire station #3 The fire station has salt caked on the top of the hose and the indicator loop is full of standing water (refer to fire station #1).

The student returns under the shaft the same way he/she came. Walking past the duplex oil strainer on the right, and fire-pump #4 on the left, the student sees the fuel service heater controller on their left

Fuel Service Heater Controller This controller is tagged out with a red tag hanging on the controller. Walking close to the controller the student sees that the date and time is missing from the tag.

Continuing to walk forward the student walks past the AFFF hose reel and stops parallel to the ladder he/she came down. Looking to the left they see 2A fuel oil service pump.

2A Fuel Oil Service Pump The service pump is missing a safety guard around the shaft, and fuel oil is pooled on the foundation of the pump. Additionally one flange shield is missing.

The scenario should end when all discrepancies are found and identified or after 45 minutes of operation.

Appendix B
Revised Training Scenarios for Material Inspection of Engineering

Virtual Environment Training for Engineering (VET-E) Training Scenarios

Contract N66001-96-D-9000
Order 7J04
Item A017

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Background

The Navy Personnel Research and Development Center (NPRDC) has been directed to develop a training environment that will assist in enabling Naval Engineering Officers to adequately assess the material condition of engineering plants. The Virtual Environment Training for Engineering (VET-E) Project was developed to reinforce classroom training with an environment that augments the training communities efforts in providing material assessment training. Instructional Science and Development Inc. (ISD) was tasked to provide NPRDC with descriptions of two detailed material assessment scenarios (Contract N66001-91-D-9502, Order 7J21, March 1996) to be modeled in a virtual environment (VE) resembling a DDG51 class main engine room (MER). The scenarios were developed for potential inclusion in the PEO course curriculum.

To develop effective training scenarios ISD employed a methodology which included conducting a data analysis of (a) the Operational Propulsion Plant Examination (OPPE) inspection data and (b) the PEO course materials. OPPE inspection data from over 31 different ships were reviewed, along with the PEO course curriculum and materials covering 72 hours of classroom instruction over the two week period of the course. Using the findings from the analysis, specific deficiencies were identified for inclusion in the scenarios. The material deficiencies were categorized into subgroups which were included in the report.

In addition to the data analysis, shipboard walk-throughs were conducted on board the USS John Paul Jones DDG-53, to orchestrate the inclusion of the deficiencies into the training scenarios. These walk-throughs provided a sequence for displaying equipment, piping, and machinery the students need to see during the VET. Consideration was also given to the sensory perceptions used in the actual engineering plant environment by personnel, as well as comments and recommendations made by ships company about their usage in the virtual environment.

Introduction

On 24 October 1996, roughly seven months after the submission of the original training scenario design plan report, a meeting was held at Surface Warfare Officer School (SWOS) Engineering Department Head School, Newport, RI. Representatives from NPRDC and the engineering department head school were present. The purpose of the meeting was to clarify objectives for the VET-E project and to review and discuss the scenario content for usage in the project. It was determined that the current scenarios were too simple to stimulate the critical thinking required at the department head level. It was determined that modification of the existing scenarios is required to make them more cognitively challenging.

To fully understand the concerns and desires of the SWOS principals, ISD has communicated directly with SWOS personnel concerning the scenario modifications. Two major concerns were aired during the conversation. The first concern was the cognitive recognition of material discrepancies based on multiple indicators, and the second concern was the development of time-based scenarios with progressive deterioration of material conditions. The former requires the student to correlate data from multiple sources and to recall that information during the scenario walk-throughs. The latter requires that progressive scenarios be developed that, over time, cause material discrepancies to develop into dangerous situations. This discussion and the ideas presented were passed along to the NPRDC representative for future consideration.

This report modifies the original training scenarios by adding additional discrepancies to the equipment presented in the original scenarios. The additional discrepancies are indicated in this report by bolded print. It is estimated that the additional discrepancies will increase the length of each scenario by approximately 10 minutes per scenario.

Scenario No. 1

In this scenario the student is standing on the 1st platform of No.2 Main Engine Room (MER). The student will travel from the 1st platform to the 2nd platform. The down ladder is directly behind them and the student is facing the AFFF hose reel which is slightly to the right. The student moves to the AFFF station.

AFFF Station #1

The following discrepancies exist: (1) The hose is tangled and not properly wound around the reel. (2) The AFFF inlet valve has safety wire hanging and not connected to valve properly. (3) **The nozzle is visible and appears to be clogged with debris.**

Following the inspection of the AFFF station, the student then moves to the down ladder between No.2 GTG and No.2A GTM. As the student approaches the down ladder there is a heat stress thermometer hanging from the overhead.

Heat Stress Thermometer

The thermometer should appear to indicate a temperature in excess of 100 degrees Fahrenheit.

The student then travels down the ladder to the 2nd platform. On the 2nd platform the student turns to the left and passes between the #2A GTM module and the ladder.

2A GTM Module

The module door is closed and the lock is missing from the door. Details of the door and the lock hinge have to be shown, including any warning signs that are present.

After walking pass the module, the student moves to the area directly behind No. 2 GTG. As the student looks straight ahead they see the rear of the GTG, the fire station to the left and the halon cylinders to the right. As the student stands looking at the stator of the GTG, the following discrepancies can be seen. The student should be able to move close to each of the three objects for inspection.

No.2 GTG (rear)

The stator oil piping has two flange shields missing. **On the two flanges missing flange shields, on one flange there is a missing stud and the other flange has a short stud.** n addition lube oil is pooled on the foundation. **One flange shield is loose and improperly attached.**

Fire station #1

The fire station has obvious standing water in its hose coming from the valve to the first hose loop. This is indicated by the hose being swollen at this point. This causes the loop to lie on the deck. **The adjustable spanner wrench is missing from its holder.**

Halon Cylinders #1

The pressure gauges on the halon bottles indicate zero.

Moving to the right the student is allowed to walk past the halon cylinders. Making a left turn and moving straight ahead the student moves down the side of the GTG to the module door.

No.2 GTG Module

The module door is closed and the lock is missing from the door. Details of the door and the lock hinge have to be shown, including any warning signs that are present.

The student then moves forward pass the GTG module door to the fire station.

Fire Station #2

The nozzle has small drips of saltwater coming from the tip, causing the deck directly below it to have salt caked on it. **The wye gate on the quick cleaning strainer is closed.**

The student is then allowed to walk back down the path just taken; allowed to move to the right between the dry air system dehydrator No.4 and SSAS air dehydrator No. 2 or; allowed to move to the left past the halon cylinders and up to the start air reducing station. No further discrepancies can be noted if the student moves back towards the area they came from. If they decide to turn left and go past the halon cylinders, the student can see that the start air reducing manifold is tagged out.

Start Air Reducing Manifold

Danger tags are hanging from the start air reducing manifold. On the deck is a danger tag that is adrift in front of the manifold.

If the student decides to turn right between the dry air system dehydrator No.4, once they are in front of No. 2 LPAC, the student walks down past the air compressors and dehydrators. The noise levels in this area should increase, as appropriate, with #3 LPAC operating. The student can then continue to walk past No. 2 HPAC with No. 2 HP dehydrator on the opposite side.

No. 2 HPAC Seawater Strainer

The seawater strainer has caked salt around the gasket seal indicating a leak. A small amount of seawater is seen leaking on the deck plates.

No. 2 HP Air Dehydrator

There are three gauges on this dehydrator. The calibration stickers should be missing and the red line pointers on the gauges should be pointing to zero. **One gage has a broken face cover.**

Heat Stress Thermometer

Place a heat stress thermometer in the overhead hanging from the electrical cables. The thermometer glass column should appear to be broken.

HPAC Controller

As the student passes the HPAC controller they see that a caution tag is hanging from the controller. If they inspect the tag closer they see that there is no signature or date on the tag.

The scenario should end when all discrepancies are found and identified or after 45 minutes of operation.

Scenario No. 2

The starting point of this scenario places the student standing on the hold platform of #2 main engine room at the foot of the down ladder. With the ladder directly behind, the student walks straight ahead as he/she is facing the lube oil service pumps. The fuel oil service filter/separators are positioned to the right.

Fuel Service Filter/Separation 2A & 2B

The gauges on the gauge board for the filter/separators have calibration stickers missing, and half of the red line pointers are at zero. The other half are at the proper locations.

Fire station #2

1. The adjustable spanner wrench is missing from its holder.

2. The multi-purpose nozzle is missing form the hose end.

PKP Bottle 1

The PKP bottle via the AFFF station to the right of the student has a tag torn and oil soaked.

AFFF Station #2

The following discrepancies exist on the AFFF station to the student's right:

1. The hose is tangled and not properly wound around the reel.
2. The AFFF inlet valve is missing the required safety wire that should be connected to valve.

Following the inspection of the AFFF station, the student moves down to the seawater cooling pump.

Seawater Cooling Pump No. 4

The cooling pump is operating and the coupling guard is missing.

The student then moves to the lube oil service pumps. While standing in front of 2B lube oil service pump and looking at the two vertical discharge valves, they see the following discrepancies:

2B Lube Oil Service Pump

1. The flange shields on the lower valve are oil soaked and there is pooled oil on the flange.
2. The handwheel is missing a proper valve label and there is lube oil pooled on the foundation of the service pump.

2A Lube Oil Service Pump

The remote operator on the suction valve of 2A LOSP is disconnected and lying on the valve wheel.

Walking past both of the lube oil service pumps and moving along straight ahead, on the student's left is a duplex lube oil strainer. If the student turns around they will see No. 4 Fire Pump

No. 4 Fire Pump

The automatic bus transfer for the fire pump has been tagged out and the danger tag hanging from the controller is torn and half of the tag is missing.

Duplex Lube Oil Strainer

The strainer has pooled lube oil standing on the foundation and an oily rag is balled up in the drip pan and **the strainer cover is off the strainer.**

Heat Stress Thermometer

Place a heat stress thermometer in the overhead hanging from a pipe directly above the service pump. The thermometer should show the mercury at the top of the glass column.

The student walks past the duplex saltwater strainer and makes a right turn. On the right is the lube oil purifier.

No. 2 Lube Oil Purifier

Two flange shields are improperly attached and oil soaked.

After identifying the discrepancies on the lube oil purifier the student faces the port shaft. They see the shaft turning (the shaft is painted with barber pole stripes).

Fluorescent Light #1

A fluorescent light in the overhead on top of the shaft is flickering, indicating a tube getting ready to go out. This flickering can cause the shaft to appear to be stopped and is a safety hazard.

At this point there is a single step going down that allows personnel to step under the shaft and a single step going up on the other side of the shaft. The student should be able to see the steps and be able to walk forward and see the affects of stepping down and stepping up while passing under the shaft. Once the student has passed under the shaft and stepped up on the other side, they are allowed to go to the fire station and no further.

Fire station #3

The fire station has salt caked on the top of the hose and the indicator loop is full of standing water (refer to fire station #1).

The student returns under the shaft the same way they came. Walking past the duplex oil strainer on the right, and fire-pump No. 4 on the left, the student sees the fuel service heater controller on their left

Fuel Service Heater Controller

This controller is tagged out with a red tag hanging on the controller. Walking close to the controller the student sees that the date and time is missing from the tag.

Continuing to walk forward the student walks past the AFFF hose reel and stops parallel to the ladder they came down. Looking to the left they see 2A fuel oil service pump.

2A Fuel Oil Service Pump

The following discrepancies are found on the service pump:

1. The service pump is missing a safety guard around the shaft
2. Fuel oil is pooled on the foundation of the pump.
3. One flange shield is missing.
4. **The remote operator is disconnected on the pump suction valve.**

The scenario should end when all discrepancies are found and identified or after 55 minutes of operation.

Appendix C

Case-Based Instructional Scripts

1/15/98

Control Group A (Visuals Only)
Scenario 1

Materials

This group will be given pictures of the engineering spaces as well as the accompanying documents.

Method

Students will be given materials and general written instructions and will proceed on their own.

Script

We are looking into optimal ways of teaching material inspection to Engineering Officers. You have been selected to try out some new visual materials that have been developed from pictures taken aboard ship. First we will give you some pictures to examine for 45 minutes. Then we will give you a new set of similar pictures and ask you some questions.

Here are some pictures of the engineering spaces on an Arleigh Burke class ship where you are the CHENG. You are in port and getting ready to do a walk through your spaces to assess their material readiness. You have wheelbook and logs available to you.

Ordinarily we would proceed though the spaces in a particular order. However, due to time limits, for this demonstration we have selected certain locations (nodes) for you to examine.

Examine the following areas for discrepancies. Not all areas will have discrepancies.

-- Platform 1, Nodes 1, 4, 7, 14, 23.

-- Platform 2, Nodes 4, 8, 14, 15, 6, 13.

-- Hold, Nodes 2, 4, 5, 12, 15, 16.

For each discrepancy you find:

1. Consider what actions you would take to correct it.

2. Consider how you would prioritize your action on a scale of 1 to 5, using the following categories:

    1. Security breach or CAS REP.
    2. Fix immediately.
    3. Put on the 8 o'clock report/ fix this week.

4. Place discrepancy on the CSMP or order repair parts.

5. Conduct repairs or correct after completing higher priorities.

3. If applicable, consider how this discrepancy affects the functioning of other equipment or systems aboard ship.

4. Consider, what information led you to this situation assessment and these actions.

5. Consider potential errors that less experienced engineers might make.

You will not have to write your answers to these questions. You many consult any information you wish.

You will have one hour for this part.

Control Group A (Visuals Only)
Scenario 2

Materials

This group will be given a new set of paper visuals of the engineering spaces as well as the accompanying documents.

Test

Here are some pictures of the engineering spaces on the USS Arleigh Burke. You are in port and getting ready to do a walk through the spaces for a material readiness assessment. You have some documents available to you.

Examine the following areas, and answer the questions on the answer sheet for each discrepancy you find. Some nodes may not contain a discrepancy.

-- Platform 1, Nodes 5, 15, 16, 18, 19, and 21.

-- Platform 2, Nodes 5, 10/11, 18, 19, 7.

-- Hold, Nodes 1, 10, 11, 13, 14, 19.

You will have one hour to complete this part.

1/14/98

Control Group B (Visuals & Case-based Instruction)
Scenario 1

Materials

This group will be given a paper visual of the engineering spaces as well as the accompanying documents.

Method

An instructor will lead three students through the material assessment process, using pictures.

Script

Allow 45 minutes for this part.

"We are looking into optimal ways of teaching material inspection to Engineering Officers. You have been selected to try out some new visual materials that have been developed from pictures taken aboard ship. First I will lead you through the process and then give you some time to examine the pictures individually. Then we will give you a new set of similar pictures and ask you some questions."

Step 1. Preparation for material inspection.

Instructor says to the students:

"You are in port on an Arleigh Burke class ship as the CHENG getting ready to do a walk through your spaces to assess their material readiness. You have a wheelbook available to you. At 1200 you stop by control and check the logs." (Logs available: Tag Out, Out of Commission (Instrument), Engineering.)

> "For example, from the Tagout Log you learn that the MER 2 HFFF hose reel actuation button is tagged out for repair." (Platform 2, Node 13).

Instructor should model the performance of the CHENG as s/he prepares to do a material assessment. The instructor should explain (as it is done) what s/he is looking for, what s/he finds, etc. Talk about making written notes in the wheel book, prioritizing discrepancies at the end of the inspection, and making the appropriate entries in logs. The instructor should discuss tracking material discrepancies: when it is appropriate to put it on the 8 o'clock report; when to make a note of it. The instructor might also ask the PEOs questions about this stage of the assessment.

Step 2. Instructor Modeling of Material Inspection Process. Modeling consists of a demonstration by the instructor of the process of solving a problem. Here the instructor will model how he performs material inspection.

A. First inspection item: Instructor says, "Ordinarily we would proceed though the spaces in a particular order. However, due to time limits, for this demonstration we will select certain locations (nodes) to examine."

Platform 1, Node 1. The instructor proceeds to the first zone where he will start the inspection. (Explain that a set of pictures were taken from a certain location and views were shot around a 360° angle. Explain the labels on the pictures: platform, node, image.)

The instructor explains:

1. That he is looking for something out of the ordinary (such as corrosion) or that he is looking for something written up in one of the logs. (Discuss the discrepancy at Platform 1, Node 1—AFFF hose improperly stowed.)

2. What actions he will take with different types of discrepancies, i.e. safety, housekeeping.

3. That he will write down what he finds, and at the end of the inspection he will prioritize actions to be taken, using the following categories (point these out on the answer sheet):

   1. Security breach or CAS REP.
   2. Fix immediately.
   3. Put on the 8 o'clock report—fix this week.
   4. Place discrepancy on the CSMP or order repair parts.
   5. Conduct repairs or correct after completing higher priorities.

4. How this discrepancy affects the functioning of other equipment or systems aboard ship.

5. What information led him to this situation assessment and these actions.

6. How s/he would follow-up on discrepancies noted to see if they had been resolved.

7. At the end of the inspection, s/he will decide which discrepancies to report to the CO.

Then the instructor asks the students for anything they might want to add or any questions they might want to ask.

B. Second inspection item:

Instructor goes to Platform 2, Node 14 and checks the breakers. Instructor models the inspection here using the same procedure as used for the first item. The instructor asks the following questions, "What's wrong with this? Why might it be in the off position? If you authorized repairs on that piece of equipment this morning, do you have any concerns by seeing this?" (Answer: Possibly, if people are not following tagout procedures. Or if they are not doing repairs.) "What caused this?" (Answer: Safety—equipment grounded.) "Is this something you want to get fixed immediately?"

C. Third inspection item: Go to Node 15 (Plat. 2). Look around. Say, " I don't find any discrepancies here."

Step 3. Instructor Coaching. Coaching involves the instructor observing students as they try to complete tasks and providing hints and helps when needed.

A. Fourth inspection item: Go to the Hold, Node 16. The instructor tells the students to look for any discrepancies. The instructor asks the students what they have found. (Frayed cable to 110 outlet.) Then he asks them to answer questions 2 through 6 above regarding this item. If the students have trouble, the instructor should lead them to the answers by asking them leading questions to help them discover the answer.

B. Fifth inspection item: The instructor goes to Node 4 (Hold) and asks the student to examine this area for any discrepancies. When they find it, the instructor asks the students to answer questions 2 through 6 above regarding this item. If the students have trouble, the instructor should lead them to the answers by asking them leading questions to help them discover the answer. For example, ask the student what reference to access. Then the instructor asks the student, "Do you see any other discrepancies in this area?" If they find it, the instructor asks the students to answer questions 2 through 6 above regarding this item. If the students have trouble, the instructor should lead them to the answers by asking them leading questions to help them discover the answer. If the students do not find it, the instructor should give them hints to lead them to it.

Step 4. Student practice.

A. Practice: The instructor says to the students:

"I selected only a few items for inspection, but now you should examine the materials supplied individually on your own and look for other discrepancies. Look at:

-- Platform 1, Nodes 4, 7, 14, and 23.

-- Platform 2, Nodes 4, 8, 13, 6.

-- Hold, Nodes 2, 5, 15, 12.

Some nodes may not contain a discrepancy. Write down your answers to each of questions 2 through 6 above."

"When you have completed the inspection, write down the discrepancies you would report to the CO."

Then the students should be given time to inspect several more items, writing down their selections and the answers to questions 2 through 6 above for each item.

B. Feedback: When the student completes his/her inspection, s/he returns to the instructor to present the results and get feedback. If items were missed, the instructor should review the documents with the student and question him/her about possible discrepancies to investigate. Then the instructor should send the student back to look for other discrepancies. Again, the student returns to the instructor and receives feedback. If additional items were missed, the instructor should point out the discrepancies on the visuals and ask the student questions 2 through 6 about the items.

Control Group B (Visuals and Case-based Instruction)
Scenario 2

Materials

This group will be given a new set of paper visuals of the engineering spaces as well as the accompanying documents.

Test

"Here are some pictures of the engineering spaces on the USS Arleigh Burke. You are in port and getting ready to do a walk through the spaces for a material readiness assessment. You have some documents available to you."

"Examine the following areas, and answer the questions on the answer sheet for each discrepancy you find. Some nodes may not contain a discrepancy."

-- Platform 1, Nodes 5, 15, 16, 18, 19, and 21.

-- Platform 2, Nodes 5, 10/11, 18, 19, 7.

-- Hold, Nodes 1, 10, 11, 13, 14, 19.

You will have one hour to complete this part.

Control Group C
(Virtual Environment and Case-based Instruction)
Scenario 1

Materials

This group will see and be able to navigate in virtual engineering spaces on the computer and will be given accompanying documents.

Method

An instructor will lead three students through the material assessment process, using the virtual engineering spaces as depicted in the computer.

Script

Allow 45 minutes for this part.

"We are looking into optimal ways of teaching material inspection to Engineering Officers. You have been selected to try out a new depiction of the engineering spaces on a computer. First I will lead you through the process, and then give you some time to try out the computer system individually. After that you will be asked to examine certain engineering spaces on the computer to find discrepancies."

Step 1. Preparation for material inspection.

Instructor says to the students:

"You are in port on an Arleigh Burke class ship as the CHENG getting ready to do a walk through your spaces to assess their material readiness. You have a wheelbook available to you. You stop by control and check the logs."

"For example, from the Tagout Log you learn that the MER 2 HFFF hose reel actuation button is tagged out for repair." (Platform 2, Node 13).

Instructor should model the performance of the CHENG as s/he prepares to do a material assessment. The instructor should explain (as it is done) what s/he is looking for, what s/he finds, etc. Talk about making written notes in the wheel book, prioritizing discrepancies at the end of the inspection, and making the appropriate entries in logs. The instructor should discuss tracking material discrepancies: when it is appropriate to put it on the 8 o'clock report; when to make a note of it. The instructor might also ask the PEOs questions about this stage of the assessment.

Step 2. Instructor Modeling of Material Inspection Process. Modeling consists of a demonstration by the instructor of the process of solving a problem. Here the instructor will model how he performs material inspection.

A. First inspection item: Instructor says, "Ordinarily we would proceed though the spaces in a particular order. However, due to time limits, for this demonstration we will select certain locations (nodes) to examine."

Platform 1, Node 1. The instructor proceeds to the first zone where he will start the inspection. The instructor explains:

1. That he is looking for something out of the ordinary (such as corrosion) or that he is looking for something written up in one of the logs. (Discuss the discrepancy at Platform 1, Node 1—AFFF hose improperly stowed.)

2. What actions he will take with different types of discrepancies, i.e. safety, housekeeping.

3. That he will write down what he finds, and at the end of the inspection he will prioritize actions to be taken, using the following categories:

    1. Security breach or CAS REP.
    2. Fix immediately.
    3. Put on the 8 o'clock report—fix this week.
    4. Place discrepancy on the CSMP or order repair parts.
    5. Conduct repairs or correct after completing higher priorities.

4. How this discrepancy affects the functioning of other equipment or systems aboard ship.

5. What information led him to this situation assessment and these actions.

6. Potential errors that less experienced engineers might make.

7. At the end of the inspection, s/he will decide which discrepancies to report to the CO.

8. How s/he would follow-up on discrepancies noted to see if they had been resolved.

Then the instructor asks the students for anything they might want to add or any questions they might want to ask.

B. Second inspection item: Instructor goes to Platform 2, Node 14 and checks the breakers mentioned in the Tagout log. Instructor models the inspection here using the same procedure as used for the first item. The instructor asks the following questions, "What's wrong with this? Why might it be in the off position? If you authorized repairs on that piece of equipment this morning, do you have any concerns by seeing this?" (Answer: Possibly, if people are not following tagout procedures. Or if they are not doing repairs.) "What caused this?" (Answer: Safety—equipment grounded.) "Is this something you want to get fixed immediately?"

C. Third inspection item: Go to Node 15 (Plat. 2). Look around. Say, " I don't find any discrepancies here."

Step 3. Instructor Coaching. Coaching involves the instructor observing students as they try to complete tasks and providing hints and helps when needed.

A. Fourth inspection item: Go to the Hold, Node 16. The instructor tells the students to find that item. The instructor asks the students what they have found. (Frayed cable to 110 outlet.) Then he asks them to answer questions 2 through 6 above regarding this item. If the students have trouble, the instructor should lead them to the answers by asking them leading questions to help them discover the answer.

B. Fifth inspection item: The instructor goes to Node 4 (Hold) and asks the student to examine this area for any discrepancies. When they find it, the instructor asks the students to answer questions 2 through 6 above regarding this item. If the students have trouble, the instructor should lead them to the answers by asking them leading questions to help them discover the answer. For example, ask the student what reference to access. Then the instructor asks the student, "Do you see any other discrepancies in this area?" If they find it, the instructor asks the students to answer questions 2 through 6 above regarding this item. If the students have trouble, the instructor should lead them to the answers by asking them leading questions to help them discover the answer. If the students do not find it, the instructor should give them hints to lead them to it.

Step 4. Student practice.

A. Practice: The instructor says to the students:

"I selected only a few items for inspection, but now you should examine the engineering spaces on the computer individually on your own and look for other discrepancies. Look at:

-- Platform 1, Nodes 4, 7, 14, and 23.

-- Platform 2, Nodes 4, 8, 13, 6.

-- Hold, Nodes 2, 5, 15, 12.

Some nodes may not contain discrepancy. Write down your answers to each of questions 2 through 6 above." "When you have completed the inspection, write down the discrepancies you would report to the CO." Then the students should be given time to inspect several more items, writing down their selections and the answers to questions 2 through 6 above for each item.

B. Feedback: When the student completes his/her inspection, s/he returns to the instructor to present the results and get feedback. If items were missed, the instructor should review the documents with the student and question him/her about possible discrepancies to investigate. Then the instructor should send the student back to look for other discrepancies. Again, the student returns to the instructor and receives feedback. If additional items were missed, the instructor should point out the discrepancies on the computer and ask the student questions 2 through 6 about the items.

Control Group C
(Virtual Environment & Case-based Instruction)
Scenario 2

Materials

This group will be given a new list of locations on the computer to examine; accompanying documents will be provided.

Test

"Using the computer scenes depicting the engineering spaces on the USS Arleigh Burke (in port),. you are getting ready to do a walk through the spaces for a material readiness assessment. You have some documents available to you."

"Examine the following areas, and answer the questions on the answer sheet for each discrepancy you find. Some nodes may not contain a discrepancy."

-- Platform 1, Nodes 5, 15, 16, 18, 19, and 21.

-- Platform 2, Nodes 5, 10/11, 18, 19, 7.

-- Hold, Nodes 1, 10, 11, 13, 14, 19.

You will have one hour to complete this part.

Appendix D

Equipment Requirements

1/13/98

Hardward and Software Requirements

Digital Image-Based System

The image-based application runs on a conventional pentium class desktop computer. The minimum requirements are:

Hardware	Software
166Mhz MMX Pentium CPU Accelerated SVGA graphics card with 2MB of video ram 17" .28 SVGA non-interlaced monitor (21" optional) 2.1 GB Hard Drive 32MB Ram 256KB L2 cache 16X CD-ROM	Windows 95 QuickTime for Windows

Model-Based System

The model-based application runs on a pentium II desktop computer in a Windows NT environment. The minimum requirements are:

Hardware	Software
300 Mhz Pentium II CPU Intel AL440LX chipset motherboard or equivalent 128 MB Ram 512K Pipe cache Open GL 3D graphics and texture accelerator for visualization and animation (Diamond Fire GL 3000 board with 8MB of VRAM and 32MB of DRAM or equivalent) 17" .28 SVGA non-interlaced monitor (21" optional) 4.3 GB Hard Drive 24X CD-ROM Sound Blaster compatible sound card with .wav capability	Windows NT 4.0 World Tool Kit Open GL Drivers

Appendix E

Surface Warfare Officer School Student Questionnaire Of Virtual Environment Training

Surface Warfare Officer School Student Survey of Virtual Environment Training

Please indicate extent to which you agree or disagree with the following statements. Circle the appropriate letter on the form below.

	Greatly Disagree	Somewhat Disagree	Uncertain	Somewhat Agree	Greatly Agree	Doesn't Apply
1. It was easy to "move" through the propulsion plant with the approach I was given.	A	B	C	D	E	F
2. I was able to view the scenes fairly quickly.	A	B	C	D	E	F
3. Many of the images were unclear.	A	B	C	D	E	F
4. I had to spend too much time going back-and-forth within a node to find a discrepancy.	A	B	C	D	E	F
5. The propulsion plant scenes were arranged in a logical order.	A	B	C	D	E	F
6. The viewing area in the propulsion plant was too restricted to be useful.	A	B	C	D	E	F
7. I was able to learn about material readiness assessment using the approach I was given.	A	B	C	D	E	F
8. It was difficult to figure out where I was in the propulsion plant.	A	B	C	D	E	F
9. This approach to identify discrepancies was confusing.	A	B	C	D	E	F
10. The discrepancy identification process was confusing.	A	B	C	D	E	F
11. It was fairly easy to move from none-to-node.	A	B	C	D	E	F
12. It was easy to move from platform-to-platform.	A	B	C	D	E	F
13. There should be an easier way to navigate through the engine room spaces.	A	B	C	D	E	F
14. The fidelity or clarity of the propulsion plant was good.	A	B	C	D	E	F
15. It was difficult to clearly see any discrepancies.	A	B	C	D	E	F
16. It was difficult to distinguish between platforms.	A	B	C	D	E	F

	Greatly Disagree	Somewhat Disagree	Uncertain	Somewhat Agree	Greatly Agree	Doesn't Apply
17. The views of the propulsion plant were very accurate.	A	B	C	D	E	F
18. I have a better understanding than I had before of what the propulsion plant of the ARLEIGH BURKE class of ships looks like.	A	B	C	D	E	F
19. The instructions I was given were helpful in understanding my task.	A	B	C	D	E	F
20. The instructions I was given were helpful in "navigating" through the spaces.	A	B	C	D	E	F
21. This approach to learning about material discrepancies was useful.	A	B	C	D	E	F
22. This approach should be a bigger part of the course training process.	A	B	C	D	E	F
23. Compared to the typical classroom instruction, the present approach used to examine the engineering spaces helped me to understand the material assessment process better.	A	B	C	D	E	F
24. The approach used by the instructor is one that is also used in the classroom.	A	B	C	D	E	F
25. The information given by the instructor was clear.	A	B	C	D	E	F
26. In general, I was satisfied using this approach to learn about the material discrepancy process.	A	B	C	D	E	F
27. In general, I was satisfied using this approach to identify discrepancies.	A	B	C	D	E	F
28. In general, I do not think this approach for identifying material discrepancies is a good one.	A	B	C	D	E	F
29. This form of instruction was useful compared to the traditional forms of classroom instruction.	A	B	C	D	E	F
30. Compared to the typical classroom instruction, the present approach helped me to understand how the equipment worked together better.	A	B	C	D	E	F
31. Compared to the typical classroom instruction, the present approach used to examine the engineering spaces helped me to visualize the work spaces better.	A	B	C	D	E	F

Please provide the following information:

What is your rank?________________________

How long have you been in the Navy? ______________________

How many tours have you had at sea?_______________________

How many years have you served at sea?______________________

How many ships have you served aboard?____________________

What types and how much engineering training have you had (e.g., education, OJT)?

College____

Navy____

OJT____

Civilian____

Other (specify)____

What engineering related jobs have you held aboard ship and for long?

On your most recent tour, you served as a:_______________________________________

On your next tour, you will serve as a:____

How much experience have you had using computers?

None

Six months or less

Six months to 1 year

1 to 3 years

More than 3 years

Appendix F

Surface Warfare Officer School Instructor Questionnaire of Virtual Environment Training

1/13/98

Surface Warfare Officer School Instructor Survey of Virtual Environment Training

Please indicate extent to which you agree or disagree with the following statements. Circle the appropriate letter on the form below.

	Greatly Disagree	Somewhat Disagree	Uncertain	Somewhat Agree	Greatly Agree	Doesn't Agree
1. I like this approach to teach about the material condition of the propulsion plant.	A	B	C	D	E	F
2. It was easy for the students to "move" through the propulsion plant with the approach I used.	A	B	C	D	E	F
3. Many of the images were unclear.	A	B	C	D	E	F
4. I had to spend too much time clarifying information for the students.	A	B	C	D	E	F
5. The propulsion plant scenes were arranged in a logical order.	A	B	C	D	E	F
6. The viewing area in the propulsion plant was too restricted to be useful.	A	B	C	D	E	F
7. The students were able to learn about material readiness assessment using the approach I used.	A	B	C	D	E	F
8. The present approach added information that otherwise would be difficult to include to understand the material condition of the propulsion plant.	A	B	C	D	E	F
9. This approach to identify discrepancies was useful.	A	B	C	D	E	F
10. The discrepancy identification process used in this approach was confusing.	A	B	C	D	E	F
11. It was fairly easy for students to move from none-to-node.	A	B	C	D	E	F

	Greatly Disagree	Somewhat Disagree	Uncertain	Somewhat Agree	Greatly Agree	Doesn't Agree
12. It was fairly easy to move from platform-to-platform.	A	B	C	D	E	F
13. This approach provided a useful way to teach about material discrepancies.	A	B	C	D	E	F
14. The fidelity or clarity of the images of the propulsion plant were good.	A	B	C	D	E	F
15. It was difficult for students to clearly see discrepancies.	A	B	C	D	E	F
16. It was difficult to distinguish between platforms.	A	B	C	D	E	F
17. The views of the propulsion plant were accurate.	A	B	C	D	E	F
18. The present approach should give a good perspective of what the propulsion plant of the ARLEIGH BURKE class of ships looks like.	A	B	C	D	E	F
19. The present approach did not add useful information beyond what is presently taught in the classroom.	A	B	C	D	E	F
20. The present approach will detract from students learning about the propulsion plant operations.	A	B	C	D	E	F
21. The present approach has applications beyond its use in the propulsion plant.	A	B	C	D	E	F
22. This approach should be a bigger part of the course training process.	A	B	C	D	E	F
23. Compared to the typical classroom instruction, the present approach used to examine the engineering spaces will help students understand the material assessment process better.	A	B	C	D	E	F
24. Compared to the typical classroom instruction, the present approach used to examine the engineering spaces will be more confusing to the students.	A	B	C	D	E	F

	Greatly Disagree	Somewhat Disagree	Uncertain	Somewhat Agree	Greatly Agree	Doesn't Agree
25. In general, I was satisfied using this approach to teach about the material discrepancy process.	A	B	C	D	E	F
26. This approach required me to spend more time to prepare for my students.	A	B	C	D	E	F
27. In general, I do not think this approach for identifying material discrepancies is a good one.	A	B	C	D	E	F
28. Compared to the traditional classroom instruction, I would recommend this approach as an important supplement.	A	B	C	D	E	F
29. Compared to the traditional classroom instruction, the present approach used to examine the engineering spaces required me to change my teaching style.	A	B	C	D	E	F
30. The present approach used to examine the engineering spaces will help students when they serve as a CHENG.	A	B	C	D	E	F

Please provide the following information:

What is your rank?________________________

How long have you been in the Navy? ____________________

How many years have you served at sea?____________________

How many ships have you served aboard?___________________

How long have you been an instructor at SWOS? ______________at other locations?___________

What types and how much ***engineering*** training have you had (e.g., education, OJT)?

College____

Navy____

OJT____

Civilian____

Other (specify)____

What engineering related jobs have you held aboard ship and for long?

On your most recent tour, you served as a:_____________________________________

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How much experience have you had using computers?

None

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