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Report of the First Annual Airborne Weapons Training Technology Review

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A special thanks is due to Dr. Webster. She and her staff organized the First Annual Airborne Weapons Training Technology Review documented in this report.

ABSTRACT

This report documents the First Annual Airborne Weapons Training Technology Review. The Review was held at Oak Ridge Associated Universities from March 29 to 31, 1989. It was an exchange of ideas and information among the members of the network supporting the Naval Air Systems Command's (NAVAIR's) PMA205-11, Program Manager for Ordnance Training. This report describes the briefings and demonstrations presented at the Review, and summarizes the discussion at the informal caucus where significant issues were raised from the first two days' presentations. The report also contains the meeting agenda, a participant list with addresses and telephone numbers, a list of the Department of Defense activities represented, NAVAIR's follow-up communication, and a brief description of Martin Marietta Energy Systems, Inc.'s training technology project support.

A broad range of topics related to training systems and training support was covered during the Review. Synopses of the presentations and demonstrations included here cover computer-based and interactive systems, portability of software, reuse of training systems for different weapons, standardization of trainers, instructional systems design, cognitive task analysis, tracking of training resources, and the application of Computer-aided Acquisition and Logistic Support.

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OVERVIEW OF SESSIONS

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This report documents the First Annual Airborne Weapons Training Technology Review held in Oak Ridge, Tennessee, March 29, 30, and 31, 1989. The Review was conceived as an occasion to share information and to exchange ideas across the network of military, civilian, and private sector professionals supporting the Naval Air Systems Command's (NAVAIR's) PMA205-11, Program Manager for airborne weapons and ordnance training. The Data Systems Engineering Organization of Martin Marietta Energy Systems, Inc. sponsored and organized the meeting as part of their training technology project. Energy Systems is an active member of the worldwide team of Navy personnel and contractors that supports PMA205-11.

William J. Walker, the program manager, has provided the initiative for the PMA205-11 team. Walker identified the Fleet's need for weapon-specific part-task trainers, initiated new activity in the Airborne Weapons Training Program, and continues to fund the extensive network that exists today. Walker's guidance and enthusiasm have resulted in productive training initiatives, one of which is the Annual Review of Training Technology documented in this report.

More than 90 individuals attended the Review, representing Navy and Marine organizations, prime weapons contractors, Navy support contractors, universities, and Energy Systems. Contributions and contributors represented a broad range of specialtists, from Navy enlisted personnel to psychologists, discussing topics from shipboard maintenance problems to expert mental models.

The team members were welcomed by Cathrine Snyder, project manager for the Oak Ridge Training Technology team. Ms. Snyder discussed the Oak Ridge team's role in the Work for Others Program and in NAVAIR support. She pointed out that weapons training systems grow more important as weapons systems become increasingly complex. The Oak Ridge team uses an interdisciplinary approach to computer-based training for weapons operation and maintenance. The team's goal is to ensure that human factors engineering, instructional design, and modern software engineering are integrated in the development of interactive training systems purchased by NAVAIR from the private sector. An objective is to aid NAVAIR in purchasing computer-based systems as training, not just as hardware/software.

Phyllis Campbell, PMA205-11C, welcomed the group on Walker's behalf. Following Ms. Campbell's welcome, Dr. Robert Merriman, Energy Systems Vice President of Atomic Vapor Laser Isotope Separation (AVLIS) and Work for Others Programs, presented the opening remarks. Dr. Merriman described the Oak Ridge research facilities and the many types of work conducted within those facilities for the Department of Energy and other agencies.

A day of briefings by the participants followed the opening remarks. The briefings, summarized in Section 2, included talks on a broad range of topics related to training systems and training support. Three of the themes that emerged repeatedly at the Review are human factors engineering, standardization, and cost reductions. Over the last two years there has been a marked increase in funding for training on specific missile systems and the role of the human operator in complex, automated systems. The problem of standardization has also drawn attention because the Navy wants to increase reusability while taking advantage of rapidly changing technology. Proposals made in briefings include other specific ways to make training technology more cost-effective:

- decrease redundancy
- use commercial off-the-shelf software
- increase modularity of courseware design for ease of updating
- identify standards for training requirements

- work toward transportability of courseware
- work toward translatability of software
- develop training systems for use on more than one weapon
- reuse weapons parts for trainer development
- combine testing and training processes
- improve lines of communication.

The second day of the meeting was comprised of formal and informal demonstrations. The formal component, summarized in Section 3, included cognitive task analysis, tracking of training resources, and the evolution of the Computer-aided Acquisition and Logistic Support (CALS) initiative. Informal demonstrations were conducted in the lobby to provide attendees with hands-on experience with training systems. These systems were the Maverick Engagement Decision Aid developed by Ketron, Inc., a Missile Training Interactive Video developed by VSE Corporation, and Computer Aided Instruction for Naval Aviation Logistics Data Analysis (NALDA) developed by Energy Systems. On the final day of the Review, an open caucus allowed the participants to discuss their reactions to the briefings and demonstrations and to discuss plans for the coming year.

This report will provide a model for future Training Technology Reviews, and will also be used as a reference document for members of the PMA205-11 network and others interested in training technology. In addition to synopses of presentations, demonstrations, and the caucus, the document contains five appendixes: a participant list, a list of the Department of Defense activities represented at the review, the agenda distributed at the Review, a description of Energy Systems training technology support, and a copy of the follow-up communication from NAVAIR.

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SYNOPSES OF BRIEFINGS

by Paul Tarrant and
Inga Treitler

Pacific Missile Test Center Overview

Clyde Denham (Pacific Missile Test Center)

The Pacific Missile Test Center (PMTC), at Point Mugu, California, operates under the Weapons Support Directorate to provide advice, instruction, and training for ordnance, targets, and Unmanned Air Vehicles (UAVs). PMTC was initially established to support targets and range scoring and control systems through on-site Navy Civilian Technical Specialist personnel and to operate as support manager for targets. Its charter was expanded to establish and retain training and support capability at PMTC for aircrew ordnance training; ordnance officer, fleet, and technical community training; computer-based trainers; part-task trainers; and all ordnance, targets, and related equipment. More than 33 detachments from the Navy/Marine Corps are supported by PMTC; much of the support is available on-site. PMTC currently maintains 170 active courses and over 150 video media that employ either computer graphics or interactive video.

PMTC has recently been cleared for an increased personnel allocation but still requires a dedicated fleet training facility. Such a facility would provide a school building and library; hardware/software design, development, maintenance and logistics support; and receipt, storage, issue and inventory control. Insufficient space and poor military construction prospects currently are the major obstacles. Aircrew and weapons officers training courses are being evaluated for incorporation at Point Mugu. PMA205-11 is the sponsor of fleet training at PMTC and is dedicated to establishing PMTC as the life cycle support focal point for ordnance, targets, and UAV training of aircrew, maintenance, and technical personnel.

Key Determinants of Vendor-Prepared Computer-Based Training Development and Maintenance Cost Bids/Estimates

James P. Smith, Ph.D. (Star Mountain, Inc.)

Accurate budgeting and adequate funding are critical to the successful acquisition, implementation, and life cycle maintenance of computer-based training (CBT) systems. Despite the procurement of literally thousands of CBT systems over the last two decades, federal government organizations and supporting corporations still report serious difficulties in accurately projecting actual CBT costs. Two suggestions are made to remedy this problem. First, identify key variables that influence vendor estimates of the cost involved in developing and maintaining CBT for government clients. Second, offer ideas on how the government can improve the accuracy of budget planning through a better knowledge of vendor cost drivers.

Use of computers and other technology to deliver training is becoming widespread in the federal government. Increased automation of training leads to rising costs and a need for government budget planners to estimate these costs more accurately. Improved estimates can be achieved through better government understanding of factors that influence vendor cost estimating.

Vendor cost components are made up of the following: direct costs including labor, hardware/software, travel, and consultants; indirect costs such as fringe benefits, occupancy, general and administrative support, and internal R&D; profit; subcontract management fees; and contract vehicle fees. CBT must be evaluated through all life cycle phases.

Cost determinants from the vendors' standpoint dictate that each business opportunity be evaluated separately. The vendors' evaluation is based primarily upon information contained in (or only implied by) the Request for Proposal (RFP). Many types of information are needed for accurate and competitive vendor cost estimating. Most importantly, where information is lacking, assumptions in the vendors' best interest are often made and specified. General cost determinants include government-furnished resources, analysis/design, development/production, implementation/revision, and maintenance. Within these general categories, the six areas of concern are total number and type of lessons to be developed; level of required student interactivity; hardware/software system to be used; Interactive Video Disc (IVD) requirements; system design; and the production schedule.

The following suggestions are made to achieve a better fit between government budgeting and vendor cost estimates. Provide a clear, specific statement of what is needed in the RFP. Ensure that RFP writers and source selection personnel understand the need for and the cost of Instructional Systems Development approaches in the CBT life cycle. Base contract award on technical and cost considerations. Do not specify CBT where it is not technically appropriate or cost-effective. Understand the CBT development and maintenance process from the vendor (as opposed to in-house) perspective. Provide a stable source information database. Provide Government Furnished Equipment that will support the desired CBT outcome (use it for vendor development and student delivery). Develop realistic expectations and freeze them early in the design phase. Provide knowledgeable Subject Matter Experts throughout the project. Finally, identify "buy-off" authorities for all phases of the project up front and leave them in place through project completion.

Interactive Courseware and Interactive Videodisc Technology

Leo J. Violette (Naval Underwater Systems Center)

The Missiles Division has developed interactive courseware (ICW) using the Sony VIEW System 2000, to provide missile operation and maintenance training. ICW was chosen for the following reasons. Interactivity enables students to see, hear, read, and gain realistic hands-on experience. The student works closely with the courseware. The student controls the pace, makes decisions, and has immediate feedback on errors. The interactive courseware and interactive video technology under discussion here was developed to address the following problems: The Submarine Force lacked formal initial and refresher Navy training for Tomahawk loading and handling. Additional expertise and proficiency were required in Tomahawk pre-launch operations. There was a need to address the primary training requirements of safety, assembly/disassembly of loading and handling equipment, and loading evolution.

Three training options were identified and evaluated for efficacy of training and cost-effectiveness before ICW was developed. The first option was formal classroom training at one primary facility. Formal training for Tomahawk loading and handling would be established at the Naval Training Systems Center in Orlando, utilizing tube mock-ups, shapes, and curricula. The primary advantage would be the suitability of the environment for training, because the student would be isolated from his/her command. The disadvantages would include the need for additional instructors, the high initial cost and the high cost of training equipment maintenance, 3.5 years lead time for some training equipment, limited hands-on experience, loss of manpower, and high overall costs. Overall costs would include training, equipment, and travel.

The second option was formal classroom training at multiple sites. Formal training for Tomahawk loading and handling training would be established at training facilities in five submarine home ports. The advantages would include the reduction of man-hours lost by excessive travel, the reduction of travel costs, and the provision of hands-on training through the use of mock-ups. The disadvantages would include the need for additional instructors, the cost of training equipment and maintenance, the 3.5 year lead time for training equipment and military construction, limited hands-on training, and the overall cost of establishing five training centers.

Option three was the establishment of Interactive Video Learning Centers. The advantages perceived include the reduction of man-hours/cost lost by travel, savings of $3M over formal classroom training programs, improvement of communication between I-level and O-level, responsiveness of training (remediation), low maintenance, presentation of actual loading and handling evolution in an environment, individualized instruction, and low overall cost. No additional instructors or construction is required and only minimal equipment is needed. The disadvantages of this option include the need for an area to house the learning center and the assignment of a monitor for the center as a collateral duty. Cost comparisons of implementation and maintenance of hardware/curriculum (Options I and II) with interactive video equipment and development cost, and maintenance (Option III) proved ICW most cost-effective. Consequently, Interactive Learning Centers have been established at the five home ports. Three courses have been implemented, five more are being developed, and four courses are in the proposal stage. To date these courses have provided refresher training only, but they are scheduled to be used in formal training within the year.

There is a formal ICW development cycle with an elaborate, documented standardized life cycle management plan. ICW is gaining widespread acceptance as a cost-effective method of training with excellent results.

Computer Aided Instruction (CAI) for the Naval Aviation Logistic Data Analysis (NALDA) System

Barbara Hershey Handler
Martin Marietta Energy Systems, Inc.

Data Systems Engineering Organization (DSEO) personnel developed a prototype computer aided instruction (CAI) system for the Naval Aviation Logistic Data Analysis (NALDA) system in order to enhance existing NALDA training. The prototype was constructed by following a five-step Instructional Systems Development (ISD) model of analysis, design, system development, implementation, and evaluation. Members of the CAI team filled 14 clearly defined roles: project manager, program or course sponsor, instructional designer, subject matter expert, writer, editor, programmer, data input or entry specialist, media expert, graphics designer, technical systems expert, learner, production administrator, and CAI administrator.

Phase I included analysis of the problem, evaluation of alternative solutions, and recommendations for an approach to NALDA CAI. A user profile was also developed during Phase I. In Phase II, a structured design and specification document was developed and the prototype CAI was created following the standards set forth in the document. A program generator was designed and developed to automate the production of a majority of the authoring language programs required to drive a course. Phase II concluded with the testing and implementation of a CAI prototype that enhances user productivity, efficiency, and skill in using the NALDA system by providing a readily available training package with optional degrees of training, no time constraints, and on-line help and evaluation similar to that received in a regular classroom.

The overall prototype was created in a way that makes it modular, standardized, and transportable. A technology-transfer procedure was developed to enable the Naval Aviation Maintenance Office to assume responsibility for building and maintaining a complete CAI system based on the methods and tools established through the development of the CAI prototype. A demonstration of CAI for the NALDA System was made available in the lobby.

Standoff Land Attack Missile (SLAM) Captive Air Training Missile Technology

Tom Benedik (Naval Ordnance Station, Indian Head)

Standardization of electronic training devices is a strategic objective for Naval Odnance Station, Indian Head (NOSIH) because a competitive edge cannot otherwise be gained. The major areas for standardization are methodology, hardware, software, and equipment development. The development equipment utilized is Computer Aided Design/Computer Aided Engineering/Computer Aided Software Engineering, general support equipment, VAX technology, and IBM PCs.

In order to keep pace with state-of-the-art technology trends, all operating standards are geared to MIL-STD-2167A, MIL-STD-2168, Ada, C language, and common structures. The main thrust in hardware is the VME bus. NOSIH provides true integration and design automation.

NOSIH's electronic design development includes four systems: MLITS (DATM-84E-1B), H/SAWS (CATM-84E-1C), H/SAWS (CATM-84A-1C), and the H/SAITS (the two-station-capable unit lab box). H/SAWS provides the fleet with a versatile Captive Air Training Missile (CATM) Harpoon/SLAM simulator. Prototype parts have now been procured, and development of software and standards specifications is in progress.

Computer-Based Aircrew and Tactical Training

Linda Childs (Delex Systems, Inc.)

Delex Systems Computer Based Training products include shore-based multistations, multistudent tactical trainers, courseware on diskettes that can be run on any IBM compatible AT, and sophisticated part-task trainers built to be deployed aboard a carrier. The part-task trainers use state-of-the-art, off-the-shelf technology in a compact rack-mounted system that employs three-dimensional graphics, full color illustrative graphics, pressure-sensitive touch screens, and actual aircrews control sticks to train aircrews in all aspects of weapon system employment including prelaunch, launch, and postlaunch procedures and decision making. Freeplay of all weapon system-related aircrew activities is provided as requested.

The tactical trainers employ high-resolution graphics to provide interactive tactical training on a variety of weapons for a variety of platforms. The trainer uses up to three student stations and one instructor station. Students see the results of tactical decisions made during mission planning in a world environment created or chosen by the instructor. These interactive tactical trainers provide individual, coordinated, or one to two-on-one attack scenarios.

The engagement training aid courseware is designed for use by tactical decision makers for either an air or a sea platform against up to 20 different targets. Students become familiar with weapon system performance capabilities and limitations through tutorials and exercises that provide an aerial view of weapon system setup decisions as reflected by missile performance. Exercises can be built by the instructors to provide situational currency with immediate feedback.

Encapsulated Harpoon Certification and Training Vehicle (EHCTV)

Allen F. McGuy (Naval Underwater Systems Center)

The Naval Underwater Systems Center (NUSC) is the principal research and development, testing and evaluation center for submarine warfare and submarine weapons systems. Its function is to conduct in-house research and to maintain the capability to develop, test, evaluate, and integrate submarine warfare systems including sonar, communications, navigation, weapons and targets, launchers, fire control, command and control, and underwater ranges.

NUSC Missile Division Encapsulated Harpoon responsibilities include Encapsulated Harpoon technical cognizance, Encapsulated Harpoon Command and Launch Subsystem (EHCLS) technical cognizance; CAP/CAN test set technical cognizance; system integration for fast attack submarines (SSNs); fleet introduction/SSN certification; tender/shorebased I-level maintenance certification; training, certification, and inert vehicle design and acquisition; Integrated Logistic Support management for submarine platforms; and foreign military sales support. NUSC has recently prepositioned interoperability kits in the United Kingdom for the utilization of U.K. Encapsulated Harpoons by the U.S. Navy, should hostilities arise.

Because the Harpoon is a one-time-only use weapon and because current planning allows only four live firings a year, the Encapsulated Harpoon Certification and Training Vehicle (EHCTV) was developed to provide the SSN community with a reusable vehicle that simulates the warshot through loading, handling, fire control interface and presets, launch sequence, and underwater trajectory parameters. EHCTV's operational cycle allows SSN continually to meet guidelines concerning preparedness and proficiency capabilities of the weapon. The cycle is powered, initialized, and launched using SSN fire control. EHCTV is retrieved by torpedo recovery boat or helicopter. The data cartridge is then removed for evaluation, servicing, and reissue.

Launches of EHCTV revealed major fire control hardware/software problems. Underwater trajectory studies were initiated after EHCTV launches uncovered excessive broach pitch angles, excess roll rate limits on 688 Class SSN, and broach yaw angles dispersions.

BIGEYE Loading/Handling Training Rounds

William Gentry (S. T. Research)

The idea to convert expended test rounds into handling and loading training rounds was conceived by Don Jackson of Naval Weapons Station, Fallbrook site. Because BIGEYE is a chemical carrier that uses a mechanical rather than explosive device to deploy the chemical, much of the original weapon remains intact after a test round is expended. The remanufacture of expended test rounds will yield an estimated $13M in savings over the manufacture of new trainers. Remanufacture includes installing chambers to contain fluids that simulate the shape, weight, and center of gravity of a live weapon.

S. T. Research built an automatic test sequencer that provides safety interlocks during tests, automatic test control, all-up-round testing for BIGEYE, electrical and mechanical stimuli for BIGEYE, measurements of functional parameters without affecting weapon operation, and printouts of tabulated and plotted data. S. T. Research also designed and constructed an accelerated aging test chamber to simulate seasonal temperature changes. The chamber accommodates eight CNU-396/E reactor body containers and provides for containment in case of leakage. Handling/loading is done by forklift facilitated by dollies supporting CNU-396/E containers.

Standoff Land Attack Missile (SLAM) Trainer*

Richard Davenport (LTV Missiles and Electronics Group)

This trainer is designed to provide video output in real time with the capabilities of simulating time delays on preplanned missions. The flight profile includes determination of waypoints and search altitude, target area within test area, five initial firing scenarios defined by PMTC, other firing scenarios that can be generated the same day or over night, and a seeker field of regard that is equivalent to five seeker fields of view.

The training scenario proceeds as follows. The operator chooses a missile firing scenario that begins at seeker-turn-on coordinates. There is a time delay from launch to seeker turn on. The seeker video displayed/target location is in the field of view. The operator slews the seeker and utilizes discrete controls as necessary. After missile impact, the operator reviews the exercise and chooses the next scenario.

The photographic-based test area was developed using photometric techniques. The simulation is comprised of the following five areas: the test area, the missile airframe, the missile seeker, the operator video display, and the operator station. Adhering to "SLAM System Data Document to Support Trainer Development" and its associated Classified Appendix, both missile and seeker simulation were built to A-6E aicraft capabilities.

Sensor video simulation has imaging infrared (IIR) characteristics, reduced screen area, and sensor resolution simulation. SLAM symbology incorporates the field of view brackets, nose index, video cursor, and informative messages.

*Following the briefing a videotaped demo of the video target simulation at White Sands was shown.

Maverick Engagement Decision Aid (MEDA) Overview

Jerry West (Ketron, Inc.)

The objectives of this training aid are to improve aircrew understanding of Maverick and its performance capabilities and limitations, to improve aircrew understanding of engagement variables, weather, etc., that affect Maverick, and to exercise aircrew abilities to respond to any contingency. Training material to introduce the laser Maverick was mandated because the Marine Corps was concerned about using laser in close air support missions, i.e. air strikes close to the designator and friendly troops.

The system consists of a tutorial, an exercise generator, freeplay, and evaluation and playback. Different modules were developed to provide learners with experience in different features of weapon design and use. Maverick Engagement Decision Aid (MEDA) development responsibilities include project manager, Naval Air Development Center (NADC); sponsor, NAVAIR; and contractor, Ketron, Inc. The MEDA was designed to incorporate both a heads-up display and a heads-down display for the AV-8B.

Government-furnished requirements mandated development of the system on a Zenith Z-248 and installation within two years. Prototype MEDA tests revealed hardware incompatibility problems. The dual monitor proved to be too bulky, and a lack of human factors in engineering resulting in negative training was a common complaint.

A two-phased approach was implemented to correct prototype problems. In Phase I single monitor capability was developed, system layout was improved, and the system was made user friendly. Phase II will involve automation of the tutorial, development of an advanced interactive exercise generator, and generic switchology for freeplay (AV-8B simulation change to F/A-18 simulation by use of functional menus). Phase III will extend the system to infrared Maverick, to generate 3-D images, and to show infrared images.

DoD Weapons Systems Acquisition Process

Bill Jones (Naval Aviation Maintenance Office)

The Naval Aviation Maintenance Office (NAMO) provides all Navy Training Plans on newly acquired weapons. It provides information to all interested parties through a newsletter and telephone directory. It supports NAVAIR's and OPNAV's total quality management process. The goal of this briefing was to provide the PMA205-11 team with a reminder about several aspects of the acquisition process.

The DoD system acquisition process is guided by circular A-109 from the Office of Management and Budget, and DOD Directives 5000.1 and 5000.2. Four milestones are essential in the process. Milestone "0" is the concept exploration stage. This stage requires a decision memo, mission need statement, and Plan of Action and Milestone approval. Milestone "1" is the demonstration/validation stage. This is a Secretary of Defense approval milestone with a requirements validation. Milestone "2" is the full-scale development stage. This is also a Secretary of Defense milestone for program go-ahead. Milestone "3" is the production/deployment stage. This is a service milestone for production go-ahead.

The Training Development Process includes 17 events starting with the Hardman Analysis and finishing with Post Production Analysis. Each event must be achieved and is integral with the acquisition phases. There are four important elements to remember for the Training Device Acquisition Specification: Integrated Logistic Support (ILS) requirements, factory training, technical data, and configuration management (CM).

ILS is an integrated support process that makes a weapon system functional in its intended environment. The ILS management organization is made up of Program Decision Authority (PDA), Program Manager Aircraft (PMA), Assistant Program Manager Logistics (APML), Logistic Element Managers (LEMs), and Cognizant Field Activities (CFAs). All elements of ILS must be planned for in the acquisition proposal.

CM contains four vital areas: identification, audits, control, and status accounting. Integating CM up front for all three phases of weapon acquisition -- platform, weapon, and trainer -- will eliminate many of the usual difficulties and automatically allow for possible engineering changes. Engineering change proposals provide the total impact of proposed changes, enable informed decisions at all levels of management, and permit orderly introduction and required support of necessary changes.

Ordnance, Maintenance, and Training Requirements Review (OMTRR)

John Vaughan (Systems Management Technology)

The Ordnance, Maintenance, and Training Requirements Review (OMTRR) has been proposed as a means to establish communication links between the Fleet and NAVAIR, to enhance NAVAIR awareness of Fleet training needs, and to provide a personnel interface between OPNAV, NMPC, NAVAIR, NAMTRA, and the Fleet. The goal is to establish a procedure parallel and analogous to the Maintenance Training Requirements Review (MTRR) for ordnance and ordnance-men concerns, which include Aviation MTRR, direct fleet training feedback, direct impact on training course content (NEC, NTP, and CANTRAC/OTTMS), and the provision of Action Item tracking capabilities. OMTRR would have three branches: the executive committee, the review committee, and working groups. Key personnel would be OPNAV (OP-59), NAVAIR (PMA205), NMPC, AIRLANT/PAC, NAMTRAGRUHQ, and fleet personnel.

OMTRR considerations include conference policies/procedures, conference frequencies/sites, conference information to the fleet, conference agenda, attendance requirements, and travel/expense responsibilities. OMTRR's major benefits would be reduction in training costs, elimination of redundant training, and enhanced control of training courses, training tracks, Navy classification assignments, and personnel distribution.

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SYNOPSES OF DEMONSTRATIONS

by Barbara Oliver and
Inga Treitler

Cognitive Task Analysis Techniques for Operators of Airborne Weapons Systems

Michele Terranova, Ph.D.
(Oak Ridge National Laboratory, Martin Marietta Energy Systems, Inc.)
Tom Seamster, Ph. D. (Carlow Associates, Inc.)

The objective of the presentation was to discuss the benefits of Cognitive Task Analysis for use in determining training needs and identifying training methods for the Navy. By identifying the knowledge and skills necessary for proficient expert performance, a more efficient training program can be designed. Two types of knowledge were discussed in the presentation: knowledge structures and mental models.

Knowledge structures incorporate those concepts required to perform a job, and the manner in which those concepts are organized in the operator's memory. Mental models are intangible systems of information that exist in relationship to a specific environment and task. These models allow the user to partition a world of stimuli that is otherwise infinite, and thus operate within it with degrees of efficiency that increase proportionally with task familiarity. A mental model is a cognitive simulation or typology of a system -- a dynamic internal representation that guides the individual's performance of a task.

Cognitive Task Analysis seeks to gain access to the expert's mental model and knowledge structures and to identify the stages passed through on the way to the expert stage. The expert knowledge is then compared to that of the novice. Identification of the knowledge lacking from the novice model points the researcher to learner misconceptions and helps the trainer redirect the learner so that his or her knowledge resembles more closely the expert knowledge.

Expert mental models have several universal characteristics regardless of the task for which they are developed. Expert knowledge is arranged hierarchically into functional, tightly organized groupings, with high agreement across users. Because of these features, experts are better at solving problems related to the mental model and more efficient in the performance of tasks related to it. The hierarchical organization of knowledge in expert mental models allows for a greater degree of automation, and less reliance upon memory in frequently repeated actions and processes. Because of uniformity of expert models across users, trainers who have access to these models can aim for a narrow area, rather than the broad area represented by the heterogeneous, scattered models of novice populations. The "bugs," or incorrect information possessed by novice operators can be used to predict and prevent specific operator errors under specific tactical situations.

With the improved understanding to be gained from the Cognitive Task Analysis of expert performance in the complex jobs performed within the Navy, it is hoped that training programs can be designed that emphasize conceptual fidelity rather than procedural knowledge (physical fidelity). This kind of training helps the learners to develop expert models and knowledge structures of task performance. In turn, the trainers are able to anticipate errors and to teach transfer of skills to other tasks. This approach to training could beneficially be applied within NAVAIR, improving the efficiency of Navy training.

Fleet Modernization Program/Interactive Videodisc Instruction (FMP/IVI)

David Smith
(Oak Ridge National Laboatory, Martin Marietta Energy Systems, Inc.)
Helen Porter
(HMP Systems, Inc., Knoxville, Tennessee)

The Fleet Modernization Program/Interactive Videodisc Instruction system is a prototype training program developed by a team that consisted of a subject matter expert, a curriculum designer, a systems engineer/programmer, and a production director and crew. The product is a videodisc incorporating computer graphics and text that provides a stimulating educational experience for students. Special presentation features include touch screen response, student-driven pace, feedback, and remediation capabilities. The system was designed to be both mobile and durable.

Development of a similar IVI approach for other training areas would take approximately six to eight months and cost an estimated $100,000 to $150,000 for development. Because of the nature of the videodisc, the IVI system is hard to update and is not recommended for volatile information.

Training Resources and Data Exchange (TRADE)

Tina McKinley and Bill McCauley
(Oak Ridge Associated Universities)

Oak Ridge Associated Universities manages Training Resources and Data Exchange (TRADE), a network of DOE contractor training professionals. TRADE was developed to bring contractor personnel with common training interests together to exchange ideas, techniques, and resources.

TRADE's on-line file includes over 3,000 training programs within the DOE contractor network. Programs can be identified by contractor, length of course, and intended audience.

Instructional packages are being developed for the Navy Military Personnel Command (NMPC-47) to train the staff responsible for the Navy personnel assignment system. Computer-based training, interactive videodisc, and audiovisual aids are integrated into a series of training modules and instructional aids to help the staff become proficient with the system.

The Course Builder Series

H. Lee Martin and Janet Tocher
(TeleRobotics International, Inc.)

The Course Builder Series is a commercial software product offering an authoring environment for preparing in-house teaching, testing, and training applications. It is especially applicable for classified or volatile information.

Using a Macintosh-based system, the Course Builder Series allows the trainer to use options such as graphics, animation, a variety of student input, random sequencing, sound effects, and the option of a touch-sensitive screen to develop the most effective interactive training possible. The trainer can build in techniques to track and evaluate the student's progress and allow the course to branch according to past answers. The results treat the student/trainee as an individual and allow for personalized training. The series is a visual language designed to be easily used by noncomputer/nonprogramming-oriented trainers as well as trainers requiring sophisticated testing/training software.

Computer-aided Acquisition and Logistic Support (CALS)

Al Klein
(Martin Marietta Energy Systems, Inc.)

Computer-aided Acquisition and Logistic Support originated as a method for improving the collection of technical data by means of digital transfer. The initiative is a cooperative effort between the Department of Defense and the private sector. The initial goal of CALS was to establish a set of standards that would allow similar computer systems to communicate with each other, thus increasing productivity and improving quality of data within DoD. Later phases of CALS will deal with the development of integrated data bases shared by both government and industry, supported by and encompassing product data models.

The recent CALS impetus has resulted in "islands of automation." Because technology has not kept up with the need for automation, these islands must be connected by paper. Major logistics support problems result, causing delays in fleet readiness. In 1988, Deputy Secretary of Defense William H. Taft III circulated a memo mandating CALS compliance according to MIL-STD-1840A within DoD and among supporting contractors. Total compliance for new weapons systems acquisitions is expected by the year 1990.

CALS is designed to begin addressing some of the following problems currently faced by DoD in acquiring and using logistic and technical information:

* Technical manuals and training materials are out of date and difficult to use
* Engineering drawings are incomplete, illegible, and impossible to control
* Complete configuration management is impossible to attain
* Logistic support data are voluminous and redundant
* Technical data packages for spare parts replacement are inaccurate, incomplete, and time-consuming.

The objectives of CALS are to accelerate the integration of design tools in contractor CAD/CAM systems, to automate contractor processes for generating logistic technical information, and to increase DoD capability to receive, distribute, and use technical information in digital form.

The current era is a particularly good one for CALS development because of lessened international tensions. International attention is on market forces and savings resulting from digital transfer of information. The focus of the military is on improved efficiency, quality, and cost-effectiveness of weapons systems, rather than on weapons buildup.

Development of CALS will be reflected in improved quality and the reduction of overall weapons costs. Through the use of concurrent engineering, engineering change requests will be reduced at later stages in life cycle development. DoD will be better equipped to receive proposals and designs up front rather than staggered throughout the development cycle. A concurrent design process involving a logician, a designer, and an engineer will reflect the total set of DoD needs, which should eliminate later changes. CALS has a crucial role to play in this process.

Standard Generalized Markup Language (SGML)

Jeanne Dole and James Mason
(Martin Marietta Energy Systems, Inc.)

Standard Generalized Markup Language (SGML), International Standard 8879-1986, is one of the currently mandated standards for CALS. (MIL-M-28001 is the DoD-wide implementation of SGML.) An SGML document contains the SGML declaration, the document type definition, and the markup and content (the document instance). The creation of an SGML application involves the following steps:

* analysis of the document and naming of structural elements
* identification of data elements
* assignment of a symbol (generic identifier) to each element
* creation of a document type definition
* creation of the SGML declaration.

Information is managed in the form of electronic documents. SGML describes document structures in whole classes of documents then identifies these structures in individual documents within a class. The development of SGML was stimulated by the need for a more efficient system of information management and dissemination.

Benefits of SGML are immediately obvious. The Internal Revenue Service has made use of this computer language to distribute policy information quickly. CALS, using SGML as the standard for exchanging text, and other standards for exchanging graphics, has been able to share maintenance and logistics data between contractors and users. SGML can also manage documents with multiple content types, complex imaging requirements, and complex structures. For example, a document might contain multiple graphics types as well as text.

Software to enable use of SGML is developing rapidly, pushed by the CALS initiative. This software includes authoring tools for personal computers, artificial intelligence-based markup tools, parsers, media conversion devices, pagination and composition systems, and CD-ROM applications.

What Does Tom Brokaw Have to Do with Training?*

Robert Hasentufel (Kennedy Maxwell Motion Picture Productions)

The Navy is relying increasingly on the use of videos to provide more effective training for the Fleet, especially in the use of weapons. However, these videos tend to be static and sometimes tedious. Such lessons fail to hold the attention of the learners -- especially those accustomed to the sleek production of network and cable television.

Four lessons can be learned from the recent successes of network news shows.

* First, even when presenting highly technical material in a high tech format, it is important not to exaggerate the electronic appearance of the medium. Viewers are put off by the absence of a human element.
* The presentation should have some entertainment value to help offset monotony, thereby increasing viewer attentiveness.
* Third, instruction should be sectionalized to accommodate the limited attention span of the viewers. This can be done with actual breaks in the action, or with varying pace.
* Finally, high standards for video production should always be applied. Poor quality productions are less effective and tend to erode credibility.

Training videos in use today range in quality from poor to highly professional. High-quality videos engage the full attention of the learner, making lessons more easily understood and retained.

*Several training videos were shown to illustrate the range that exists in the quality of training videos.

4

NOTES FROM THE CLOSING CAUCUS

by Cathrine Snyder
Gail Payne and
Inga Treitler

NOTES FROM THE CLOSING CAUCUS

The members of the PMA205-11 team participated in an open discussion on the morning of March 31. The session was coordinated by Phyllis Campbell, representing Bill Walker, and by Cathy Snyder, manager of the Oak Ridge PMA205-11 team. Ms. Snyder fielded comments and suggestions and coordinated the discussion, and Ms. Campbell presented a time line for achieving a coordinated game plan to incorporate the entire network.

31 May — Provide updated Airtasks and Spend Plans for FY-1989 and FY-1990.

30 June — Provide information on multiyear contracts within the group. The goal of this task is to gain an idea of who's involved in applying for long-term contracts, where the resources are, and how we can improve our chances of placing more contracts.

31 July — Provide a statement regarding your group's desired role within the PMA205-11 community.

31 August — Draft a "white paper" for your group. This document will provide

* an outline of activities
* a statement of tasking
* an account of the structure needed to set up required technical programs both internal and external to government.

This time line prompted the Navy Communication that is provided in Appendix E. The information received in response to these requests should improve the team's functioning while reducing overlap of activities.

The following issues were discussed at the caucus:

The Foreign Military Sales community should be more fully supported. Currently China Lake has a program in New Zealand funded by AIR 419 and NUWES is involved in some programs.

Reserve training for Marines is inadequate, according to Master Gunnery Sergeant Owens (Fourth Marine Air Wing). PMTC is aware of the problem and does have courses available for the Marines. They will try to ensure that the Marines know how to request the desired training.

John Vaughan (Systems Management Technology) and Mike Evans (PMTC) suggested that the Naval Air Training and Operating Procedure Standardizations (NATOPS) be used as a model for ordnance training and emergency handling. A NATOPS exists for each type of aircraft and ship in the Navy, to provide training and support on handling procedures in emergency situations. Phyllis Campbell has endorsed the idea of a program modeled after NATOPS that would provide general support (a guidebook) for ordnance with primary emphasis on training. Mike Evans is currently working on this program. Bob Coffey (VSE Corporation) suggests that the "guidebook" for training be modeled after something other than NATOPS or be written as a unique manual. When the subject matter is explosive ordnance, manuals need to be written with extreme care. If modeled after the wrong prototype, problems of accuracy can ensue. Support equipment for maintenance training is lacking. Armament repair, bomb racks and missile launchers, engineering change proposals, out-of-date manuals, wrong test sets, and

negative training were all mentioned as problems. Al Sargent (NAMTRAGRU) mentioned that research is currently under way to identify the best approach for correcting these problems.

Jim Sakata (NUWESDET) indicated that a training system opportunity exists in the high loss rate caused by improper loading of torpedoes. Because each failure can cost as much as $50,000, a training system costing $130,000 can be considered affordable.

Some participants expressed concern that MIL-STD-1379C and -1379D do not address interactive training needs. A document being produced by the Oak Ridge PMA205-11 team will propose solutions to this problem from a human factors perspective. This document may contribute to better use of Data Item Descriptions (DIDs) to document and control the training system development process. Leo Violette (NUSC) stated that DIDs customized for interactive training systems are currently being developed.

Phyllis Campbell suggested that a consistent and uniform reporting system would benefit the whole PMA205-11 community. Applications for Oak Ridge VAX E-mail will be distributed to a limited group as a means for improving communication.

Al Sargent would like to see maintenance training emphasized in future meetings, in addition to the pilot/aircrew training technology that was the focus of many of this year's presentations. Technology transfer from maintenance training to pilot/aircrew training is another area for future discussions.

Caucus participants were impressed by the breadth and scope of activities, and the depth of experience and expertise evident within the network. During the Review, team members were updated on training problems and solutions, as well as on innovative approaches being used throughout the PMA205-11 program. The desire to continue the series of Annual Reviews was widely expressed by participants; and Phyllis Campbell announced Bill Walker's request that the next Annual Airborne Weapons Training Technology Review be held at Naval Ordnance Station, Indian Head.

The first Review allowed the PMA205-11 team members to focus on needed changes for a consensus approach to a strengthened Airborne Weapons Training Technology Program. Future Technology Reviews should build on the precedents established at the Oak Ridge Review: continuing to keep members current on activities and expertise within the network, and providing opportunities to develop new programs that reflect contemporary concerns.

APPENDIXES

A

APPENDIX A
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B

APPENDIX B
Department of Defense
Activities Represented at the
First Annual Airborne Weapons
Training Technology Review

Department of Defense Training Activities Represented

AWTU-3	Air Weapons Training Unit-3, Marine Wing Headquarters, Squadron 3, Third Marine Aircraft Wing, MCAS El Toro
AWTU-4	Fourth Marine Air Wing
NADC	Naval Air Development Center
NAVAIR	Naval Air Systems Command
NWC	Naval Weapons Center, China Lake
NAMO	Naval Aviation Maintenance Office
NAMTRAGRU	Naval Air Maintenance Training Group
NOSC	Naval Ocean Systems Center
NOSIH	Naval Ordnance Station, Indian Head
NUSC	Naval Underwater Systems Center
NUWES	Naval Undersea Warfare Engineering Station
NUWESDET	Naval Undersea Warfare Engineering Station, Detachment Hawaii
PMTC	Pacific Missile Test Center
NWS	Naval Weapons Station, Seal Beach, Fallbrook Site

C

APPENDIX C
Welcome and Agenda

Welcome to the First Annual Airborne Weapons Training Technology Review!

The Oak Ridge federally funded research and development community has been a part of the PMA205-11 network since October of 1987. This week's Review celebrates the network's accomplishments to date and looks ahead to the incorporation of new technology into the training systems that support the fleet. The Review is designed to allow an informal exchange of ideas and information and to promote discussion of training issues among members of the PMA205-11 team. We believe that this Review will provide you with an opportunity to learn how other members of the team are contributing to the Airborne Weapons Training Program and that contacts you establish here will support your activities throughout the coming year.

Your program coordinator is Sheila Webster of The University of Tennessee. She and her associate, Inga Treitler, will answer any questions you may have. Other Oak Ridge and Knoxville PMA205-11 team members are Marilyn Ayers, Ned Clapp, Joyce Finney, Pam Guthrie, Cathy Higdon, Jim Myers, Gail Payne, Helen Porter, Dave Smith, and Michele Terranova. All of these people will assist you in any way they can.

In addition to participating in the Review, you may take advantage of this occasion to visit designated sites and other areas of interest that are detailed in your registration packet. These site visits are designed to provide previews of related technical work at the Oak Ridge National Laboratory and the Oak Ridge Associated Universities. You may also choose to take a drive through the scenic Cumberlands and the Great Smoky Mountain National Park.

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First Annual Airborne Weapons Training Technology Review

MEETING SCHEDULE
March 29, 30, and 31, 1989

Wednesday, March 29, Pollard Auditorium

8:00 - 8:45	Registration and Refreshments
8:45 - 9:15	Opening Remarks and Introductions Cathy Snyder, Data Systems Research and Development, Martin Marietta Energy Systems Bill Walker, PMA205-11, Naval Air Systems Command
9:15 - 9:45	Keynote Address J. Robert Merriman, Vice President, Martin Marietta Energy Systems

BRIEFINGS

9:45 - 10:15	PMTC Overview Clyde Denham, Pacific Missile Test Center
10:15 - 10:30	BREAK
10:30 - 11:00	Key Determinants of Computer Based Training Development and Life Cycle Maintenance Costs James P. Smith, Star Mountain, Inc.
11:00 - 11:30	Interactive Courseware - Submarine Force Training Leo Violette, Naval Underwater Systems Center
11:30 - 12:00	Computer Aided Instruction for the Naval Aviation Logistics Data Analysis System Barbara Hershey Handler, Data Systems Research and Development, Martin Marietta Energy Systems
12:00 - 13:00	LUNCH - Lobby, Pollard Auditorium Building
13:00 - 13:30	Standoff Land Attack Missile Captive Air Training Missile Technology Tom Benedik and Jim Wills, Naval Ordnance Station, Indian Head
13:30 - 14:00	Shipboard Part Task Training Linda Childs and Mike Naber, Delex Systems, Inc.
14:00 - 14:30	Encapsulated Harpoon Certification and Training Vehicle Al McGuy, Naval Underwater Systems Center
14:30 - 14:45	BREAK

14:45 - 15:15	Standoff Land Attack Missile Trainer Richard Davenport and Venkat Devarajan, LTV Missiles and Electronics Group
15:15 - 15:45	Maverick Engagement Decision Aid Overview Jerry West, Ketron, Inc.
15:45 - 16:15	DoD Weapons Systems Acquisition Process Bill Jones, Naval Aviation Maintenance Office
16:15 - 16:30	Closing Remarks
16:15 - 18:00	Cash Bar, Garden Plaza Pool Area

Thursday, March 30

8:00 - 8:45 Coffee, Lobby of Pollard Auditorium Building

8:45 - 9:00 Program Announcements

SESSION 1
9:00 - 10:00

Cognitive Task Analysis Techniques for Operators of Airborne Weapons Systems
Michele Terranova, Oak Ridge National Laboratory, Martin Marietta Energy Systems and Tom Seamster, Carlow Associates, Inc.
Pollard Auditorium

TRACK A	TRACK B
Training Technology	Automated Data Delivery in DoD

SESSION 2
10:15 - 11:15

Fleet Modernization Program/Interactive Videodisc Instruction Dave E. Smith, Oak Ridge National Laboratory, Martin Marietta Energy Systems and Helen Porter, HMP Systems, Inc. Pollard Auditorium	Computer-aided Acquisition and Logistic Support Al Klein, Data Systems Research and Development, Martin Marietta Energy Systems Room 240

SESSION 3
11:30 - 12:30

Training Resources and Data Exchange Tina McKinley, Oak Ridge Associated Universities Room 240	Standard Generalized Markup Language Jeanne Dole and James Mason, Information Resources Organization, Martin Marietta Energy Systems Room 240

LUNCH - 12:30 - 13:30, Lobby, Pollard Auditorium Building

SESSION 4
13:30 - 14:30

Course Builder Series Janice Tocher, TeleRobotics International, Inc. Pollard Auditorium	HyperView Systems Overview

CLOSING REMARKS - 14:30 - 14:45, Pollard Auditorium

SITE VISITS - 14:45 - 17:00

BIG ED'S PIZZA! - 18:00 - 21:00 (See directions and description, p. 16 of Agenda)

Friday, March 31

8:30 - 9:00	Coffee, Lobby of Pollard Auditorium Building
9:00 - 11:30	PMA205-11 Team Caucus

D

APPENDIX D
Energy Systems
Training Technology Support

Energy Systems Training Technology Support
to Naval Air Systems Command Airborne Weapons Training

Background

Work in training technology is being performed by a team of Energy Systems staff under the direction of the Data Systems Engineering Organization. The tasks were initiated under an interagency agreement with the Naval Air Systems Command, but the work is applicable to any sponsor who requires modern training systems development for the operation of sophisticated weapons or machines. Increasing automation has not reduced the need for training: man continues to be in the loop for operation, maintenance, and handling for weapons and other systems. The skills required for use of the systems, however, have increased in complexity and have shifted from procedural to conceptual because of a greatly increased requirement for cognitive understanding of the system.

Interactive training systems lend themselves well to filling the need for this increase in conceptual understanding on the part of the trainee. At this time, there are no government standards or procedures applicable for the development of interactive training systems. Energy Systems has identified a need for the integration of three engineering disciplines in the process of developing a state-of-the-art interactive trainer: instructional technology, software design and development, and human factors engineering. As part of the work in training technology, we are developing a set of procedures that incorporates all three disciplines, but integrates them in such a way that the increased cost of development is minimized.

Generic Training Systems

All efforts at Energy Systems, regarding this Training Technology project, have so far been directed towards the goal of using Navy standard contracts for personal computers as the basis for generic training systems. The update and currency of training systems is very difficult if the training systems manager must become a supplier of computer systems bought specifically for the purpose. If fleet-available computers can be used, the chances of keeping the training up-to-date with the weapons fielded to the fleet will be increased manifold.

In support of developing the procedures, Energy Systems staff is participating as part of the government/contractor team that develops training systems for NAVAIR Airborne Weapons. Energy Systems is providing third-party reviews of documentation, critical design reviews, and test and acceptance for Navy trainer development currently under way under the old guidelines.

Technical Library

Energy Systems staff is establishing a technical library in Oak Ridge of DoD, American National Standards Institute (ANSI), and International Standards Organization (ISO) standards that apply to the engineering of software, instructional design, and human factors. This technical library will also include technical data on the weapons systems NAVAIR is involved with.

Standards

Energy Systems is incorporating user system interface improvements into the training systems themselves and in the communication among the team members supporting NAVAIR in these efforts. The staff is investigating the role that training systems managers can play in supporting the shift to CALS (Computer-aided Acquisition and Logistic Support)-compliant documents within DoD. International and national standards committees developing standards implemented in CALS and User System
Interfaces are being supported as part of our NAVAIR work.

Human Factors

Energy Systems staff is developing and testing means of identifying the role that cognitive task analysis should play in determining the impact of new weapons systems being introduced to the fleet. The staff is studying ways to tailor software development standards to include the use of authoring systems and program development languages for interactive training development. The staff also is collecting all human factors guidelines and standards applicable to military systems and extracting those that might be applicable to small, interactive training systems development.

Hardware/Software

Energy Systems staff is studying and testing state-of-the-art hardware for the purpose of including images and image manipulation in the desk-top interactive trainers developed for operation of sophisticated weapons systems. The staff is evaluating software engineering issues including the use of fourth-generation languages (authoring systems), other program development languages, and Ada.

Instructional Design

Energy Systems is studying the instructional design guidelines currently in use by the DoD and identifying guidelines and deliverables that are applicable to interactive training. Energy Systems will also identify steps in the instructional design process that are absent in the current standard and attempt to find ways to include these in future NAVAIR procurements.

E

APPENDIX E
NAVAIR Follow-up Communication

DEPARTMENT OF THE NAVY
NAVAL AIR SYSTEMS COMMAND
NAVAL AIR SYSTEMS COMMAND HEADQUARTERS
WASHINGTON, DC 20361

8800
Ser PMA205-11C/048985

IN REPLY REFER TO

APR 18 1989

From: Commander, Naval Air Systems Command

Subj: REQUEST FOR ORDNANCE TEAM TRAINING PROGRAM SUPPORT SUBMISSIONS

Ref: (a) Mtg-First Annual Airborne Weapons Training Technology Review of 29-31 Mar 89

1. This letter is to confirm those items identified during reference (a) as requested inputs to PMA205-11 for program organization. In addition, the letter serves to inform those activities unable to attend of the requested inputs.

a. Provide updated Airtasks and Spend Plans for FY-1989, FY-1990 by 31 May 1989,

b. Provide status of multi-year contracts by 30 June 1989,

c. Define requirements based on facilities, personnel, and your role in the network by 31 July 1989.

d. Provide white paper recommendations/ideas on technology, network communications/reporting, configuration management, etc. to include:

1. Outline
2. Statement of taskings
3. Structure required to set up program both internal and external to government, by 31 August 1989.

2. We request you to provide inputs to PMA205-11 by the due dates as noted. My point of contact is Phyllis Campbell, PMA205-11C, A/V 222-9464/5 or Comm. (202) 692-9464/5.

W. J. WALKER
By direction

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IOSC (Code 643)
IUWES (Code 9024)
)OE (Attn: Cathy Snyder)