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NAVAL POSTGRADUATE SCHOOL

MONTEREY, CALIFORNIA

ANALYSIS OF SYSTEM TRAINING IMPACT FOR MAJOR DEFENSE ACQUISITION PROGRAMS

by

Robert A. Wisher, Frederick E. Hartman, Charles G. Sanders, and Anthony Ciavarelli

August 2011

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Prepared for: Office of the Deputy Assistant Secretary of Defense (Readiness), The Pentagon, Room 1E537, Washington, DC 20301-4000

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14. ABSTRACT
The study examined the time-course results of planning and executing training from the inception of a new system to its acquisition and support after fielding, in particular for Major Defense Acquisition Programs. This study is the first phase in addressing these issues surrounding the impact of partial, inadequate, misguided, or diminished resources for training for new systems. This phase gathered evidence from the literature published over the past 30 years, consolidated that evidence into a database, and searched for potential gaps between what was done and what could have been done given the extant level of knowledge about training. Reports were identified and coded across 36 variables. More than 4,000 technical reports and 500 General Accountability Office reports were analyzed for inclusion, with more than 75 being coded. A gap analysis was conducted which searched for differences between an 'ex*isting status*' and a '*potential status*.' Four types of gaps were identified: knowledge gaps, awareness gaps, implementation gaps, and commitment gaps. The analysis yielded 26 instances of gaps, validating the need for a more critical treatment of training in major acquisitions. The gap and trend analysis of this data provide a start point for the second phase of the study which, based on the current findings, examines a series of selected systems for detailed training assessment through a case study methodology.

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EXECUTIVE SUMMARY

Background

Training prepares individuals, teams, and leaders to operate and maintain the vast array of systems that are being acquired, modernized, updated, and enhanced to provide operational capabilities. If a human cannot be properly trained, the entire system will function sub-optimally. The focus on the current study is the time-course results of planning and executing training from the inception of a new system to its acquisition and support after fielding, in particular for Major Defense Acquisition Programs. This study is the first phase in addressing these issues surrounding the impact of partial, inadequate, misguided, or diminished resources for training for new systems.

Approach

The purpose of this phase is to gather evidence from the literature published over the past 30 years, consolidate that evidence into a database, and search for potential gaps between what was done and what could have been done given the extant level of knowledge in the training community. This first phase begins to lay the foundation to quantify a relationship between the quality of training and its effect on optimizing total systems performance. Reports were identified in the published literature and coded across 36 variables. More than 4,000 technical reports and 500 General Accountability Office reports were analyzed for inclusion, with more than 75 being coded.

Findings

A gap analysis was conducted which searched for differences between an 'ex*isting status*' and a '*potential status*' or what might be the desired status. Four types of gaps were identified: knowledge gap – a best training practice has not been fully validated or proven for application for a given training system.; awareness gap – a best training practice is proven, established, and relevant, but has not been applied for the training system of interest; implementation gap – a valid best training practice has been identified and attempted, but did not work properly in the case of a given training system, commitment gap – a valid best training practice is recognized but not applied due to policy, cost, schedule or other factors. The phase one analysis yielded 26 instances of gaps, validating the need for a more critical treatment of training in major acquisitions. The gap and trend analysis of this data provide a start point for the second phase of the study which, based on the current findings, examines a series of selected systems for detailed training assessment through a case study methodology.

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I.   INTRODUCTION

The goal of training is to provide military members with the capacity to perform military tasks, both individually and collectively. Military training is seen as a disciplined approach to preparing individual warfighters and units for military operations. Training is about exercising troops in the field, training staffs at their operations centers, training aircrews while in real or simulated flight, or training maintenance technicians on brand new or decades old systems. Training, then, prepares individuals and teams to operate and maintain the vast array of systems that are being acquired, modernized, updated, and enhanced to provide operational capabilities. If a human cannot be properly trained, the entire system will function sub-optimally.

The focus on the current study is the time course of planning and executing training from the inception of a new system to its acquisition and support after fielding, in particular for Major Defense Acquisition Programs (MDAPs) which are defined as those costing in excess of 2 billion dollars. How adequate are the training plans, what is their priority as the system evolves, do they take advantage of known advances in training that others have proved to be effective? This study is the first phase in addressing these issues with a longer view to understanding the impact of partial, inadequate, misguided, or diminished resources for and approaches to training for new systems. The purpose of this phase is to gather evidence from the literature published over the past 30 years, consolidate that evidence into a database, and search for gaps between what was done and what could have been done given the level of knowledge in the training community. This first phase begins to lay the foundation to quantify a relationship between the quality of training and its effect on optimizing total systems performance.

By itself, this study does not answer fully the issue at hand; rather it is the beginning of a multi-phased approach to systematically investigate, document, and conclude what the relationship is. Later phases may revise or expand the database, conduct case studies, and explore quantitative techniques that can clearly elucidate the many aspects of the problem and how they tie together. This study, then, is the beginning of that endeavor and it starts with collecting and organizing relevant reports from sources internal and external to DoD.

The report first develops a training perspective and discusses the impact of simulation and instrumentation on training practices in recent decades. Continuing the background discussion, the role of instructional systems design is then covered, followed by the advocacy of training and other people-related consideration in system acquisition. The acquisition process is then summarized and policies that impact training are also summarized.   The study itself is then presented with methods, data collection and analysis, and the essential findings. We then offer how this study forms the foundation for future work and what that work can be. Appendices supplement the main body of the report.

II.   TRAINING PERSPECTIVE

Gorman (1990) in his report, *The Military Value of Training,* discusses the value of training in terms of historical "combat exposure" data drawn from air combat fighter engagements from World War I and II, the Korean conflict, and Viet Nam. In all these wars, the data show that a relatively few number of participants account for most of the successful engagement outcomes – or enemy kills. The data from wartime statistics showed clearly that those warriors who survived the first 5 or so combat engagements went on to engage and succeed in producing most of the combat kills. Such data led to strategies that created training systems designed to replicate wartime engagement experiences – or in the words of the warrior- *you train like you will fight*.

Examples often used to describe highly realistic combat training include the Fighter Weapons School, known as TOPGUN (Baranek, 2010). This school provides air-to-air combat training using instrumented ranges that allow pilots under instruction to fly their combat aircraft in realistic engagements against professional aviation instructors who serve as competent adversaries. Air to air combat engagements are recorded and played back in order to provide after action review and expert tactical instructor performance feedback to pilots under training. As a result of such planned, organized and systematic application of technology and explicit instructional principles exemplified by TOPGUN, the kill to loss ratio in Vietnam moved from 3:1 to 12:1 over a four year training period between 1969 – 1973 (Gorman, 1990).

Unless manpower and personnel selection approaches can acquire and assign highly qualified, pre-trained individuals directly from the civilian economy to operate and maintain new equipment, the development of training is an imperative. This necessity, of course, has been recognized and training has always been a component of system acquisition plans.   Indeed, training systems acquisition is an increasingly important aspect of program acquisition extending over the full acquisition life cycle.

A.   TRAINING SIMULATION

The use of instrumented training ranges, like the US Navy's Tactical Air Combat Training System used by TOPGUN and the USAF Red Flag Training Range was closely followed by the rise of advanced simulation training. The use of advanced flight simulators also emphasized the principle of providing "realistic combat training." A key aspect of simulation, over instrumented ranges was the expectation of reducing training cost by using simulators instead of actual operational aircraft or other expensive weapon platforms. But the use of simulation during the 70's and 80's in particular raised certain questions and concerns about technical issues surrounding the degree of realism that such simulation could deliver. Some of the main issues and concerns that arose during development and application of simulation training were summarized and discussed in a report published by the Institute for Defense Analysis entitled *The Value of Simulation for Training*. Some of the key issues are as briefly summarized below:

- Can the simulation constructed actually represent the actual equipment and/or operating environment with sufficient "fidelity" – or in the eyes of the operator and maintainer – is the simulation "realistic" enough for the training required?
- How do the relative costs and effectiveness of simulators compare to simply using the actual equipment in its real – world environment?
- Can a given simulation device be used to reduce the time or number of training events required to achieve the same training objectives in the actual equipment?
- What are some of the best practices in using simulation? Such as (1) the proper balance between the use of simulation and live training ranges, (2) the appropriate allocation of training time between part task and full mission simulation devices.
- Can certain exclusions and limitations be employed in simulation with minimum impact on training effectiveness (for example, lack of motion in flight simulation or limited visual field of view, and or display resolution for visual flight simulation?
- What is the most appropriate type and level of training management and instructional support required to facilitate device utilization and instructional quality (Orlansky, Dahlman, Hammon, Metzko, Taylor, and Youngblut, 1994).

The authors (Orlansky, et al 1994) conclude that flight and maintenance simulators train as well as the actual equipment and typically cost less to produce and operate than the actual equipment. Another important finding was that across simulation domains, most problems were not attributed to the lack of operational realism or simulation fidelity but rather were due *to poor training development planning, the absence of instructional support and training features on the simulation device* (such as recording and playback).

Finally, it is clear from the information provided in the Orlansky study's literature review and other studies that the effectiveness of a training device depends less on the simulation technology used and more on the quality of the training plan and how the simulation training process is actually supported and managed. See also Stewart, J.E., Johnson, D.M, & Howse, W.R. (2008) for more detail on this subject. There are some persistent issues associated with the development and application of such technology - based training systems that may impact training effectiveness, such as:

1. Training need is not recognized or requirement is misunderstood.
2. Training need is recognized but is not supported because of policy or resource limitations.
3. Technology needed for training is not mature enough or otherwise unavailable.
4. Training System is implemented but it is not properly managed or used effectively.
5. Training System development lags behind the weapon system operational implementation.
6. The Training System implemented is poorly designed /or otherwise cannot meet the operational training requirements.

B.   INSTRUCTIONAL SYSTEMS DEVELOPMENT (ISD)

With the rise of advanced training simulation application in the 70's and 80's, there was a concerted attempt to broadly apply various "systems approaches" to the design, development and evaluation of military training systems. During this period the US military training establishment ultimately created a uniform standard referred to as the Interservice Instructional Systems Development (ISD) procedure (Branson, 1978).

In brief, ISD was supposed to provide a means to drive training design and development through the use of a phased systematic process that began with detailed requirements analysis (including trainee knowledge and skill specification) and finished with specific training evaluations dedicated to validating the effectiveness of the training system. However, after ten years of application of the ISD model in military training, it became apparent that simply having a systematic framework with its detailed procedural process was not enough to ensure effective training. McCombs, B.L. (1986) reviewed literature on the origin, application and effectiveness of *ISD* Analysis, Design, Development, Implementation, and Evaluation - or the so-called ADDIE model. McCombs concluded that the use of ISD per se did not necessarily result in the most effective training.

For example a serious problem with ISD was the assumption that people using the approach have the requisite knowledge and skills to appropriately and effectively apply the process. Unfortunately, this has not been the case. McCombs argued that often the people implementing ISD did not fully understand the training requirement, or lacked the technical skills necessary to apply the methods specified in the ISD process (such as task analysis, skill specification, and evaluation methods).

Another ISD issue is that the process itself does not provide sufficient detail to map out valid instructional strategies and media selection prescriptions, based on a scientific understanding of specific learning domains or complex tasks. For an updated description of the ADDIE model and its application in education and training see Hodell (2000) *ISD from the Ground Up*. And for an updated military equivalent description see also Department of Defense (2001) *Instructional Systems Development/Systems Approach to training and education (*MIL-HDBK-29612-2A), which applies to training development for new systems.

Training is often joined with other 'people factors' and variably termed human systems integration (HSI) or by Service programs, such as the overarching Army effort known as MANPRINT, or manpower, personnel and training integration program. Current acquisition policy requires that a program manager have a plan for HSI in place early in the acquisition process to "ensure that the system is built to accommodate the characteristics of the user population that will operate, maintain, and support the system."   Further requirements are that "human-factors engineering to design systems that require minimal manpower; provide effective training; can be operated and maintained by users; and are suitable (habitable and safe with minimal environmental and occupational health hazards) and survivable (for both the crew and equipment)" (DoDI 5002.2, 2008). Program managers are required to summarize the HSI plan in the Acquisition Strategy and the Systems Engineering Plan. Extracts from relevant DoD policies

as issued in various directives, instructions, and regulations are presented in Appendix A.

C.   HUMAN SYSTEMS INTEGRATION (HSI)

The concept of Human Systems Integration emerged in the 1990's and is the current prevailing systems engineering framework now promulgated by the Department of Defense. The founding premise of HSI as stated by (DoD 5000.02: Operation of the Defense Acquisition System, 2009) is as follows:

The Program Management (PM) shall have a plan for HSI in place early in the acquisition process to optimize total system performance, minimize total ownership costs, and ensure that the system is built to accommodate the characteristics of the user population that will operate, maintain, and support the system.

Human Systems Integration (HSI) refers to the planning and integration of such areas as manpower, personnel, training, human factors engineering, system safety, personnel survivability, and health hazards – thereby clearly reflecting the origins of the systems framework originally outlined by MANPRINT (Booher, 1990, Clark and Goulder, 2002).

An important goal of HSI is to influence acquisition decisions early in the Defense acquisition management framework. In particular, HSI solutions need to be identified early enough to allow changes in design. For example, 40 percent of the Life Cycle Cost (LCC) is determined by Milestone A. LCC is the total cost to the government of acquisition and ownership of that system over its useful life(Office of Naval Research, 2011).

With the brief overview here, we have come full circle with attempts to integrate training into the system acquisition process, beginning with ISD, then MANPRINT and now HSI all emphasizing early and systematic consideration to personnel training within a "systems engineering" framework that addresses all of the design and logistical support functions thought to be essential in creating and effective weapon system.

The program manger is required to work with the training community to develop options for individual and collective training for operators, maintainers, and support personnel. Training decisions need to be based on training effectiveness evaluations to maintain skill proficiencies and reduce individual and collective training costs. The PM shall develop training system plans to maximize the use of new learning techniques, simulation technology, embedded training and distributed learning (DoD Instruction 1322.26), and instrumentation systems that provide "anytime, anyplace" training and reduce the demand on the training establishment. Where possible, the PM shall maximize the use of simulation-supported embedded training, and the training systems shall fully support and mirror the interoperability of the operational system (DoD Directive 1322.18).

D.   MANPOWER AND PERSONNEL INTEGRATION (MANPRINT)

The Manpower and Personnel Integration (MANPRINT) program initiated in the 1980's is a more comprehensive, attempt to apply a "systems approach" to weapon system acquisition by providing a framework that calls for early consideration of key system planning activities and development requirements. The founding premise of

MANPRINT holds that the… *The system must be designed so that the specified target population can be easily trained to perform to standard (p.6)*

MANPRINT is a comprehensive management and technical effort designed to assure integration of all relevant information from MANPRINT domains. The primary goals of MANPRINT are to develop the most effective system and to achieve effectiveness at lower life cycle costs. (Metzler, and Lewis 1989, p.1) MANPRINT considers seven key areas in the process of system acquisition (US Army 2001) – with Training as the third area:

Seven MANPRINT areas:
1) Manpower – The number of personnel, both military and civilian required, authorized and potentially available to operate, maintain, and support each system acquisition.
2) Personnel – The human aptitudes, skills, and capabilities required to operate, maintain, and support a system in peacetime and war.
3) Training – The instruction and resources required to provide [Army] personnel with requisite knowledge, skills, and abilities to properly operate, maintain, and support [Army] systems.
4) Human Factors Engineering – The comprehensive integration of human capabilities and limitations into system definition, design, and evaluation to promote effective soldier – machine integration for optimal total system performance.
5) System Safety – The design and operational characteristics of a system that minimize the possibilities for accidents or mishaps caused by human error or system failure.
6) Health Hazards – The systematic application of biomedical knowledge, early in the acquisition process, to identify, assess and minimize health hazards associated with the system's operation, maintenance, repair or storage.
7) Soldier Survivability – The characteristics of a system that reduce fratricide as well as reduce detectability of the soldier, prevent attack if detected, prevent damage if attacked, minimize medical injury if wounded or otherwise injured, and minimize physical and mental fatigue (p.8)

MANPRINT, in part, was developed as a consequence of documented problems found in weapon system acquisition due to a failure to properly integrate Manpower, Personnel, and Training (MPT) into the weapon system. For example study completed by the General Accounting Office (GAO) in 1985, p. 2, raised the following issues:
- No one was in charge of implementing MPT integration
- MPT requirements were not being identified early enough in the acquisition process to influence system design
- The Army was not clearly defining weapon system MPT needs for the developers

In this 1985 study, the GAO concluded that *The Army must effectively integrate manpower, personnel and training into its weapon systems acquisition process to ensure that when the weapon systems are deployed, they can be satisfactorily operated and maintained (p.1)*

It is one purpose of this current study to determine how many of these problems, and other possible issues remain after 26 years – given the expected improvements in the acquisition process following the introduction and implementation of MANPRINT.

III.   ACQUISITION PHASES

The acquisition of new systems, of course, progress through phases. The DoD acquisition model encompasses five phases related to pre-systems acquisition activity, the formal system acquisition, and the necessary sustainment phase. Training is conceived, planned, developed, and implemented throughout these phases.   Three Milestone Decision Reviews (A, B, and C) accompany the phases.   The five phases are:

- Concept Refinement –During this phase a study called an *analysis of alternatives* is conducted to assess alternatives to provide the desired capability identified in the Initial Capabilities Document (ICD). To achieve the best possible system solution, *materiel solution analysis* places emphasis on innovation and competition and on existing commercial off-the-shelf and other solutions drawn from a diverse range of large and small businesses. An analysis of alternatives and a technology development strategy are developed to help guide the efforts during the next phase, which is technology development. Materiel solution analysis ends when materiel solution to the capability need identified in the ICD is recommended by the lead component.

- Technology Development – This phase addresses the set of technologies to be integrated into a full system, including the training capability. This phase depends on the system developer having productive relationships with both the user and the science and technology community. The process is continuous and iterative, refining user requirements while assessing the maturity and feasibility of technologies.

- System Development and Demonstration – The acquisition is formally initiated and a Program Manager assumes responsibility for system development. Transition to this phase requires approval of a capability development document, which reflects a technically mature capability that is logistically supportable. This phase develops a system or an increment of capability, completing full system integration. Operational supportability is ensured with particular attention to minimizing the logistics footprint and implement human systems integration to include training.

- Production and Development – The purpose of this phase is to achieve an operational capability that satisfies mission needs. Operational test and evaluation shall determine the effectiveness and suitability of the system. Milestone C authorizes entry into low rate initial production (for MDAPs and major systems), into production or procurement for non-major systems that do not require low rate initial production, or into limited deployment in support of operational testing.

- Operations and Support –During this phase, full operational capability is achieved, each element of logistics support is evaluated (e.g., supply, maintenance, training, technical data, support equipment), and operational readiness is assessed. Logistics and readiness concerns dominate this phase. The operations and support phase includes life cycle sustainment and disposal.

Milestone A occurs upon the approval of the Concept-Refinement Stage and Milestone B upon approval to proceed into the Technology Development Phase. The achievement of Milestone C launches the production and deployment phase.

A. MILESTONE A: ENTRY INTO TECHNOLOGY DEVELOPMENT PHASE

The purpose of this phase is to reduce technology risk and to determine the appropriate set of technologies to be integrated into a full system. The project shall enter Technology Development at Milestone A when the MDA has approved the Technology Development Strategy.

B. MILESTONE B: ENTRY INTO SYSTEM DEVELOPMENT AND DEMONSTRATION (SDD) PHASE

The purpose of the SDD phase is to develop a system or an increment of capability; reduce integration and manufacturing risk (technology risk reduction occurs during Technology Development); ensure operational supportability with particular attention to reducing the logistics footprint; implement human systems integration (HSI); design for producibility; ensure affordability and the protection of critical program information (CPI); and demonstrate system integration, interoperability, safety, and utility.

This effort is intended to demonstrate the ability of the system to operate in a useful way consistent with the approved Key Performance Parameters.

The completion of this phase is dependent on a decision by the MDA to commit to the program at Milestone C or a decision to end this effort.

C. MILESTONE C: ENTRY INTO PRODUCTION AND DEPLOYMENT PHASE

The purpose of the Production and Deployment phase is to achieve an operational capability that satisfies mission needs. Operational test and evaluation shall determine the effectiveness and suitability of the system. Milestone C authorizes entry into Low

Rate Initial Production (for MDAPs and major systems), into production or procurement (for non-major systems that do not require LRIP) or into limited deployment in support of operational testing for MAIS programs or software-intensive systems with no production components. This effort delivers the fully funded quantity of systems and supporting materiel and services for the program or increment to the users. During this effort, units shall attain Initial Operational Capability.

D.   POST MILESTONE C: OPERATIONS AND SUPPORT

The objective of this activity is the execution of a support program that meets operational support performance requirements and sustains the system in the most cost-effective manner over its total life cycle. When the system has reached the end of its useful life, it shall be disposed of in an appropriate manner. Operations and Support has two major efforts: Sustainment and Disposal.

Over the last several decades the DoD has initiated several efforts aimed at process update, and the increased efficiency to be found in a streamlined process for major systems acquisition. Consistently during this time the user/operators have observed that the acquisition process is too slow, too cumbersome in terms of the quantity and volume of documents and in the end provides some systems that by the time they are fielded are out of date with technology once they emerge from the long arduous process. It should be recognized that technology insertion is very dependent on the class of acquisition with systems with intense software and communications dependencies being the most likely to suffer from the decades long process.

E.   FRONT END ANALYSIS

The Defense acquisition process consists of the phases and milestones described in earlier paragraphs. During the early or "front end" of the acquisition process, the Concept Refinement Phase, incorporates detailed analysis including an analysis of alternatives to assess various materiel, software, and technologies solutions to shape capabilities to best meet the military operational requirements. A recent topic of discussion in Defense Leadership meetings (Hartman, 2009) has been the need for more rigorous assessments in the earliest stages of the acquisition process. Assessment in the earliest stages can be most productive in effectively and efficiently meeting the warfighter needs. It is further believed that early incorporation of system training details in the pre-milestone A analysis has great benefit in achieving the best possible system solution and can positively impact each stage of the acquisition life cycle. Particularly those systems with significant human interface requirements are found to benefit from bringing in training systems planning in the concept refinement process in a series of iterations with the end users. Early systems prototypes (constructive or virtual simulations) for instance can be a very effective tool in narrowing down and shaping the final desired capability with the warfighters. The use of modeling and simulation and incorporation of a systems engineering approach to systems training can logically drive the future system training tools, simulators and part-task trainers, as appropriate. In major acquisition programs, the ability to insert training early in the program can help shape the final quantities and technical complexity of the end capability. From a senior DoD management perspective, proper front end analysis to include the systems training

considerations can permit a go or no-go decision and/or justify significant modifications prior to the commitment of large, long term fiscal resources.

IV.   OVERVIEW OF PHASE I PROJECT

This research addresses key topics raised in the recent *Strategic Plan for the Next Generation Training for the Defense Department*, issued by the Office of the Deputy Assistant Secretary of Defense (Personnel and Readiness) and signed by the Deputy Secretary of Defense on September 23, 2010. In particular, the call for action to develop training capabilities and regimens before a system is fielded to improve initial operational effectiveness of new capabilities (§5.6.2) and the call to treat the training capabilities of new systems with the same rigor as their operational capabilities and updating as appropriate (§5.6.3) are relevant to the current study. Training is required to bridge the gap between the operators, maintainers, and leaders existing level of knowledge and that level required to operate and maintain the system.

An underlying theme of the study is to estimate the role of training on optimizing total systems performance for major acquisitions. Traditionally, training for major new systems is not fully provided until after initial operational capability. However, if the human operator of the system cannot perform efficiently, the entire system will not function optimally. Training is but one factor here. The purpose of this study is to assess the value of early consideration of Acquisition System training requirements for new systems being acquired, or being considered, by the Department of Defense. The study is to be based on evidence gathered in the research and analysis literature, dating to systems acquired from 1976 to the present day.

The two central research questions are: 1) Is there a benefit to the warfighters (operators, maintainers and leaders) and the acquisition community with early consideration of systems training in major acquisitions? and 2) Does early system training contribute to initial readiness and full utilization of system's capability upon initial delivery? In constructing a database to address these specific questions, other relationships of interest can emerge. For example, research that documents the success of a particular training approach relevant to a specific system may have been available, but was neglected in planning the training system requirements of another. The identification of such gaps is pivotal to the Phase I study. The gaps, for example, can separate occurrences of diminished system performance on the basis of the training practices used or not used, serving as a basis for improvement.

This study draws from historic documents and the traditional knowledge that the systems acquisition process, although inclusive of training plans, traditionally addresses training late in the process and doesn't incorporate the advantages found in going beyond the instructional systems development process to determine training system characteristics. The technology advances that enable the ability to deliver learning content in a many forms of simulators, simulations, games and on-line courses has radically impacted the traditional ways of considering systems training in the acquisition process. Longitudinal analysis of key program documents provides specific examples,

both positive and negative, regarding the need for including training systems analysis early in the acquisition and continuing throughout the system life cycle.

A.   GOALS

The goal of this phase is to establish an overarching framework and research methodology for the study. The more detailed objectives of the initial phase are to identify source material, specify a working set of variables, establish coding rules, and set plans for the data capture during the second phase. The study formally started on 1 October 2010 with the Naval Postgraduate School as the lead activity, supplemented by technical staff from the Institute for Defense Analyses and Alion Science and Technology. The study team consisted of experts with backgrounds in research psychology, operations research, training analysis, human factors engineering, and system safety, totaling more than 100 years of expertise within DoD.

B.   KEY CONCEPTS

At a meeting hosted by the Naval Postgraduate School on 21 October 2010, the study team openly considered a wide range of concepts relevant to the study, such as system training plans, training support plans, human systems integration, domain integration, cost training effectiveness analysis, isometric performance curves, DoD 5000 series of instructions, service regulations, training thresholds, manpower factors, instructional methods, and many others. The discussion stimulated numerous ideas for refinement in planning the scope and research methodology for Phase I.

C.   RESEARCH QUESTIONS

1.   What is the value of early training system design, development, implementation and a well-planned training program? (i.e. "doing it right").

2. Are there specific gaps in applying "best training practices" during the major weapon system acquisition process that impact training effectiveness, and/ limit operational capabilities and readiness?

IV.   RESEARCH METHODOLOGY

The study team considered alternative methods for assessing the evidence from the literature. Developing a predictive model was deemed unsuitable as there was no clearly defined dependent variable to predict in a consistent way across a wide variety of systems. The nature of the evidence can sometimes be qualitative and subjective, while at other times it can be quantitative and objective, such as 'striking a target' or achieving a certain level of reliability. Rather than pursue a purely quantitative but highly limited analysis, the study team adopted a holistic point of view on capturing data values from the body of published evidence. Thus, at times a documented deficiency might be poor performance in operational testing. At other times, a low level of acceptance by field units due to training issues or a high rate of safety mishaps after fielding due to human error, human systems integration, or insufficient training would be the documented deficiency. The key is to link any deficiencies to a lag in delivering a robust training capability at the time of initial delivery of the system. Such a search for evidence from

reports and other case studies would be conducted on a case-by-case basis across the spectrum of major systems acquired between 1976 and 2010. The priority and status of training early in the acquisition process is of greatest concern.

The study team decided to focus first on a comprehensive collection of reports and documents relevant to the research questions, beginning with a sample of reports. A preliminary set of variables were nominated within the first two weeks of the study. Furthermore, the team saw value in identifying gaps in what the system training offered compared to what it could have offered as documented elsewhere in the literature, mainly by reports from industry and the Defense Laboratories. This value addresses the call to develop training capabilities and regimens before a system is fielded, as advocated in the *Strategic Plan for the Next Generation Training*. In view of the goals of the study and the limitations of source data, a gap analysis was chosen as the appropriate research methodology.

Gap analysis generally refers to the activity of studying the differences between an 'ex*isting status*' and a '*potential status*' or what might be the desired state. It is a method more commonly used in the study of business processes and services, such as closing the gap in the level of service quality or the time for service delivery. In the context of the Training Systems Study, the *existing status* is the documented approach to training as part of a major systems acquisition, especially at the time a system acquisition passes Milestone B, the entrance of the System Development and Demonstration phase within the Defense Acquisition Management Framework. Analysis of these data and trends would address the two central research questions. The '*potential status*' refers to a training capability, also documented in the literature, for the same or a like-kind system that has demonstrated level of effectiveness that might exceed that of the training system portrayed in Milestone B documentation. Such cases of exceptional training may be considered a best practice. For example, there may be documented findings concerning the training for a command and control system for an air-ground system in the land forces that could equally apply to training for a maritime command and control system. Gap analysis relies upon determining the *existing status* is for a system and comparing it to a *potential status* at a particular point in time.

The focus of the early work on the study is to create a comprehensive record of findings, first on the status of training plans and intentions for an existing system and secondly on the status of training capabilities known beforehand or at the same point in time. To accomplish this, source materials need to be identified, variables need definition, rules for coding the variables need explanation, and the overall record needs a database structure suitable for detailed analysis. The four key steps needed to be taken are:

1. Seek an understanding of the environment surrounding the training issue.
2. Take a holistic view of the acquisition and training environment to gain a complete understanding.
3. Determine what framework the study will use for assessment of the problem.
4. Provide data supporting the analysis that is undertaken.

A.   STEP 1 – UNDERSTANDING THE TRAINING ISSUE

The systems acquisition process is governed by rules, regulations, instructions, handbooks, etc. Planning documents for training define the design, development, funding, equipment, support, modification, operation, and management for future training system requirements. The training system design typically uses the instructional systems development (ISD) process to determine specific training system characteristics, including media, training requirements, and instructional courses. How all of this fits into the total acquisition picture needs to be understood, and how it has changed over time is important to recognize.

B.   STEP 2 – HOLISTIC VIEW OF THE ACQUISITION AND TRAINING ENVIRONMENT

The acquisition of a major system is a long and complex process in which costs must be controlled while tradeoffs are being made. The GAO has consistently designated the DoD management of its major weapon acquisitions as a high-risk area (GAO-09-431T), with an average schedule delay in delivering initial capabilities of 21 months. A perspective is needed on how training system plans, or a lack thereof, may contribute to system deficiencies and delays, while considering technological advances that could improve training effectiveness/efficiency.

C.   STEP 3 - GAP ANALYSIS FRAMEWORK

Gap analysis is an effective solution for ongoing performance improvement and quality assurance activities that identify shortcomings in a business practice, here the acquisition process. Gap analysis utilizes comparative analysis techniques, thus it is essential to identify the nature of the current processes in order to make comparisons. The types of gaps that can be examined are:

Knowledge gap – a best training practice has not been fully validated or proven for application for a given training system.

Awareness gap – a best training practice is proven, established, and relevant, but has not been applied for the training system of interest.

Implementation gap – a valid best training practice has been identified and attempted, but did not work properly in the case of a given training system.

Commitment gap – a valid best training practice is recognized but not applied due to policy, cost, schedule or other factors.

D.   STEP 4 – DATA FOR ANALYSIS

The collection of valid data, based to the greatest extent possible on empirical findings and from trusted sources is critical. Not acceptable are 'sea stories', anecdotal evidence, or other forms of judgments that are not firmly rooted in fact. Benchmarking, the process

used to evaluate performance against other systems' practices and performance standards, is also an acceptable tool.

E. APPROACH

The main approach is to refine the concepts into a workable set and then formulate a set of variables that reflect the concepts for inclusion in the database structure. The database consists of an organized collection of data captured from source documents. Each record in the database represents an individual document, although it is possible that multiple documents may be merged into a single record, such as data from a GAO report on a particular system which has other data already recorded. As depicted in Table 1, the record is the title of the report, represented as a row (in SQL terminology) or a tuple (in relational terminology). The variables, represented as a column (in SQL terminology) or attribute (in relational terminology) represent data values. For example, a Year variable indicates the year of publication for a particular report, such as 1999. The data types will vary, and coding rules will specify the rules and constraints for variable declarations.

Table 1. Organization of Database

	Record 1	Record 2	etc.
Variable 1			
Variable 2			
etc.			

The study team then considered potential variables. The principal investigator proposed a starting set of variables: six as report descriptors, thirteen related to system specifics, and seven related to training practices.

F. REFINEMENT OF VARIABLES

The study team reviewed 60 variables nominated by individual members of the team. To make the study practical, the number needed to be reduced by about one-third or more. Upon feedback from the sponsor and another round of internal review, the variables were pared down based on discussion and consensus building. The coding rules for the database were then articulated, and the pursuit of reports and other forms of documentation can begin.

The variables can further be clustered into topical areas such as those relating to the nature of the report, those providing specifics on the system and acquisition of training for the system, and those related to training capabilities from experimentation with the system or with like-kind systems. This list was narrowed several times, resulting in 37 variables including a summary comment block. The final set of variables selected are listed in Table 2. The coding rules are presented in Appendix B.

Table 2. Listing of variables

Variables

Database Entry #

Rater Initials

1. Report Document Title
2. ADA number (DTIC)
3. Other reference (journal, book chapter, conference paper, other report)
4. Pages
5. Corporate Author
6. Year of Report
7. Type of Activity publishing/submitting report (not necessarily sponsor)
8. Funding for Report Document (possible R&D funding for report on Major System)
9. System Name or Program Number (PNO) for more recent acquisitions
10. System Type - Functional Capability
11. Acquisition Phase (as of *Year of Report variable*)
12. Acquisition Cost - Major Defense Acquisition Program
13. Requirement Source
14. Who developed training – prime, sub
15. Training Support Plan – completeness, depth, etc.
16. System Training Plan – completeness, depth, etc.
17. Embedded Training
18. System Safety/Health Hazards/Survivability - training relationship specified
19. Domain Integration - training tradeoffs between domains
20. Rapid Acquisition - training consideration
21. Spiral Development (or incremental analysis, evolutionary acquisition)
22. System of Systems approach - training consideration
23. Training Effectiveness Analysis or TE Evaluation
24. Individual Training MOE/MOPs
25. Collective MOE/MOPs
26. Maintenance MOE/MOPs (crew related & system related)
27. Operational Test Sites

28. Based on empirical evidence

29. Use of military test subjects

30. Quantifiable Level of Learning (Kirkpatrick Model, (Kirkpatrick, 1988))

31. Based on multiple studies

32. Proprietary solution for training delivery (relates to S9)

33. Generalizability within/across system types

34. Year of GAO (or DOTE, IG) report

35. Year of GAO/DOTE/IG Report

36. Shortcomings on training (effectiveness, cost, currency etc.)

37. Summary comments, potential gaps, observations

G.   SOURCE DOCUMENTS

Databases for a computer-based literature searches were identified early. The primary sources are the Defense Technical Information Center, the National Simulation and Training Asssociation's collection of papers from the I/ITSEC conferences, PsychInfo, and the ERIC databases, and also collections at the Naval Postgraduate School and the Air Force Institute of Technology. Inquiries to relevant programs and system documentation in the Services, the Joint Staff, and the Defense Acquisition University led to additional sources. The reports from these sources belong to the general category of Technical Reports. The annual report of the Director, Operational Test and Evaluation, reports from the DoD Inspector General, and reports from the General Accountability Office served as sources for documented shortcomings in acquisitions from a training standpoint. The sources belong to the general category of Consequential Reports.

The study team then focused on source documents. Some initial results of searching data sources include 2,694 hits on the Defense Technical Information Center (DTIC) database using the terms "training AND acquisition." A search of the General Accountability Office (GAO) database resulted in 1,600 hits using the term "Defense Acquisition." A secondary search of a small number of individual reports returned occasional references to training, some incidental some useful. For example, an examination of a 1985 GAO report (GAO/NSIAD-85-154) to the Secretary of the Army on integrating manpower, personnel and training into the weapons acquisition process contained an appendix listing of 85 reports on the topic from across the Services and DoD. Other sources identified are two academic databases, IITSEC papers, theses and dissertations, reports available from the Defense Acquisition University, documentation from program management offices, reports from Operational Testing and Evaluation, and internal industry reports. MANPRINT assessments and related reports from the Army were also sampled from the comprehensive collection assembled by the U.S. Army Research Laboratory (Middlebrooks, 2010). Cost data were derived primarily from the Selected Acquisition Report Summary Tables, provided every month by Office of the Under Secretary for Defense, Acquisition Technology & Logistics. The data for the month of June were used for a given year.   The net search would likely lead to several thousand source documents, a selected set which would be coded for Phase I of the study.

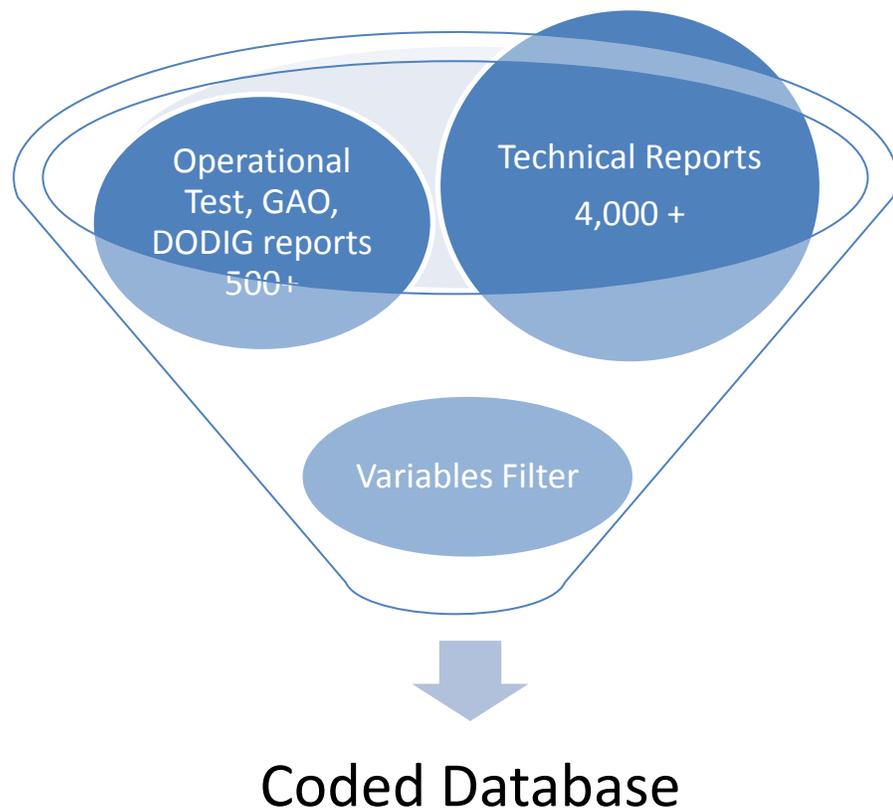Figure 1 depicts the flow of materials from the two categories of source materials to the coded database.

Figure 1. Depiction of Coding Process

H. CODING DATABASE

Searches on key databases resulted in more than 4,000 candidate reports that were technical in nature. Since the nature of the study was exploratory, the list was narrowed. Each report was searched for the term 'train' and if a rater judged the context as relevant to the study, a copy of the report was obtained and coded. Members of the study team served as coders. A workshop in March 2010 provided examples of coding with feedback and comments by team members as a means to reach agreements in coding protocol and later maintain a high level of coding conformity. Many of the variables, though, were simply facts identified in the study reports or from external sources on a particular acquisition program, such as costs.

Abstractions of the database are provided in Appendix C, with separate sections for the technical and GAO reports. The technical reports are presented in chronological order so the database entry is a unique but arbitrary assignment used for quickly locating the record. For the purposes of the immediate gap analysis presented later in this report, the abstractions provide: database entry (locator), title of report, year of report, Service or Joint, name of system or training device, whether human performance data were reported,

whether the findings can be generalized to other systems, and a brief description of the finding as it relates to the goals of the study. An example is:

49

Human Factors Performance Data for Future Forward Area Air Defense Systems (FAADS)

1989

Army

Forward Area Air Defense Systems (FAADS)

Human performance data reported

Generalizable

Testifying before Congress in 1977, an Army official stated that "We expect this somewhat unorthodox approach to permit a much reduced development time, thus resulting in an earliest fielding date, albeit with higher but acceptable risks." Despite the use of many off the shelf technologies that were intended to allow rapid and low-cost development, a series of technical problems and massive cost overruns resulted in the cancellation of the Sergeant York project in 1985 by the Secretary of Defense. Although much of the processing of the collected data was also cancelled or brought to a hasty conclusion, an extensive follow-on evaluation was conducted. The research documented the analysis of training and human factors-related data from the Sgt York Follow-On Evaluation I, which generated objective performance measures on individual soldier, team, and system performance. Objective performance data were examined with respect to fourteen issues, such as varying target workloads on the operator or the negative impact of some semi-automation. The data yielded findings on many issues relevant to the design of a future area air defense system. The report provides suggestions on applying such data to future soldier-system performance models, which can be remarkably helpful in making decisions about future FAADS. Awareness Gap input: Failures of cancelled system can lead to training and performance improvements in similar, follow on systems if properly analyzed. Implementation Gap input: Maintaining detailed human performance data during DT/OT allows secondary analyses for other system designers.

The GAO reports were abstracted in a slightly different manner. To distinguish these from the technical reports, the database entry numbering begins with 500. The abstractions provide: database entry (locator), title, year, Service or Joint, system, GAO report identification, passabe from report with context for training issue. An example is:

503

Missile Risk Reduction Underway But System Production Plans Need to be Reexamined

1998

Joint

AIM-9X, Sidewinder

NSIAD-98-45

In commenting on a draft of this report, DOD stated that the projected range and sensor tracking capability of AIM-9X without the helmet-mounted cueing system is equivalent to the capability of the AA-11 threat missile in azimuth and exceeds the capability of the AA-11 in range. DOD's position is based on using the fighter aircraft radar to cue the AIM-9X missile to the target of interest when it is beyond the view of the aircraft's heads-up display. Using the radar to cue the missile, however, will take more time and be less certain than with the helmet and will require DOD to **train** pilots in yet to be developed procedures and tactics that would be considerably different than current practices for aerial combat.

VI.   RESULTS

A.   DESCRIPTIVE STATISTICS

Technical reports were drawn from 1970 to 2011. By decade, the frequency of reports is presented in Table 3. There was a relatively even distribution of the publication dates across the four decades which we examined.

Table 3. Distribution of technical reports by decade

Decade	Percentage of Reports
1970 – 1979	25%
1980 – 1989	30%
1990 – 1999	23%
2000 – 2011	22%

The distribution of reports by Service is presented in Table 4. The reports were approximately evenly distributed. Since the Navy and Marine Corps have a common acquisition authority, they were aggregated.

Table 4. Distribution of technical reports by decade

Service	Percentage of Reports
Army	37%
Navy & Marine Corps	33%
Air Force	30%

The systems that were examined in this review are listed in Table 5, along with the year(s) of the report in which the system was examined. Each system listed below was highlighted in the report with a specific training-related issue. Thirty-one systems were identified.

Table 5. Systems reported in the literature searches

System	Year	System	Year
A-7	1976	AIM-9X (Sidewinder)	1998
P-3C	1977	FBCB2	1998
T-37	1978	JCCS	1998
AC-130E	1978	MILSTAR	1998
CH-47	1979	Javelin	1998, 1999
AH-1	1980	F-22	1994, 1999, 2004
H-3, SH-3	1981	V-22	2001
F-111	1982	KC-135	2004, 2010
C-130	1982	JSF	2004
F-16	1987	LCS	2004
FAADS	1990	Longbow	2006
B-2	1993, 1997	Patriot	2007
AH-64	1994	Predator	2009
JSTARS	1996	Global Hawk	2009
THAAD	1996, 1999	Reaper	2009
JPATS	1997, 2003		

B.   ANALYSIS OF GAPS

In a speech that was in the Congressional Record dated October 1, 1997, Representative Ike Skelton shared with his colleagues his views on the successes of the MANPRINT program. He pointed to notable MANPRINT assessments that led to operational improvements, such as the reduction in tools for a Comanche helicopter T-800 engine from 134 to only 6. In an example in which MANPRINT considerations were not incorporated and in fact purposely rejected, according to the Army Audit Agency, the Armored Gun System was cancelled prior to its being fielded for several reasons including HSI factors. Booher (1990) provides additional examples from the 1980s. Such problems occurred when human performance assessments were either not done or done too late to have an impact on the system design process. Representative Skelton argued that MANPRINT domains, of which training is one, were not being integrated in the acquisition process on a continuous basis. There were gaps between a hoped-for *potential status* versus an actual *existing status* at critical times in the acquisition cycle.

The gap analysis in this study examines differences in the existing status of training for a system as reflected in a published report and the potential of what could have been the desired state if training plans or training execution had been done more efficiently or effectively. It is easy, certainly, to look back at a consequential fault and recommend an "if only they had done this or considered that." We cannot, of course, judge with certainty if alternatives were considered or plans were reduced for a variety of reasons, many of them may have seemed reasonable at the time. What we can do is detect and classify a pattern of gaps that highlight the importance of early design of

training and well-planned training programs and what the consequences can be if training is not fully integrated throughout the acquisition. There is a degree of supposition on our part as to the causes of why these gaps materialized, so we can go no further than offering a professional appraisal based on our working experience in the field. That these gaps persist is reason to explore the problem area, and seek relief through policy change and educating the acquisition and industrial workforces. Future work can consider extensions, deeper fact-finding approaches, or case study methods to understand the issue and its antecedent causes in greater depth and with greater accuracy.

Four categories of gaps were identified earlier. For each gap, we supply instances and examples drawn from the database. This example serves to suggest this methodology as a way to explore further questions surrounding the value of training early in an acquisition program. The results are organized by the type of gap, which was determined based on a comparison of a training consequence from a GAO record with one or more findings in the technical database, a summary statement of the consequence, and a record number. The record number refers to the database locator. A listing of database entries and abstracts is provided in Appendix C, with the technical entries listed chronologically and the GAO entries listed in order of entry.

Knowledge Gap – a best training practice has not been fully validated or proven for application for a given training system

- Training in a Navy aviation logistics system was augmented by word-of-mouth training due to a lack of proper technical documentation and availability of manuals, raising costs and resulting in an instance of a knowledge gap (record 516, 1990).

- Insufficient estimates for supporting costs related to training, particularly maintenance training, appears to have resulted from a lacking front end analysis, resulting in a knowledge gap (record 506, 1993).

- Pilot training for the Predator advanced concept technology demonstration was found to be deficient since the demonstration was not designed to do so, an example of a knowledge gap (record 504, 1998).

Awareness Gap – a best training practice is a proven and established method, but has not been applied for the training system of interest.

- Insufficient front end analysis for special operations aircrew training led to a schedule slippage, resulting in an instance of an awareness gap (record 519, 1992).

- Training targeting using the radar to cue a missile, rather than using a helmet-mounted cueing system, requires training in procedures and tactics that have not yet been developed, despite training methods capable of delivering such instruction, resulting in an awareness gap (record 503, 1998).

- Operator training for a command and control system was found to be inadequate, despite successes with training such skills in the technology base, resulting in an awareness gap (record 510, 1998).

- The training of gunners for the Javelin antitank weapon limits the weapons capabilities, notably due to training software that will not teach gunners to recognize moving targets or properly train identification and recognition of thermal images, resulting in an awareness gap (record 511, 1998).

- Training shortfall led to shipboard operators performing manual tuning of radio frequencies without prior training due to reliability issues, resulting in an awareness gap (record 527, 2001).

- Lack of synchronization between needed training capabilities, particularly the information management of training, and production decisions in primary aircraft training system resulted in an awareness gap (record 530, 2003).

- The availability of F/A-22 and Joint Strike Fighter aircraft for training (or combat) use can be diminished without improvements in reliability, resulting in an awareness gap (record 532, 2004).

- Inadequate front end analysis reduced the availability of refueling aircraft for the Navy due to a lower priority placed by the Air Force, resulting in an awareness gap (record 533, 2004).

- A weak cost estimate for training due in part to new operational concepts for multi-skilled sailors to operate and maintain the Littoral Combat Ship resulted in an awareness gap (record 535, 2010).

Implementation Gap – a valid best training practice has been identified and attempted, but did not work in the case of a given training system.

- Aircraft are not fully available for crew training, so not planning sufficient aircraft, simulators, or part task trainers for training purposes through better front-end planning limits operational effectiveness, resulting in an instance of an implementation gap (record 501, 1997).

- Training requirements may be able to be met with a smaller quantity of primary aircraft training system, which appears not to be following a proper economical approach during early analysis, resulting in an implementation gap (record 505, 1997).

- Inadequate collective training for units contributed to an inadequate experiment related to operational testing of battle command system, which may have resulted

from an inadequate front end analysis of levels-of-training needed for testing, resulting in an implementation gap (record 508, 1998).

- Changes resulting from upgrades to communication satellites required a reconfiguration of software and a retraining of operators; a more inclusive front end analysis could have better modularized the training and reduced the retrain requirements, resulting in an implementation gap (record 514, 1998).

- An adjustment in the number and model type of end items to be acquired (fighter jets) resulted in a greater percentage of trainer aircraft, with less capability, as part of the total buy. Expanding the use of simulation and simulators may have been able to mitigate this, resulting in an implementation gap (record 509, 1999).

- A change to the Javelin system's launch unit resulted in requiring personnel to be trained for two configurations, an example of training not keeping up with engineering changes in the system, resulting in an implementation gap (record 512, 1999).

- Inadequate training of shipboard technicians resulted in an implementation gap (record 524, 2000).

- Inadequate front end analysis in several tactical aircraft acquisitions translates to fewer aircraft being available for training (record 529, 2001).

- Win-T (record 534, 2011).

Commitment Gap – a valid best training practice is recognized but not applied due to policy, cost, schedule or other factors.

- A general issue raised was a practice of program sponsors maintaining low cost estimates by excluding costs such as costs of training equipment, resulting in an instance of a commitment gap (record 517, record 521 1992).

- Shortfalls in operator training for the Joint Stars Ground Station caused problems during operational testing, many later isolated to software fixes resulting in a commitment gap (record 513, 1996).

- Additional training is needed to improve anti submarine warfare crew proficiency, so training resources were insufficient or not properly committed in view of other priorities, resulting in a commitment gap (record 502, 1999).

- Potential over reliance on contractor personnel in general may reduce rotational positions to meet training requirements in logistics support areas, resulting in a commitment gap (record 525, 2000).

23

- In February 2010 the program reported a Nunn-McCurdy unit cost breach of the significant cost growth threshold, which it attributed to factors such as the omission of training devices and adequate spares from initial estimates, and delays in the production decision. (record 534, 2011).

Twenty six gaps were uncovered based on judgments of training analysts involved in the study. Undoubtedly, many more could be identified with a more thorough analysis and other source materials from operational testing results. The breakout of type of gap by category is presented in Table 6.

Table 6. Percentage of cases for each of the gaps studied

	Percentage
Knowledge Gap	11%
Awareness Gap	35%
Implementation Gap	35%
Commitment Gap	19%

C. CROSSWALK WITH TECHNICAL REPORT DATABASE

The thrust of this analysis is to determine the extent to which there was pre-existing knowledge in the technology base that could have potentially alleviated or even eliminated the gap. In each case of the gaps identified, information in the Technical Report portion of the database indicated the availability of one or more documents that preceded the documented circumstance and could have potentially circumvented the gap, at least in a notional way without deeper study of the details. For example, the awareness gap identified as insufficient estimates for supporting costs related to training, particularly maintenance training, appears to have resulted from a lacking front end analysis (record 506, 1993) could have potentially been remediated by applying the knowledge gained in an Air Force report, or follow on work, describing a methodology which is useful for applying human resources, logistics, and cost factors in weapon system acquisition programs. The methodology, termed the coordinated human resources technology (CHRT), was developed from an integration of five individual human resources technologies: maintenance manpower modeling, instructional system development, job guide development, human resources in design tradeoffs, and system ownership costing (record 30, 1980).

D. FRONT END ANALYSIS AND GAPS

The Defense acquisition process consists of the phases and milestones described in earlier paragraphs. During the early or "front end" of the acquisition process, the Concept Refinement Phase, incorporates detailed analysis including an analysis of alternatives to assess various materiel, software, and technologies solutions to shape capabilities to best meet the military operational requirements. A recent topic of discussion in Defense Leadership meetings has been the need for more rigorous assessments in the earliest stages of the acquisition process can be most productive in effectively and efficiently meeting the warfighter needs. It is further believed that early

incorporation of system training details in the pre-milestone A analysis has great benefit in achieving the best possible system solution and can positively impact each stage of the acquisition life cycle. Particularly those systems with significant human interface requirements are found to benefit from bringing in training systems planning in the concept refinement process in a series of iterations with the end users. Early systems prototypes (constructive or virtual simulations) for instance can be a very effective tool in narrowing down and shaping the final desired capability with the warfighters. The use of modeling and simulation and incorporation of a systems engineering approach to systems training can logically drive the future system training tools, simulators and part-task trainers, as appropriate. In major acquisition programs the ability to insert training early in the program can help shape the final quantities and technical complexity of the end capability. From a senior DoD management perspective, proper front end analysis to include the systems training considerations can permit a go or no-go decision and/or justify significant modifications prior to the commitment of large, long-term fiscal resources.

VII. DISCUSSION AND CONCLUSION

Representative Skelton, in his speech to Congress referenced earlier, stated 'it seemed that whenever a new system was put into the hands of the soldier, actual field performance often failed to match the standards predicted during its development.' What went wrong with the acquisition? This report defined a potential acquisition concern – slow or poor integration of training during weapon system development, proposed methodologies needed to examine further issues surrounding training system integration. The study reviewed selected documents that reveal that the direction of training R&D, the status of training practices, and shortcomings in systems being acquired by DoD running from the early 1970s to early 2011. The review of technical reports focused primarily on determining the training effectiveness of specific training systems as related to technological and methodological concerns, while the other reports highlighted training-related issues identified primarily during developmental and operational testing.

There were thousands of reports to choose from, so a systematic sample was selected from the technical side given the resource limitations of the study. The reports related to training issues for specific systems were more complete over a twenty year span. Given the particular sample of reports reviewed here, we cannot fully judge the impact of late, or inadequate training support for a given weapon system, nor can we make the general case relating training development timing and weapon system mission readiness and operational effectives. However, we suspect that further inquiry into the subject, with additional source materials and the inclusion of complementary methods such as case study and archival document content analysis would be productive and bringing us closer to answering the stated research questions regarding the impact of early training system development on weapon system acquisition and deployment.

It is therefore suggested that further investigation continue, using the database formulated during this study as a point of departure. Also, it is believed that the study methodology should consider incorporating systematic case study analysis (Yin, 1997) to identify program outcomes (successful and unsuccessful) for benchmarking and

establishing a final Lessons Learned Database. A transition to a second phase is warranted.

The development of training early in the acquisition can have other, unexpected benefits. For example, in developing the Army's future forward air defense system, analysts discovered what training revealed – that the projected air threat could strike ground forces from a distance beyond the range of the missile system. The Secretary of Defense cancelled the DIVAD program in 1985.

Top management within the Department of Defense has taken steps in an attempt to make the acquisition process more disciplined, and it has redefined the basic strategy for acquiring weapons. For example, the Joint Capabilities Integration and Development System (JCIDS) is the current DoD procedure which defines acquisition requirements and evaluation criteria. It replaces the previous service-specific requirements systems, which focused on addressing future threat scenarios. New acquisition programs were not considered in the context of other programs, such as would be the case in a system-of-systems approach. These previous practices created redundancies in capabilities and failed to meet the combined needs of all the Services. JCIDS guides the development of requirements for future acquisition systems to reflect the needs of all four services. The central theme is to address capability shortfalls, or gaps as defined by combatant commanders. Thus, JCIDS is said to provide a capabilities-based approach to requirements generation.

The reform of the acquisition process seeks to advance technology while holding down procurement costs. Better training of the acquisition workforce, tighter monitoring of contractor performance, and the availability of tools for those involved in acquisition all contribute to reform activities. As an example of an overarching tool, the basic concepts of the Simulation Based Acquisition (SBA) program formed a decade ago are still viable – but largely unachieved today. The SBA vision encompassed an acquisition process in which the DoD and industry partners are enabled by the robust, collaborative use of simulation technology integrated across all acquisition phases and programs. The goals of SBA are still in sync and consistent with the current acquisition reform policy initiatives.

- Reduce time, resources, and risk associated with the entire acquisition process
- Increase the quality, military worth and supportability of fielded systems
- Reduce total ownership costs throughout the system life cycle, and
- Enable integrated product and process development across the entire acquisition life cycle

In keeping with the SBA vision and goals, the Department can provide a systems engineering environment that emphasizes modeling and simulation (M&S) as a primary analysis tool and fosters the use and reuse of data and M&S content across programs and phases. It is envisioned that use of models can refine the needs and provide the underpinning for more rigorous analyses prior to Milestone A, while transitioning critical content to guide systems design and later development and production processes.

From the early requirements and conceptualization stages, the use of M&S and in particular system prototyping provides a powerful analytic capability to meet user needs. It has been argued that prototypes are platforms for productive participation, as well as for perfecting products and performance. The power of producing systems prototypes early in the process serves as a way to iterate feedback from and dialogue with the end user to arrive at better systems and solutions for the operational needs. The more obvious use of prototypes is to guide the engineering analysis in the development planning stage of the acquisition. Many firms can be found proposing services to industry in the area of model building and prototyping and are highly successful in providing rapid prototyping services that encompass proof of concept and proof of design with functional working simulations and models. The use of prototyping can encompass constructive simulations, virtual environments or physical mock ups of the end system or product. With the use of such tools as 3D visualization one can progress to "model making" to influence the construct of actual 3D models. The area of rapid prototyping uses state of the art CAD/CAM (computer-aided design and computer-aided machining or modeling) techniques. Significant advances in the area of M&S make it now more important than ever that we incorporate oversight directives to include contracting language that require the use of simulations, models and prototypes in all phases of the acquisition process.

Another example of an acquisition workforce tool is the Improved Performance Research Integration Tool, or IMPRINT. Developed by the U.S. Army Research Laboratory, Human Research and Engineering Directorate, IMPRINT is a network modeling tools that factors in people-driven constraints on system design, evaluating the capability of operators and maintainers to gain optimal performance from a system under environmental stressors. The IMPRINT Pro tool, available free of charge for U.S. government agencies and industry under contract to the U.S government, now has the capability to examine missions and systems from the Services and Joint commands.

During the last decade the Department has initiated programs such as "lean six sigma" and "streamlining acquisition" to make the acquisition process more effective as well as more efficient. Today there seems to be a growing consensus that more rigorous analysis should be included in acquisition, and especially in the early phases of the process. Consistent with these approach training systems considerations should be included in the requirements, concept definition and refinement phases of the process. Early in his administration, President Obama announced acquisition reform goals and policies and outlined actions that impact government procurement, acquisition programs and contractors in a wide variety of areas. The convergence of new administration priorities, burgeoning costs, and outdated procurement processes prompted a series of major contracting and policy initiatives designed to:

- Develop more agile acquisition processes to increase the speed of technology deployment
- Increase transparency of the acquisition process
- Institute stricter risk and performance parameters

- Reduce costs through cuts in contractor spending and use of "high-risk" contract types

At the International Training Equipment Conference (ITEC) held May 10-12, 2011 in Cologne German, Director of Training Readiness and Strategy in the office of the Deputy Assistant Secretary of Defense for Readiness again expressed the belief, from the training community, that acquisition practices, particularly in the modeling and simulation area, have not kept pace with technology advances. He went on to say, *"We have an Industrial Age approach to acquisition, and we are in an e-commerce environment."* In today's e-commerce environment there is an opportunity to track customer preferences and look at demand from the user community in real time. As part of his ITEC presentation the Director, TRS appealed to the military to adopt more training tools that can customize content to the user by understanding their learning style and allowing them to progress at a more natural pace. He appealed industry to embrace a new business model and to recognize training includes the soft skills found in today's full spectrum operations to maximize human performance potential.

A. CLOSING COMMENTS

The DoD spends billions of dollars each year developing and procuring major weapon systems. These expenditures have produced the most technologically advanced weapon systems. Nevertheless, the process through which systems are determined and acquired has often proved costly and inefficient, as hundreds of reports by the DoD Inspector General and the Government Accountability Office have repeatedly reported. Cost and schedule can be overly optimistic, leading to instability and cost increases in the long run. Powerful incentives and interests can influence the behaviors of those involved, including DoD components, industry, and Congress. More funds may be made available for training and other human system considerations through a reduction of inefficiencies without necessarily adding to baseline costs. Early consideration of training can have clear benefits in reducing certain problems that have been documented in weapon system acquisition.

The Phase I effort provides a relatively extensive list of reports and studies relating to training systems acquisition in MDAP programs. The automated data base with common variables provides ready access to details from several hundred program documents. The gap and trend analysis of this data has provided a start point for the Phase II study which will examine a series of selected systems (by type and category) for detailed assessment through case studies. During Phase II the database of historic examples will be extended, as appropriate, to flesh out the selected case studies. For each system chosen, specific metric will be developed to assess the early and effective system training practices in acquisition. The selection of both common and system specific metrics will allow the research team to determine trends within and between program categories – and longitudinally across the past 20 or more years. The objective of the Phase II study is to determine / demonstrate the value added from early and effective system training practices and the life cycle benefits to detailed and rigorous insertion of system training details early on, and continuously in all phases the acquisition process.

Training Systems Study - Discussion

Phase I

- **Initial Study Phase**
  - **Determine variables of study**
  - **Identify sources of technical documents**

- **Execution Phase**
  - **Assemble and code documents**
  - **Populate database**

- **Analysis Phase (in process)**
  - **Analyze database for relationships & trends**
  - **Identify gaps and shortcomings**

Phase II

- **Extend Phase I database for historic examples**

- **Determine specific metrics for assessing early and effective system training practices in acquisition**

- **Select systems for case study**
  - **Assess the impact of early and effective system training practices**
  - **Determine trends within and between program categories**

  Demonstrate value added from early and effective system training practices and life cycle cost benefits

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APPENDIX A

POLICY AND GUIDANCE EXCERPTS

The following are excerpts of policy and guidance for development of training capabilities associated with acquisition programs. It was noted that the requirement to develop training systems plans (TSP) in DoDI 5000.02 does not specify by what point in the acquisition process these plans should be developed. Requiring submission of the TSPs early in program development would facilitate improved effectiveness of the training systems provided.

DoDI 5000.02 (Operation of the Defense Acquisition System)

8. OPERATIONS AND SUPPORT PHASE

a. Purpose. The purpose of the Operations and Support Phase is to execute a support program that meets materiel readiness and operational support performance requirements, and sustains the system in the most cost-effective manner over its total life cycle. Planning for this phase shall begin prior to program initiation and shall be documented in the LCSP. Operations and Support has two major efforts, Life-Cycle Sustainment and Disposal. The DoDI requires that Program Managers do the following in support for sustainment of the system:

(c) Effective sustainment of systems results from the design and development of reliable and maintainable systems through the continuous application of a robust systems engineering methodology.

2. Optimize operational readiness via:

a. Human-factors engineering to design systems that require minimal manpower; provide effective training; can be operated and maintained by users; and are suitable (habitable and safe with minimal environmental and occupational health hazards) and survivable (for both the crew and equipment).

b. Diagnostics, prognostics, and health management techniques in embedded and off-equipment applications when feasible and cost-effective (Reference (o));

c. Embedded training and testing, with a preference for approved DoD Automatic Test Systems (ATS) Families to satisfy ATS requirements;

d. Serialized item management techniques and the use of automatic identification technology (AIT), radio-frequency identification, and iterative technology refreshment. PMs shall ensure that data syntax and semantics for high-capacity AIT devices conform to International Organization for Standardization ISO 15418 and ISO 15434 (References (t) and (u)).

from ENCLOSURE 7: RESOURCE ESTIMATION

5. ANALYSIS OF ALTERNATIVES PROCEDURES. For potential and designated ACAT I and IA programs, the DPA&E shall draft, for MDA approval, AoA study guidance for review at the Materiel Development Decision. Following approval, the guidance shall be issued to the DoD Component designated by the MDA, or for ACAT IA programs, to the office of the Principal Staff Assistant responsible for the mission area. The DoD Component or the Principal Staff Assistant shall designate responsibility for completion of the study plan and the AoA; neither of which may be assigned to the PM. The study plan shall be coordinated with the MDA and approved by the DPA&E prior to the start of the AoA. The final AoA shall be provided to the DPA&E not later than 60 days prior to the DAB or ITAB milestone reviews. The DPA&E shall evaluate the AoA and provide an assessment to the Head of the DoD Component or Principal Staff Assistant and to the MDA. In this evaluation, the DPA&E, in collaboration with the OSD and Joint Staff, shall assess the extent to which the AoA:

a. Illuminated capability advantages and disadvantages;
b. Considered joint operational plans;
c. Examined sufficient feasible alternatives;
d. Discussed key assumptions and variables and sensitivity to changes in these;
e. Calculated costs; and,
f. Assessed the following:
(1) Technology risk and maturity;
(2) Alternative ways to improve the energy efficiency of DoD tactical systems with end items that create a demand for energy, consistent with mission requirements and cost effectiveness; and
(3) Appropriate system training to ensure that effective and efficient training is provided with the system.

from ENCLOSURE 8: HUMAN SYSTEMS INTEGRATION (HSI)

1. GENERAL. The PM shall have a plan for HSI in place early in the acquisition process to optimize total system performance, minimize total ownership costs, and ensure that the system is built to accommodate the characteristics of the user population that will operate, maintain, and support the system.

2. HSI PLANNING. HSI planning shall be summarized in the Acquisition Strategy and SEP and shall address the following:

e. Training. The PM shall work with the training community to develop options for individual, collective, and joint training for operators, maintainers and support personnel, and, where appropriate, base training decisions on training effectiveness evaluations. The PM shall address the major elements of training, and place special emphasis on options that enhance user capabilities, maintain skill proficiencies, and reduce individual and collective training costs. The PM shall develop training system plans to maximize the use of new learning techniques, simulation technology, embedded training and distributed learning (DoD Instruction 1322.26 (Reference (be))), and instrumentation systems that provide "anytime, anyplace" training and reduce the demand on the training establishment. Where possible, the PM shall maximize the use of

simulation-supported embedded training, and the training systems shall fully support and mirror the interoperability of the operational system (DoD Directive 1322.18 (Reference (bf))).

DoDD 1322.18: Military Training

4. POLICY. It is DoD policy that:

a. Individual, staff, and collective military training programs funded by the Department of Defense shall be available to Active and Reserve Component personnel, civilian employees and, when authorized, to contractors, allies, and other U.S. Government or non-Government agency personnel.

b. Military training to generate and sustain capabilities required by the CCDRs and Chairman of the Joint Chief of Staff Concept (Reference (b)) shall encompass all phases of joint campaigns and the full range of integrated operations.

c. Members of the Department of Defense shall receive, to the maximum extent possible, timely and effective individual, collective, and staff training, conducted in a safe manner, to enable performance to standard during operations.

d. The Department of Defense shall maintain a comprehensive and effective Service, Defense Agency, and joint training management capability to develop, execute, and assess military training throughout the Department.

e. Training capabilities shall be based on a DoD training architecture and an open, net-centric, interoperable standard.

f. Embedded training and development of net-centric training capabilities shall be considered as the first alternative for cost-effective delivery of instruction and training.

DoDI 1322.26: Development, Management, and Delivery of Distributed Learning

4. <u>POLICY</u>

It is DoD policy that:

4.1. Embedded training and distributed learning shall be considered as the first option to meet training requirements of defense technology projects and acquisition programs (Reference (a)).

Acquisition Guide Book

3.4.2.1. Cost Analysis Requirements Description (CARD)

System support concept
- System logistics concept
- Hardware maintenance and support concept
- Software support concept
- System training concept

It also is important that the analytic approach to the cost estimate be documented and reviewed by all potentially interested parties, before the actual work on preparing the cost estimate begins. This helps ensure that there are no false starts or misunderstandings later in the process. Normally, cost estimates are sponsored by a system program office and are prepared by a multi-disciplinary team with functional skills in financial management, logistics, engineering, and other talents. The team also should include participants or reviewers from major affected organizations, such as the system's operating command, product support center, maintenance depot, training center or command, and so forth. Typically, the analytic approach to the cost estimate has a written study plan that includes a master schedule (of specific tasks, responsible parties, and due dates). For sufficiently complex efforts, the estimating team may be organized as a formal Integrated Product Team (IPT). For independent cost estimates, the team may be smaller and less formal, but the basic principle—complete coordination of the analytic approach with all interested parties—still applies.

4.3.1.3.1. Interpret User Needs; Analyze Operational Capabilities and Environmental Constraints

This step includes the aggregation of all inputs available at this stage of the program (Initial Capabilities Document, Analysis of Alternatives Plan, exit criteria for the phase, concept alternatives for overall tactical system, as well as associated support system, training system, and interoperable systems).

4.3.1.3.3. Decompose Concept Performance into Functional Definition and Verification Objectives

This step includes the further decomposition of concept system performance to the functional level. Consideration should be given to inclusion of functionality and functional flow definition across the full system concept (tactical system, support system, training system) and how this functionality relates to other interoperable systems (functional interfaces). Critical to this analysis is an understanding of the level of functionality achievable within program constraints and risk. Trade space and risk should be analyzed and assessed against desired functional performance. Trade offs are made to stay within program constraints and may require changes to higher-level system or concept definitions.

4.3.2.3.1. Interpret User Needs; Analyze Operational Capabilities and Environmental Constraints

This step includes the aggregation of all inputs available at this stage of the program (Initial Capabilities Document, draft Capability Development Document, results of the Analysis of Alternatives and identification of the preferred system concept, exit criteria for the phase, Systems Engineering Plan, Technology Development Strategy, Test and Evaluation Strategy, as well as associated support and maintenance concepts and technologies, training system, and interoperable systems).

4.3.2.3.3. Develop Functional Definitions for Enabling/Critical Technologies and Associated Verification Plan

This step requires the further decomposition of system performance to the functional level. The functional requirements should be evaluated against available technologies, such that enabling and/or critical technologies can be defined. Consideration should be given to inclusion of functionality and functional flow definition across the full system (tactical system, support system, training system) and how this functionality relates to other interoperable systems (functional interfaces). Critical to this analysis is an understanding of the level of functionality achievable within the program constraints and program risk. Trade space and risk should be analyzed and assessed against desired functional performance. Trade-offs may be required to stay within program constraints and may require changes to higher-level system definitions.

4.3.3.4.4. Preliminary Design Review (PDR)

The PDR is a multi-disciplined technical review to ensure that the system under review can proceed into detailed design, and can meet the stated performance requirements within cost (program budget), schedule (program schedule), risk, and other system constraints. Generally, this review assesses the system preliminary design as captured in performance specifications for each configuration item in the system (allocated baseline), and ensures that each function in the functional baseline has been allocated to one or more system configuration items. Configuration items may consist of hardware and software elements and include such items as airframes, avionics, weapons, crew systems, engines, trainers/training, etc.

6.2.3 Training

6.2.3.1 Training Overview

Training is the learning process by which personnel individually or collectively acquire or enhance predetermined job-relevant knowledge, skills, and abilities by developing their cognitive, physical, sensory, and team dynamic abilities. The "training/instructional system" integrates training concepts and strategies and elements of logistic support to satisfy personnel performance levels required to operate, maintain, and support the systems. It includes the "tools" used to provide learning experiences such as computer-based interactive courseware, simulators, and actual equipment (including embedded training capabilities on actual equipment), job performance aids, and Interactive Electronic Technical Manuals.

6.2.3.2 Training Parameters/Requirements

When developing the training/instructional system, the program manager should employ transformational training concepts, strategies, and tools such as computer based and interactive courseware, simulators, and embedded training consistent with the strategy, goals and objectives of the Training Transformation Strategic Plan (March 1, 2002) and the Training Transformation Implementation Plan and Appendix 1 (June 2004). The Departments vision for raining Transformation is to provide dynamic, capabilities-based training in support of national security requirements across the full spectrum of Service, joint, interagency, intergovernmental, and multinational operations. This new approach emphasizes the mission requirements of the combatant commanders (COCOM). The COCOM is the customer. The intent is to design systems and structure

acquisition programs focused on the training needs of the COCOM. The desired outcome is to fully support COCOM requirements, missions, and capabilities, while preserving the ability of the DoD Components to train for their core competencies. The Under Secretary of Defense for Personnel and Readiness, as a member of the Defense Acquisition Board, assesses the ability of the acquisition program to support the Military Departments, COCOMs, and DoD Components. "Training," in this context, includes training, education, and job-performance aiding. Joint training must be able to support a broad range of roles and responsibilities in military, multinational, interagency, and intergovernmental contexts, and the Department of Defense must provide such training to be truly flexible and operationally effective. Training readiness will be assessed and reported, not only in the traditional joint context, but also in view of this broader range of "joint" operations. Joint training and education will be recast as components of lifelong learning and made available to the Total Force-active, reserve, and DoD civilians. The Department will expand efforts to develop officers well versed in joint operational art. The interfaces between training systems and the acquisition process will be strengthened. The Under Secretary of Defense for Personnel and Readiness, as a member of the Defense Acquisition Board, assesses an acquisition program's ability to support the Combatant Commander's and DoD Components' capabilities to provide HSI as an integral part of an acquisition program.

The program manager should summarize major elements of the training plan in the Support Strategy. This should include logistics support planning for training, training equipment and training device acquisitions and installations.

A Special Note on Embedded Training. Both the sponsor and the program manager should give careful consideration and priority to the use of embedded training as defined in DoD Directive 1322.18: "Capabilities built into, strapped onto, or plugged into operational materiel systems to train, sustain, and enhance individual and crew skill proficiencies necessary to operate and maintain the equipment." The sponsor's decisions to use embedded training should be made very early in the capabilities determination process. Analysis should be conducted to compare the embedded training with more traditional training media (e.g., simulator based training, traditional classroom instruction, and/or maneuver training) for consideration of a system's Total Operating Cost. The analysis should compare the costs and the impact of embedded training (e.g., training operators and maintenance personnel on site compared to off station travel to a temporary duty location for training). It should also compare the learning time and level of effectiveness (e.g., higher "kill" rates and improved maintenance times) achieved by embedded training. When making decisions about whether to rely exclusively on embedded training, analysis must be conducted to determine the timely availability of new equipment to all categories of trainees (e.g., Reserve and Active Component units or individual members). For instance, a National Guard tank battalion that stores and maintains its tanks at a central maintenance/training facility may find it more cost effective to rely on mobile simulator assets to train combat tasks rather than transporting its troops to the training facility during drill weekends. A job aid for embedded training costing and effectiveness analyses is: "A Guide for Early Embedded Training Decisions," U.S. Army Research Institute for the Behavioral and Social Sciences Research Product 96-06.

6.2.3.3 Training Planning

This section will prepare the Program Manager to understand training capabilities as an integral part of the Joint Capabilities Integration and Development System and, with assistance of the training community, translate those capabilities into system design features.

First, the Joint Capabilities Integration and Development System process should address joint training parameters for military (Active, Reserve, and Guard) and civilian personnel who will operate, maintain, and support the system. Training programs should employ a cost-effective solution, consisting of a blend of capabilities that use existing training programs and introduces new performance-based training innovations. This may include requirements for school and unit training, as well as new equipment training, or sustainment training. This also may include requirements for instructor and key personnel training and new equipment training teams.

Training should be considered early in the capabilities development process beginning with the analyses that supports development of the Initial Capabilities Document and continues with development of the Capability Development Document.

The Capability Development Document should discuss the specific system training requirements:

- Allow for interactions between platforms or units (e.g., through advanced simulation and virtual exercises) and provide training realism to include threats (e.g., virtual and surrogate), a realistic electronic warfare environment, communications, and weapons.

- Embedded training capabilities that do not degrade system performance below threshold values nor degrade the maintainability or component life of the system.

- That Initial Operational Capability is attained and that training capabilities are embedded and met by Initial Operational Capability.

- An embedded performance measurement capability to support immediate feedback to the operators/maintainers and possibly to serve as a readiness measure for the unit commander.

- Training logistics necessary to support the training concept(e.g., requirements for new or upgrades to existing training facilities).

- The training community should be specific in translating capabilities into system requirements. They should also set training resource constraints. Examples are:

- The training community should consider whether the system be designed with a mode of operation that allows operators to train interactively on a continuous basis, even when deployed in remote locations.

- The training community should consider whether the system be capable of exhibiting fault conditions for a specified set of failures to allow rehearsal of repair procedures for isolating faults or require that the system be capable of

- interconnecting with other (specific) embedded trainers in both static and employed conditions.

- The training community should consider whether embedded training capabilities allow enhancements to live maneuver such that a realistic spectrum of threats is encountered (e.g., synthetic radar warnings generated during flight).

- The training community should consider whether the integrated training system be fully tested, validated, verified, and ready for training at the training base as criteria for declaring Initial Operational Capability.

- From the earliest stages of development and as the system matures, the program manager should emphasize training requirements that enhance the user's capabilities, improve readiness, and reduce individual and collective training costs over the life of the system. This may include requirements for expert systems, intelligent tutors, embedded diagnostics, virtual environments, and embedded training capabilities. Examples of training that enhances user's capabilities follow:

- Interactive electronic technical manuals provide a training forum that can significantly reduce schoolhouse training and may require lower skill levels for maintenance personnel while actually improving their capability to maintain an operational system;

- Requirements for an embedded just-in-time mission rehearsal capability supported by the latest intelligence information and an integrated global training system/network that allows team training and participation in large scale mission rehearsal exercises can be used to improve readiness.

- In all cases, the paramount goal of the training/instructional system should be to develop and sustain a ready, well-trained individual/unit, while giving strong consideration to options that can reduce Life-cycle costs and provide positive contributions to the joint context of a system, where appropriate.

- Training devices and simulators are systems that, in some cases, may qualify for their own set of HSI requirements. For instance, the training community may require the following attributes of a training simulator:

- Accommodate "the central 90 percent of the male and female population on critical body dimensions;"

- Not increase manpower requirements and should consider reductions in manpower requirements;

- Consider reduced skill sets to maintain because of embedded instrumentation;

- Be High Level Architecture compliant;

- Be Sharable Content Object Reference Model compliant;

- Be Test and Training Enabling Architecture compliant;

- Use reusable simulation objects.

CJCSI 3170.01G: JCIDS

2. Introduction to the JCIDS Process

e. During the Technology Development phase (Figure A-4), the sponsor performs technology maturation activities, builds competitive prototypes, and may perform design activities leading to a preliminary design review. The ICD provides a wide aperture for operational capability to define system requirements and to encourage technological innovation. It is vital the science and technology, users, training, and system developer communities collaborate to agree on a proposed solution that is affordable, militarily useful, and based on mature, demonstrated technology.

JCIDS Manual

d. Selectively Applied KPPs. The JROC has defined two KPPs to be selectively applied to programs: system training and energy efficiency. The sponsor will perform an analysis on the use of these parameters as KPPs. If the analysis determines that they should not be KPPs, a summary of the justification will be provided in the CDD.

(1) System Training KPP. Training should be considered early in the capabilities development process beginning with the analyses that support development of the ICD and continues with development of the CDD. Ensure system training is addressed in the AoA and supporting analysis for subsequent acquisition phases and ensure projected training requirements and associated costs are appropriately addressed across the program life cycle. Embedded training and net-centric enabled training shall be considered the first alternative for cost effective delivery of instruction. The training capability requirements should be on par with operational systems capability. Further guidance on this KPP can be found in Appendix C to this Enclosure.

CODING RULES

Variable Number	Database Entry # Rater Initials:
1	Report Document Title
coding	Full title, volume number if appropriate (enter in cell below)
2	ADA number (DTIC)
coding	Enter number in cell below, If no ADA number, enter 0 (in cell below)
3	Other reference (journal, book chapter, conference paper, other report)
coding	If DTIC enter 0; APA style, or close to it (enter in cell below)
4	Pages
coding	Enter total page count as listed in document (enter in cell below)
5	Corporate Author
coding	Enter all authors: last name, first initial. If none identified, enter organization (enter in cell below)
6	Year of Report
coding	The year the report was published, YYYY (enter in cell below), enter 0 if not reported
7	Type of Activity publishing/submitting report (not necessarily sponsor)
coding	A=Army, AF=AirForce, N=Navy, M=MarineCr, D=Def Agency, J=Joint, I=industry, F=FFRDC, U=acad
8	Funding for Report Document (possible R&D funding for report on Major System)
coding	Usually a program element is supplied in DTIC abstract. 0 = unknown or n/a, R=R&D, O=O P=Procurement, I=Industry internal, X=other
9	System Name or Program Number (PNO) for more recent acquisitions
coding	Formal name or 3 digit PNO; If not system specific enter 1, if unknown enter 0 (enter in cell below)
10	System Type - Functional Capability
coding	0=unknown or n/a, 1=Battlespace awareness, 2=Building Partnerships, 3= C2, 4=Corporate Mngt/Sup 5= Force Application, 6= Force Support, 7=Logistics, 8=NetCentric, 9=Protection(examples available)
11	Acquisition Phase (as of *Year variable*)
coding	0=unknown or n/a, 1=Concept Refinement, 2=TechDevel, 3=SystemDevel, 4=Production, 5=Ops/sup
12	Acquisition Cost - Major Defense Acquisition Program From external source; in FY2000$, $365M RDTE, $2.19B procurement. 1=MDAP, 2=not MI
coding	0=unknown
13	Requirement Source

40

coding	warfare experimentation, R&D, ACTD, modernization, upgrade, P3I, Tech Readiness Level; *Scale TB*

14 Who developed training – prime, sub

coding 0=unknown or n/a, 1=prime, 2=subcontract, 3=other

15 Training Support Plan – completeness, depth, etc.

coding Qualitative judgment on training plan to maximize the use of new learning techniques, simul technology, embedded training, and instrumentation that reduce demand on the training establishr instructor training; HIS integration for training. *Scale TBD*

16 System Training Plan – completeness, depth, etc.

coding Concepts specified for simulators, classroom, distance learning. *Scale TBD*

17 Embedded Training

coding   0=unknown or n/a, 1=not included (perhaps not considered), 2= explicitly considered bu included, 3=included

18 System Safety/Health Hazards/Survivability - training relationship specified

coding 7 Human System Integration domains (per Mike McCauley). Scale TBD

19 Domain Integratation - training tradeoffs between domains

coding 0=unknown or n/a, 1=no explicit consideration, 2= yes, explicit consideration

20 Rapid Acquisition - training consideration

coding 0= unknown or n/a, 1 = no RA, 2=RA, 3=RA w/explicit training consideration

21 Spiral Development (or incremental analysis, evolutionary acq) - training consideration

coding 0= unknown or n/a, 1=no SD, 2 = SD, 3=SD w/ explicit training consideration

22 System of Systems approach - training consideration

coding 0= unknown or n/a, 1=not SoS, 2 = SoS, 3=SoS w/ explicit training consideration

23 Training Effectiveness Analysis or TE Evaluation

coding 0=unknow or n/a, 1=none reported, 2=yes, reported

24 Individual Training MOE/MOPs

coding Measures of effectiveness/performance, 0=unknown or n/a, 1=no, 2=yes

25 Collective MOE/MOPs

coding Measures of effectiveness/performance, 0=unknown or n/a, 1=no, 2=yes

26 Maintenance MOE/MOPs (crew related & system related)

coding Measures of effectiveness/performance, 0=unknown or n/a, 1=no, 2=yes

27 Operational Test Sites

coding 0=nothing to test; 1=no testing done; 2=DevTest; 3=OpTest; 4=DT+OT

28 Based on empirical evidence

coding 0=unknow or n/a, 1=none reported, 2=yes (human performance data reported)

| 29 | Use of military test subjects |
| coding | 0=unknown or n/a, 1=no (non military test subjects used), 2=yes |

30	Quantifiable Level of Learning (Kirkpatrick Model)
	0=unknown, 1=trainee reaction, 2=learning outcomes, 3=transfer to job performance, 4=organizat
coding	benefit

| 31 | Based on multiple studies |
| coding | 0=unknown or n/a, 1=only one study/experiment, 2=more than one study/experiment |

| 32 | Proprietary solution for training delivery (relates to S9) |
| coding | 0=unknown, 1=proprietary, 2=non proprietary (open source, Govt owned) |

| 33 | Generalizability within/across system types |
| coding | Can the results apply equally to other systems (one or more), such as Force Application findings app to the Logistics area (as identified in S2). 0=unknown or n/a, 1=yes, 2=no |

| 34 | GAO Report |
| coding | 0= not GAO, else GAO report number |

| 35 | Year of GAO Report |
| coding | 0=not GAO, else report year |

36	Shortcomings on training (effectiveness, cost, currency etc.)
coding	*In abstract form*
	END NOTES AND COMMENTS - enter any observations, viewpoints etc. Open ended response.
coding	What is the impact on the gap analysis?

TECHNICAL ABSTRACTS
Chronological Order

Entry #16

Training Effectiveness Evaluation of Naval Training Devices. Part 1. A Study of Submarine Diving Trainer Effectiveness

1970

Navy

SSN594, SSN613, SSN627

Human performance data reported

Not generalizable

The study had a dual orientation: that of considering problems inherent in evaluating trainer effectiveness within the context of the training environment, and evaluating the specific submarine diving trainer for its training effectiveness. A comparison was made between experienced student crew performance and inexperienced student crew performance. All training devices (SSN613 and SSN627) showed similar improvement in performance after several iterations, even though the displays and controls of each training device were different. The exception was the third device, SSN594, which was deemed ineffective as a substitute trainer for either the SSN613 or SSN627 crews. The results indicated that differences between the displays and controls of the SSN613 and SSN627 training devices did not impact training effectiveness. Rather the difference was with the effectiveness of the device itself. In that, the SSN594 device does not have redundant indicators of critical variables, such as trim angle, and provided indications in a completely different manner. Study data was not sufficient to evaluate trainer effectiveness of each device for the individual crews, as experienced crews were not available for comparison to the student crews. Another limitation of the training effectiveness evaluation was the amount of time in the trainer to practice complex situations. Many emergency situations were simply demonstrated, rather than practiced, due to lack of time.

Entry #12

Using a Ground Trainer in a Job Sample Approach to Predicting Pilot Performance.

1971

Air Force

T-37

Human performance data reported

This study has several weaknesses, including a subjective performance measure. Still, it has the interesting notion of using performance in low cost simulators to performance on high cost, high demand simulators, but the correlations are moderate, .38 is the highest. The study reflects knowledge of this training-testing technique.

Entry #15

Training Effectiveness Evaluation of Naval Training Devices Part II: A Study of Device 2F66A (S-2E Trainer) Effectiveness

1971

Navy

2F66A S-2E Trainer

Human performance data reported

Generalizable

A study was performed of the effectiveness of Device 2F66A (S-2E aircraft) in training crew members to perform air antisubmarine warfare missions. Although each conclusion must be qualified by consideration of the data sample and detailed results described in the report, it was possible to arrive at the following overall conclusions:

a. The trainer was found to be effective in training all crew members.

b. The trainer appeared to be more effective for beginning students than for operational and reserve personnel.

c. Factors which instructors used to vary the difficulty of training sessions did not appear to have a major effect on overall trainee performance.

d. The effect of team training sessions on student performance was consistent only during the early part of the first team session.

e. Instructors considered the trainer effective in training. However, equipment malfunctions and insufficient fidelity have reduced confidence and lowered the overall acceptability of the device as an integral part of air ASW training.

Entry #17

Training Effectiveness Evaluation of Naval Training Devices: An Evaluation of the 2F69B ASW Weapon System Trainer

1972

Navy

2F69B ASW Weapon System

Human performance data reported

Generalizable

Two separate experiments were conducted to evaluate the effectiveness of the Navy 2F69B Weapon System Trainer. The first series of experiments were conducted in the WST. The second series of experiments were conducted in both the WST and airborne environment. The results showed that the most beneficial training occurred in the WST trainer. As a result of these studies, it was recommended that the number of WST training sessions be increased, and the number of training flights be reduced accordingly.

Entry #2

Transfer of Training Effectiveness: A7E Night Carrier Landing Device 2F103

1976

Navy

A7

Human performance data reported

Generalizable

A transfer of training evaluation found the simulator effective compared controls receiving no device training. Five objective measures of landing performance measured during actual carrier qualification flights demonstrated statistically significant differences in landing performance, notably boarding rates. Confirmation of the effectiveness of an A7 night carrier landing simulator (awareness).

Entry #10

44

Training Effectiveness Evaluation of Device 2F87F, P-3C Operational Flight Trainer

1977

Navy

P-3C

Human performance data reported

Generalizable

A training effectiveness evaluation of P-3C operational flight trainer was tested for effectiveness through a controlled transfer of training study. Measurements were checkflight grades, number of flights and landings to criterion proficiency, number of check tasks, and errors during landing. Those pilots with six sessions of simulator training reduced flight hours by 43 percent compared to control groups. This documents the value of simulation for flight training (awareness).

Entry #3

A Strategy for the Development of Training Devices

1978

Air Force

AC-130E

Human performance data reported

Generalizable

Describes a methodology to aid simulator and training device design, employing users, training psychologists, and simulation engineers. Empirical testing on four crew positions for AC-130 gunship demonstrated a moderate level of effectiveness; value as design tool for implementation.

Entry #11

Task-specific Simulator Pretraining and In-flight Stress of Student Pilots

1978

Air Force

T-37

Human performance data reported

Generalizable

Investigation of simulated spin recovery training in reducing stress during first in-flight exposure to power-on stalls during pilot training.

Entry #29

Integration and Application of Human Resource Technologies in Weapon System Design: Consolidated Data Base Specification

1978

Air Force

1

Human performance data reported

Generalizable

Effort resulted in the detailed specification of the consolidated data base with a description of steps necessary for development and maintenance. The consolidated Human Resource Technologies to encompass maintenance manpower, instructional system development, job guide development, system ownership costs and human resources in design tradeoffs. Report outlines major data storage for all areas identified above.

Entry #5
Boom Operator Part-Task Trainer: Test and Evaluation of the Transfer of Training

1979

Air Force

KG-135

Human performance data reported

Not generalizable

Reports the rationale, methodology and results of a study of the training capabilities of the Boom Operator Part-Task Trainer (BOPPT), an air refueling simulator. The study was performed as part of an Air Force Initial Operational Test and Evaluation (IOT&E) of the device. it was found that all student groups trained in the BOPTT required significantly fewer air refueling attempts (50 versus 71) to reach proficiency in KC-135A air refueling skills than did conventionally trained students. This contributes to knowledge and awareness for transfer of training from simulators to aircraft.

Entry #7
Training Effectiveness of the CH-47 Flight Simulator.

1979

Army

CH-47

Human performance data reported

Generalizable

Test of a prototype helicopter flight simulator. Results of controlled experiments indicated overall training value, but difficulty training maneuvers close to the ground due to limitations of the visual system. Good example of value of testing training with feedback for future simulator design. Value for rapid acquisition of training simulators.

Entry #13
Transfer of Training Effectiveness Evaluation: U.S. Navy Device 2B35

1979

Navy

TA-4J

Human performance data reported

This report describes a four-phase transfer to training effectiveness evaluation for Navy Device 2B35, a computer-generated image visual display system used in the Advanced Jet phase of Navy Undergraduate Pilot Training. The transfer results provide support for familiarization maneuvers but do not support its use for night familiarization.

Entry #14

Final Report: Human Factors Research in Military Organizatoins and Systems

1979

Army

Human performance data reported

Not generalizable

This report summarizes work on seven research projects: Target handoff techniques; tank crew measures of effectiveness; fatigue effects of NAV goggle use; long range target recognition; effects of stress on performance; symbology for automated graphic displays; and suppression research. In the study of long range target detection of armored vehicle patterns, crewmen increased their recognition performance from 47% in pretraining to 79% during training and 90% in the posttest phase.

Entry #19

Human Resources, Logistics, & Cost Factors in Weapon System Development: Demonstration in Conceptual & Validation Phases of Aircraft System Acquisition

1979

Air Force

Advanced Medium STOL (short takeoff and landing) Transport

Human performance data reported

Generalizable

Effort resulted in the detailed specification of the consolidated data base with a description of steps necessary for development and maintenance. The consolidated Human Resource Technologies to encompass maintenance manpower, instructional system development, job guide development, system ownership costs and human resources in design tradeoffs. Report outlines major data storage for all areas identified above.

Entry #4

Training Device Effectiveness: Formulation and Evaluation Methodology

1980

Army

AH-1

Human performance data reported

Generalizable

Test of 'cumulative transfer effectiveness ratio'' which is the ratio of simulator training to actual aircraft training. 21 rated helicopter pilots were measured on trials to criterion for performance on 31 specific maneuvers. A control group had no simulator training. 25 to 80 percent of variance in aircraft training could be accounted for by the amount of prior simulator training. This provides evidence for the training efficiency afforded by simulators.

Entry #30

Human Resources, Logistics, and Cost Factors in Weapon System Development: Methodology and Data Requirements

1980

Air Force

0

Human performance data reported

Generalizable

This report describes a methodology which is useful for applying human resources, logistics, and cost factors in weapon system acquisition programs. The methodology, termed the coordinated human resources technology (CHRT), was developed from an integration of five individual human resources technologies: maintenance manpower modeling, instructional system development, job guide development, human resources in design tradeoffs, and system ownership costing. The CHRT methodology operates from a consolidated data base (CDB) which integrates data from these five technologies into a single data source. The CHRT methodology has two distinct capabilities: (a) it can assess the impact of baseline and alternative equipment designs and support plans on human resources, logistics, and ownership costs, and (b) it can provide an integrated maintenance personnel, training, and technical manual program for the system. The CHRT methodology is implemented by a number of computer operated models, manual operated models, and task analysis procedures. The CDB has both computer data files and hard copy data files. The description of the CHRT and the CDB is based upon a conceptual structure and the results of a preliminary tryout of the conceptual structure using data from the Advanced Medium STOL Transport System acquisition program. This methodology is applicable for tasks that are discrete, stable and well defined.

Entry #46

HUMAN FACTORS AND TRAINING EVALUATION OF THE IMPROVED TOW VEHICLE (ITV) DURING OT/DT III

1980

Army

Improved TOW vehicle.

Human performance data reported

Generalizable

The research was requested directly by the TRADOC System Manager for the Improved TOW Vehicle (TSM-ITV) and involved detailed interaction, coordination, and cooperative effort with the Operational Test and Evaluation Agency for Operational Test III and with the Army Material Systems Analysis Agency and the Test and Evaluation Command for Developmental Test III. Training developed at the Armor and Infantry Schools appeared adequate for the test requirements. No negative transfer of training appeared between ground-mounted TOW and ITV tracking systems. For knowledge gap in retention of cognitive and psychomotor skills: Skill loss on ITV performance appears to be greater than for TOW and gunners suggested ITV tracking practice on a weekly basis. Test participants indicated that intervals between ITV practice for skill maintenance should be no more than one week. TOW practice sessions should be twice monthly. Individual gunners may require additional practice. Basic ITV training should require five (5) days. An additional three days is necessary for tactics training and for operational experience.

Entry #18

Human Resources, Logistics, and Cost Factors in Weapon System Development: Demonstration of Full Scale Development Phase of Aircraft System Acquisition

1981

Air Force

0

Human performance data reported

Generalizable

This report documents the final part of a three-part demonstration of the coordinated human resources technology (CHRT) on an aircraft acquisition program. CHRT is an integration of five human resource technologies: maintenance manpower modeling; human resource in design trade-offs, instructional system development, job guide development, and system ownership costing. The CHRT methodology also includes a consolidated data base (CDR) which services the five integrated technologies. CHRT was conceived and developed (a) to assess the impact of system design and support plans on human resource, logistics, and cost throughout acquisition, and (b) to facilitate the implementation of an integrated personnel, training and technical manual support approach. In this part of the demonstration, CHRT and the CDB were applied to the avionics and landing gear system of the Advanced Medium STOL transport (AMST) using data projected for the minimum engineering development phase. This phase may be considered similar to full-scale development but lesser in scope. The following results were achieved. First, manpower requirements, training requirements, technical manual requirements, reliability, maintainability, and system ownership costs were assessed and quantified for several avionics and landing gear design and support alternative at various levels of system detail. Second, a sample integrated training program and technical manual were prepared fro a selected landing gear maintenance task. Third the consolidated database was continued and expanded for both the avionics and landing gear systems.

Entry #42
Preparation and design for a training effectiveness evaluation of device 2F64C for Replacement Pilot training
1981

Navy

H-3, SH-3

Human performance data reported

This report presents the initial effort in a program to assess the training potential of a new simulator (Device 2F64 C) for training SH-3 replacement helicopter pilots. The report contains a description of the training situation at the fleet readiness squadron prior to and during transition to a new curriculum that resulted from an instructional system development (ISD) program. The report also discusses TAEG initiatives to enhance training of replacement helicopter pilots and factors impacting syllabi content and syllabus development. Detailed scenarios are described to ensure effective syllabus implementation. An experimental plan for assessing training effectiveness of the 2f64C is included.   Gap Analysis: Classified as "best practice report", addressing a Knowledge Gap by testing the efficacy of applied ISD (task analysis; syllabus development and performance assessment) for a training system prior to operational acceptance.

Entry #57
Performance Measurement and the Navy's Tactical Aircrew Training System (TACTS)
1981

N

TACTS

Human performance data reported

Generalizable

The present report was written in response to an air combat training Fleet Project Team (FPT) requirement that a performance measurement system (PMS) for the Navy Tactical Aircrew Training System (TACTS) be developed. It provides a context for the problem and value of performance measurement as well as a set of specific functional requirements for a PMS for air-to-air combat training. In addition, the report provides systematic documentation for the conclusion that, with the development of the extremely impressive TACTS instrumentation technology, there was no parallel development to provide a system of human performance measurement to support that capability. It is thought that development of a PMS, which meets the requirements presented here, will greatly assist in more fully accomplishing the original operational training requirements which led to development of the TACTS facility. It is concluded that while the existing TACTS represents a highly advanced aviation engineering technology that can provide extremely valuable training, that same technology has largely ignoring the functional requirements for a system of human performance measurement. Improvements in the TACTS performance measurement capabilities will improve its training value even further. Performance data are essential to the training process. Measures of ACM subtask skills allow the instructor to monitor the progress of training, as well as to provide diagnostic feedback regarding problem areas. Both norm-referenced and criterion-referenced standards of aircrew proficiency can be established. These behavioral criteria and associated standards inform the instructor and student as to what is to be trained and to what level. Training effectiveness evaluations (TEEs) are then possible. The use of simulated weapons and targets has greatly decreased the cost (and increased the safety) of ACM practice. The producer of the instrumented air combat ranges for both the Navy and the Air Force estimates that the TACTS/ACMI reduces air combat training costs by more than $100 million annually (Cubic Corporation, 1978). According to Bill Dollard (1980), the TACTS manager at Miramar, the first system developed for Miramar cost approximately $25 million in R&D and installation of the system in an operational mode. The system costs less than $1,000 an hour to operate. However, these savings must be assessed in terms of performance effectiveness measures on the TACTS. In view of the above described limitations of original TACTS PMS, the recent FPT message seating the need to develop a PM system for use with the TACTS, and the tremendous potential value of TACTS performance criteria, it is clear that functional requirements for a PM system should be identified. Psychometric Requirements: objectivity, reliability, validity, sensitivity, and quality control. Training Requirements: evaluative, diagnostic, remedial, timely, affordable, adaptable, automated, manageable, accessible, and acceptable.

     Entry #6
     Training Effectiveness Evaluation of Device A/F37-A-T59
     1982
     Air Force
     C-130
     Human performance data reported

Training effectiveness evaluation of an upgrade to C-130 simulator, with addition of instrument flight simulator featuring simultaneous training of pilot, copilot, flight engineer, and navigator. A blended approach of classroom and simulator training on AF crews indicated a training effectiveness ratio of .5 with comparison to a control group not received the simulator training. This contributes to awareness about evaluating training of equipment upgrades.

     Entry #43
     Relative cost and training effectiveness of the F-111 6883 Converter/Flight Control System
     1982

Air Force

F-111 aircraft

Human performance data reported

Generalizable

TEE Study; Knowledge Gap . TEE experiment with military avionics technicians using 2D maintenance trainer. The intent of the study was to examine possible expanded use of simulation to improve training value and cost effectiveness of maintenance training. Individual maintenance troubleshooting skill and procedural knowledge were tested. Cost date, covering a 15 year life cycle were also studied.

Entry #33

Training Effectiveness Evauation (TEE) of the Advanced Fire Fighting Training System

1983

Navy

Advanced Fire Fighting Training System

Human performance data reported

Generalizable

Effort resulted in the detailed specification of the consolidated data base with a description of steps necessary for development and maintenance. The consolidated Human Resource Technologies to encompass maintenance manpower, instructional system development, job guide development, system ownership costs and human resources in design tradeoffs. Report outlines major data storage for all areas identified above.

Entry #20

Results of the Part-Task Shiphandling Trainer Pre-Prototype Training Effectiveness Evaluation (TEE)

1985

Navy

0

Human performance data reported

Generalizable

The Part Task Trainer for Shiphandling (PARTT-SHIP) device represents one portion of the Naval Training Equipment Center's shiphandling research program. This device was functional defined after conducting a Navy shiphandling task analysis, and developing a functional specification for a trainer to accomplish approximately **80** percent of the training objectives required for basic and intermediate level shiphandlers. The PARTT-SHIP is a pre-prototype of a part-task shiphandling trainer. The pre-prototype is a low cost version that mimics the actual capabilities of a fully capable shiphandling part-task trainer. The goal of building a pre-prototype was to demonstrate and evaluate in several ways the capability of the actual device which could be built. The quantitative portion of the PARTT-SHIP demonstration was recorded for Training Effectiveness Evaluation purposes. In both collision avoidance and restricted waters training, experimental results showed PARTT-SHIP to be an equally effective training device compared to a full bridge simulator. Results indicate a potential for PARTT-SHIP as part of a total shiphandling training system.

Entry #32

Literature Review - Army Training: M16A1 Rifle, TOW & DRAGON Weapons Systems

1986

Army

M16A1 Rifle, TOW, DRAGON

Human performance data reported

Not generalizable

Effort resulted in the detailed specification of the consolidated data base with a description of steps necessary for development and maintenance. The consolidated Human Resource Technologies to encompass maintenance manpower, instructional system development, job guide development, system ownership costs and human resources in design tradeoffs. Report outlines major data storage for all areas identified above.

Entry #54

On-The-Job Training: Development and Assessment of a Methodology for Generating Task Proficiency Evaluation Instruments

1986

Air Force

Generic application

Human performance data reported

Generalizable

This report describes the development and assessment of a methodology for generating on-the-job training task proficiency assessment instruments. The development procedures allow subject-matter experts without experience in assessment methodology, to construct task proficiency assessment instruments which can be used by supervisors to assess trainee proficiency at specific tasks. The reliability and validity of the procedures and of the forms resulting from procedural application were examined in two Air Force career fields, aircraft maintenance and security police. The results of the procedural assessment indicated that SMEs could reliably apply the development procedures to construct training evaluation forms which accurately and completely depict the critical aspects of task performance. This report includes a detailed descriptions of the assessment methodologies and results. Knowledge Gap input: The ability to accurately and objectively assess an individual's level of performance on the job is important to major systems for personnel selection, assignment, training, and utilization. This can be useful in Developmental Testing, offering standardization with regard to the construction of assessment instruments, administration of performance evaluations, the scoring of results, and providing feedback. Implementation Gap input: The structured technique described in this report for assessing performance, on the job or during development/operational testing can provide structured feedback to system designers.

Entry #41

F-16 Limited field of view simulator training effectiveness study

1987

Air Force

F-16

Human performance data reported

Generalizable

TEE Study; Knowledge Gap . Used subjective evaluation (trainee reaction) to limited field of view simulation. Military pilots completed a questionnaire following simulation training. Study focused on examining the effectiveness of limited field of view.

Entry #36

MANPRINT Findings from the Investigative Operational Assessment of the Joint Tactical Information Distribution System (JTIDS)

1988

Joint

Joint Tactical Information Distribution System (JTIDS)

Human performance data reported

Not generalizable

This report addressed training only in the context of the Investigative Operational Assessment (IOA) and covered training to test operator and maintenance training for the specific test event.

Entry #49

Human Factors Performance Data for Future Forward Area Air Defense Systems (FAADS)

1989

Army

Forward Area Air Defense Systems (FAADS)

Human performance data reported

Generalizable

Testifying before Congress in 1977, an Army official stated that "We expect this somewhat unorthodox approach to permit a much reduced development time, thus resulting in an earliest fielding date, albeit with higher but acceptable risks." Despite the use of many off the shelf technologies that were intended to allow rapid and low-cost development, a series of technical problems and massive cost overruns resulted in the cancellation of the Sergeant York project in 1985 by the Secretary of Defense. Although much of the processing of the collected data was also cancelled or brought to a hasty conclusion, an extensive follow-on evaluation was conducted. The research documented the analysis of training and human factors-related data from the Sgt York Follow-On Evaluation I, which generated objective performance measures on individual soldier, team, and system performance. Objective performance data were examined with respect to fourteen issues, such as varying target workloads on the operator or the negative impact of some semi-automation. The data yielded findings on many issues relevant to the design of a future area air defense system. The report provides suggestions on applying such data to future soldier-system performance models, which can be remarkably helpful in making decisions about future FAADS. Awareness Gap input: Failures of cancelled system can lead to training and performance improvements in similar, follow on systems if properly analyzed. Implementation Gap input: Maintaining detailed human performance data during DT/OT allows secondary analyses for other system designers.

Entry #52

Embedded Training Software Specifications for the FOG-M System Demonstration

1989

Army

FOG-M, Fiber-Optic Guided Missile

Human performance data reported

Generalizable

This report describes embedded training (ET) concepts investigated for the FOG-M, Fiber-Optic Guided Missile, system being developed by the U.S. Army Missile Command. This document presents ET software specifications for a demonstration of FOG-M. Specifications are included for embedded mission simulation, computer-aided instruction, and part-task training of the FOG-M gunner. The structured specifications are intended for use by FOG-M programmers-who will design and code the ET software. Knowledge Gap input: Detailed example of functions and structures to embed training in software packages of a weapon system.

Entry #53

Line of Sight-Forward (Heavy) Surrogate Assessment

1989

Army

Line of Sight-Forward

Human performance data reported

Not generalizable

The concept feasibility assessment was conducted using two manufacturers' prototype or "surrogate" weapon systems to provide baseline data for addressing manpower, personnel, and training issues. A front-end analysis identified mission and performance requirements. The training requirements analysis was guided by the TRADOC systems approach to training. Analyses indicated that the Army can support such a system with respect to quality of personnel and ability to train these personnel. The gunner's engagement task requires a seven-step operational sequence divided: between two hand-operated control devices and one foot switch. It is recommended that this method be studied to determine its trainability and impact on system effectiveness. Knowledge Gap input: This study provides an example of how to examine training requirements in a front-end analysis, with positive results.

Entry #48

Simulation-Based Assessment of Automated Command, Control, and Communication Capabilities for Armor Crews and Platoons: The Intervehicular Information System

1991

Army

Inter Vehicular Information System (IVIS)

Human performance data reported

Generalizable

The Intervehicular Information System (IVIS) is an automated C3 display in the upgraded Block 2 M1 Abrams tank. This simulation-based research compared the performance of tank crews and tank platoons using a prototype IVIS with the performance of tank crews and tank platoons using conventional C3 and navigational tools, including a radio, paper map, protractor, and compass. Armor crews and platoons equipped with IVIS significantly outperformed the crews and platoons using conventional techniques on every composite measure evaluated. IVIS-equipped crews and platoons executed a C3 exercise and offensive and defensive combat missions faster, reported their own location and battlefield events better, and successfully executed more fragmentary orders than crews and platoon equipped with conventional tools. Awareness Gap input: The findings suggest critical Armor performance and training implications and identified 25 design issues in areas such as report queueing and routing, position navigation, and icons. These can be generalized to other command, control, and communication upgrades to major systems.

Entry #37

C3I Test-Instrumentation System: MANPRINT Evaluation of the Data Collection Subsystem

1992

Army

C3I Test-Instrumentation System: MANPRINT Evaluation of the Data Collection Subsystem

Human performance data reported

Not generalizable

There was no formal training program developed or planned and a formal training evaluation was not conducted.

Entry #50

Training Requirements Analysis for the Combat Vehicle Command and Control System Tactical Operations Center

1992

Army

Close Combat Tactical Trainer

Human performance data reported

Generalizable

This research describes the results of a training requirements analysis conducted to support development of the Combat Vehicle Command and Control System. The CVCC is a set of selected futuristic components with functions simulated in the Close Combat Test Bed environment. The objective of the task analysis was to (1) provide the minimum essential task information needed to support the early assessment of CVCC Tactical Operations Center training requirements and (2) assess which TOC tasks and skills should be included in future training programs. Knowledge Gap input: Application of training analysis techniques in refining requirements as determined by user experiences in simulated environments.

Entry #51

Hardmand III: A Patriot Growth Application

1992

Army

Patriot

Human performance data reported

Generalizable

Report is an application of HARDMAN III methodology, a suite of software tools to improve the design and acquisition process for hardware and software systems that applies mission simulation to examine manpower, personnel, and training constraints. It was applied to a proposed improvement (Navigation Emplacement System) to the Patriot Air Defense System. The analyses included system performance requirements and projected manpower and personnel characteristics for Patriot occupational specialties in the fielding years; it also included workload analyses and analyses of the effects of personnel quality and training and environmental stressors on mission performance. The Patriot Growth Application is a good example of the concept, methodology, and output of HARDMAN III analyses through user participation on an actual system. Awareness Gap input: The HARDMAN methodology can be applied to the hardware/software subsystem requirements of major acquisitions from a personnel and training point of view.

Entry #9

An Investigation of Integrated Product Development: A Case Study of an F-22 Prime Contractor

1994

Air Force

F-22

Human performance data reported

Generalizable

A case study of implementing an Integrated Product Team structure into an AF System Program Office for the F-22. A Training Systems IPT is identified on p. 14, but no other explicit mention of system training. The results indicated there were problems with the implementation of the IPT concept.

Entry #40

Using the Backward Transfer Paradigm to Validate the **63007A** AH-64 for Simulator Training Research Advanced Testbed for Aviation

1994

Army

AH-64

Human performance data reported

Generalizable

TEE Study- knowledge gap. The main purpose of the study was to test the effectiveness of this simulator in training tasks required for later more advanced simulator and aircraft qualification skills. The backward training method, at the time, was an established means to teach landing and hovering tasks. There was concern that the visual system would limit effectiveness.

Entry #21

User-Oriented Design Analysis of the VESUB Technology Demonstration System

1997

Navy

1

Human performance data reported

Generalizable

This study provided good insights into design of training systems for optimum training benefit. It also offered five general areas for future research for improved IOS designs.

Entry #26

Formative Evaluations of the VESUB Technology Demonstration System

1997

Navy

VESUB Technology Demonstration System

Human performance data reported

Generalizable

Use of VR provided training opportunities that are not available during operations with the actual equipment in actual situations. Training that will expose junior officers to a variety of challenging geographical and environmental conditions is very limited since most Commanding Officers put the most experienced officers on watch during challenging situations.

Entry #22

Training Effectiveness Evaluation of the VESUB Technology Demonstration System (U)

1998

Navy

1

Human performance data reported

Generalizable

Use of this technology provided significant performance enhancements over current approaches, and shows merit for inclusion in acquisition programs. However, this is a training system development, not a weapon system. This report provides insights into how weapon system acquisition programs should address training requirements for areas lacking sufficient detail or rigor to adequately addresses operational training requirements. This report did not address cost analysis, implementation or sustainment of the system.

Entry #45

Training Effectivenes Evaluation of the VSUB technology demonstration system

1998

Navy

VSUB

Human performance data reported

Generalizable

Knowledge Gap -- The purpose of the study was to determine the effectiveness of a specific trainer for submarine personnel. The VSUB trainer fills a submarine training gap because training systems existing at the time did not provide detailed harbor and channel ship handling training for the officer of the deck.

Entry #23

VESUB Technology Demonstration: Project Summary

1999

Navy

1

Human performance data reported

Generalizable

Six conclusions and recommendations were provided to support future improvements in VE training system development: 1) VESUB provides effective shiphandling training; 2) team communications is a must in the development of complex systems; 3) legacy-based system development must be closely evaluated; 4) configuration management is essential for success; 5) complex scenes require sufficient fidelity to support training requirements; and 6) VE offers unique presentation capabilities that should be exploited.

Entry #35

Driver Performance Measurement to Support Thermal System Development

1999

Army

0

Human performance data reported

This short report described a human factors engineering study of night vision enhancement for Army vehicle drivers. Two systems, Driver's Vision Enhancer (DVE) and Night Vision Goggles (NVG) were used to detect known drop-offs in the road while driving a HMMWV. The data were not reported. A related study of non responsive pixels found found no significant effect of display variations. Training was never discussed.

Entry #58
Modeling Human Performance: Impacting System Design, Performance, and Cost

2000

Army

Comanche

Human performance data reported

Generalizable

A critical component to be considered in systems acquisition--and the earlier the better--is human performance. In this report, the importance of using human performance modeling in order to impact system design, performance, and cost is addressed. The examples given here are all based on models developed with the capabilities present in IMPRINT (the Improved Performance Research Integration Tool), developed by the Human Research and Engineering Directorate of the U.S. Army Research Laboratory. The broad use of models and simulations is being encouraged in the military at this time, the catch phrase being "simulation-based acquisition" (SBA). The answer to the question "When should human performance modeling be used?" is "Early, and often in order to ascertain the basic system requirements, the precursor to design, and the role of the human." A classic example from the U.S. Army concerns what is now the Comanche helicopter. It was first envisioned as a one-man scout and attack helicopter, but early assessments of expected task performance, mental workload, and reliance on automation proved the basic concept to be unworkable. Today, Comanche is being built as a two man helicopter, a change which would have been impossible to effect later in the acquisition process without a complete and costly re-design. Another example of the application of IMPRINT's task network modeling capability was the modeling of the Land Warrior system and U.S. Army's Crusader system, originally the Advanced Field Artillery System (AFAS). Knowledge Gap input: Example of human performance model applied to several systems, Army and Navy, resulting in design changes with impact on training.

Entry #39
Aircrew and Maintainer Warfighter Performance in Aeronatuical Systems using mission oriented MOES

2001

Air Force

1

Human performance data reported

Generalizable

Knowledge Gap . Measurement Method Study:The purpose of the study was to identify and define methods for incorporating relevant war fighting criteria into manpower, personnel and training. Authors state that R&D program descriptions and impact statements are critical. Research scientists are not clear on what the criteria are or where or how to get measures. The study focused on identifying material on MOEs/MOPs important to AF aircraft -related mission effectiveness.

Entry #28
An Assessment of the Lead Systems Integrator Concept as Applied to the Future Combat Systems Program

2006

Army

Army Future Combat System (FCS)

Human performance data reported

Generalizable

Effort resulted in the detailed specification of the consolidated data base with a description of steps necessary for development and maintenance. The consolodated Human Resource Technologies to encompass maintenance manpower, instructional system development, job guide development, system owenership costs and human resources in design tradeoffs. Report outlines major data storage for all areas identified above.

Entry #31
Longbow Stationary Target Indicator Technical Report

2006

Army

AH-64D, Apache Longbow

Human performance data reported

Generalizable

Effort resulted in the detailed specification of the consolidated data base with a description of steps necessary for development and maintenance. The consolodated Human Resource Technologies to encompass maintenance manpower, instructional system development, job guide development, system owenership costs and human resources in design tradeoffs. Report outlines major data storage for all areas identified above.

Entry #38
Looking Back at 20 Years of MANPRINT on Patriot: Observations and Lessons

2007

Army

Patriot Missile System

Human performance data reported

Generalizable

Training issues constituted the second general lesson emerging from the twenty five year evolution of the Patriot program. System enhancements (new hardware, software,etc. progressively made the system more complex. However, the Increase in training requirments was not matched by corresponding improvements/changes to institutional or unit training.

Entry #56

A Littoral Combat Ship Manpower Analysis using the Fleet Response Training Plan

2007

N

Littoral Combat Ship

Human performance data reported

Generalizable

The training requirements for each sailor assigned to the LCS, according to the Preliminary Design Interim Requirements Document, will use a human-centered design approach to automate decision processes that optimize manpower workload. This approach exploits SMARTSHIP technologies to decrease personnel workload without compromising the design capability to fulfill mission requirements. This is done to the maximum extent practicable in order to provide on-demand individual and team training mission rehearsal capability, both inport and underway. The LCS training infrastructure will incorporate a responsive and flexible training architecture in order to deliver a full range of training products and services wherever and whenever required. The onboard training systems will span the training continuum from warfare capabilities, maintenance, and logistics to professional, military, leadership and personal enrichment training. This approach cultivates the total sailor and supports the tenets of Sea Warrior. Another feature of the training system is its availability to exercise all levels of progressive, basic, intermediate, and advanced training, which includes team, unit, group, joint, and coalition training that culminates in unrestricted operations certification. A mixture of modeling and simulation systems, embedded on-board trainers, web-enabled or PCbased distance learning systems, and netted classroom environments will be installed to facilitate this paradigm shift in manpower and training philosophies. Manpower requirements are based on mission, functions, and tasks and/or required operational capability and the projected operational environment. A ship's workload is determined using industrial engineering techniques to yield those manpower requirements. The Littoral Combat Ship's total manpower requirements have been set at 75 and plans are in motion to train the first Littoral Combat ship core crew prior to stepping onboard. Once the Littoral Combat Ship is commissioned and the core crew of 40 is fully prepared to take the deck, it will enter its first training phase commonly known as the Unit Level Training and Readiness Assessment. This research centered around a 40-member crew conducting its first training certification using completed tasks, fatigue levels, and workload as measures of performance to validate its manpower requirements. Crew certification is mandatory for all new construction ships in which an emphasis is placed on the review of the ship's overall training program, the ability to provide a minimum number of qualified crewmembers to support all underway requirements, and whether all training objectives are being satisfied. After the crew certification period, core crews will experience an evaluation within the initial phase of training called the Fleet Response Training Plan (FRTP). This assessment is called the Unit Level Training and Readiness Assessment (ULTRA). The current challenge is whether a core crew of 40 can effectively complete an extensive 14-day training assessment within acceptable fatigue levels.

Entry #44

Development and Evaluation of a virtual terrain table for night vision goggle training

2008

Air Force

1

Human performance data reported

Generalizable

TEE Study; Knowledge Gap . The purpose of the study was to evaluate the effectiveness of a virtual terrain board (NVG training typically uses a physical terrain board) to teach NVG capabilities and limitations. Study focused on the feasiblitiy of replacing the physical board with a virtual simulation of same.

Entry #1

Recognition of Combatants-Improvised Explosive Devices (ROC-IED) Training Effectiveness Evaluation

2009

Army

JIEDDO sponsor

Human performance data reported

Generalizable

This evaluation assessed the effectiveness of the Recognition of Combatants-Improvised Explosive Devices (ROC-IED) computer-based training program as a stand-alone training aid and as a training aid that can supplement the training given by the unit's trainer. The evaluation employed military test subjects and used three experimental conditions measuring two levels of learning outcomes. The results indicated the knowledge level of Counter IED can be taught through computer based training.

Entry #27

Understanding Demonstration-based Training: A Definition, Conceptual Framework, and Some Initial Guidelines

2009

Army

1

Human performance data reported

Generalizable

This report explains a multi-level framework for designing training that offers, based on empirical data and sound theory, a systematic and more affordable approach to developing the full range of training strategies within an acquisition program.

Entry #59

Summary Technical Report Development of Reaper Mission Essential Competencies

2009

Air Force

Reaper UAV

Human performance data reported

Generalizable

This document summarizes the process used to create Mission Essential Competencies (MECs SM) for Reaper. It presents the final MECs and supporting competencies identified during the MEC process, as well as the associated Reaper knowledge and skills, learning environments, mission types, and experiences. MECs are higher-order individual, team, and inter-team competencies that a fully prepared pilot, operator, crew or flight requires for successful mission completion under adverse conditions in a non-permissive environment. Training programs for combat aviators have historically focused on in-flight training, not always being able to replicate the dynamic environment encountered during wartime operations. The inability to reliably and safely train in a highly realistic combat environment results in an adaptation period for aircrews during the initial stages of a conflict. This adaptation period represents a gap between what could be realistically trained and what is expected in the combat arena. Training using Distributed Mission Operations simulations overcomes this shortcoming. The Air Force, ACC has a methodology that focuses on mission execution in a non-permissive environment, centering on identifying the competencies (or MECs) required for mission completion during combat, as well as the knowledge and skills, supporting competencies, and experiences required for MEC proficiency.

Entry #60

BW

Summary Technical Report Development of Global Hawk Mission Essential Competencies

2009

Air Force

Global Hawk UAV

Human performance data reported

Generalizable

This document summarizes the process used to create Mission Essential Competencies (MECs SM) for Global Hawk. It presents the final MECs and supporting competencies identified during the MEC process, as well as the associated Global Hawk knowledge and skills, learning environments, mission types, and experiences. MECs are higher-order individual, team, and inter-team competencies that a fully prepared pilot, operator, crew or flight requires for successful mission completion under adverse conditions in a non-permissive environment. Training programs for combat aviators have historically focused on in-flight training, not always being able to replicate the dynamic environment encountered during wartime operations. The inability to reliably and safely train in a highly realistic combat environment results in an adaptation period for aircrews during the initial stages of a conflict. This adaptation period represents a gap between what could be realistically trained and what is expected in the combat arena. Training using Distributed Mission Operations simulations overcomes this shortcoming. The Air Force, ACC has a methodology that focuses on mission execution in a non-permissive environment, centering on identifying the competencies (or MECs) required for mission completion during combat, as well as the knowledge and skills, supporting competencies, and experiences required for MEC proficiency. Six MECs are identified for the Global Hawk: Plan and Prepare for Mission, Conduct Aircraft Launch/ Recovery Sequence, Conduct Aircraft Handoff/ Change-over, Collect Targets, Conduct Post Mission Review, Manage Crew Workload.

Entry #61

Summary Technical Report Development of Predator Mission Essential Competencies

2009

Air Force

Predator UAV

Human performance data reported

Generalizable

This document summarizes the process used to create Mission Essential Competencies (MECs SM) for Predator. It presents the final MECs and supporting competencies identified during the MEC process, as well as the associated Predator knowledge and skills, learning environments, mission types, and experiences. MECs are higher-order individual, team, and inter-team competencies that a fully prepared pilot, operator, crew or flight requires for successful mission completion under adverse conditions in a non-permissive environment. Training programs for combat aviators have historically focused on in-flight training, not always being able to replicate the dynamic environment encountered during wartime operations. The inability to reliably and safely train in a highly realistic combat environment results in an adaptation period for aircrews during the initial stages of a conflict. This adaptation period represents a gap between what could be realistically trained and what is expected in the combat arena. Training using Distributed Mission Operations simulations overcomes this shortcoming. The Air Force, ACC has a methodology that focuses on mission execution in a non-permissive environment, centering on identifying the competencies (or MECs) required for mission completion during combat, as well as the knowledge and skills, supporting competencies, and experiences required for MEC proficiency. Six MECs are identified for the Predator: Plan and Prepare for Mission, Conduct Aircraft Handoffs, Prepare for Mission Execution, Collect Targets, Employ Air-Ground Weapons, Conduct Post Mission Review, Manage Crew Workload, Conduct MAC Operations, Launch and Recovery.

Entry #8
Cyber Operations Virtual Environments
2010
Air Force
1
Human performance data reported

Generalizable

The report presented a review of applicable Science and Technology issues for the design of instruction related to preparing airmen to defend against and respond to cyber threats to their networks. The report provided a notional framework for a testbed offering multiple opportunities for future expansion to other platforms and a rich environment in which to explore the effects of cyber attacks. The report provides an awareness for the design of future training systems. Related to NetCentric functional capability.

Entry #24
KC-135 Simulator Systems Engineering Case Study
2010
Air Force
KC-135 Aircrew Training System (ATS)
Human performance data reported

Generalizable

Report states that simulators can provide more indepth training than can be accomplished in airplanes and provide a very high transfer of learning and behavior from the simulator to the airplane. The use of simulators has resulted in safer flight training and cost reductions for the operators as well as improvided fuel conservation and reduction in adverse environmental effects. The KC-135 training systems is managed and funded as a separate but related acquisition program. Major modifications, particularly to the Operational Flight Trainer (OFT), have been successfully planned for, budgeted, and implemented over the past 17 years. There are several reasons on why this teaming relationship has succeeded. Typically with acquisition programs the program manager or chief engineer charged with the development program would chair major reviews (like the KC-135 ATS System Review Board [SRB]) with the using command (in this case AMC) providing a briefing of their issues and concerns at the SRB. However, the arrangement that has evolved for KC-135 ATS, which has proven to be very effective, is that the AMC manager co-chairs the SRB forum. AMC, the ATS Program Office, and the prime contractor(s) draw on support as needed to ensure proper staffing is available for program execution. Another reason for the team's success is their ability to be flexible and react quickly to customer needs. The team also utilizes a requirement verification and prioritization review board (called the SPRR System Priority Requirements Review) that, in addition to upgrades driven by weapon system changes, addresses sustainment related hardware and software deficiencies/upgrades required to improve flight simulator fidelity. Prioritization reviews include representatives from the KC-135 Program Office, Ogden, Contractors (aircraft and simulator), and user. Part of the reason for the effectiveness of the KC-135 ATS upgrade program is the simulator team has, over a period of 17 years, evolved into a very effective organization. One of the challenges facing the Government in 2010, when the current contract is recompeted, will be to foster the advantages associated with long-term support contracts (i.e., workforce continuity, knowledgeable support personnel, program stability, sense of ownership, incentives for process improvements, incentive for long-range planning) while meeting the government's requirements for increased competition and shorter term contracts.

Entry #25
Systems Engineering Applied Leading Indicators
2010
Navy
0
Human performance data reported

Generalizable

Offered a systems engineering methodology for development of leading indicators for more effective program decisions based on more than just cost and schedule. But, did not address human performance or training metrics. The report also cited the challenges with consistent availability of program data for this methodology. Lastly, the report suggested maturation to address total ownership cost control.

Entry #34
Key Human System Integration Plan Elements for Command & Control Acquisition
2010
Navy
1
Human performance data reported

Generalizable

This paper from SPAWAR describes how HSI contributes to the Acquisition of Command & Control systems. Emphasis is given to Human Factors Engineering issues and HSI processes and reports. Training is listed as a domain of HSI and the need for a Total Systeme Training Architecture (TSTA) is noted along with a Navy Training System Plan (NTSP).

GAO CONSEQUENTIAL ABSTRACTS

Entry #501
Achieving B-2A Bomber Operational Requirements

1997

Air Force

B-2

NSIAD-99-97

The report states that poor low observable reliability and lengthy maintenance times reduce mission capable rates, adversely affect aircraft availability for crew **training**, restrict operations when deployed, and limit sustained combat operations**.**

Entry #502
Evaluation of Navy's Anti-Submarine Warfare Assessment

1999

Navy

ASW

NSIAD-99-85

The assessment concluded that the ASW program of record as contained in the proposed President's fiscal year 1999 budget was adequate to meet the likely future threat and identified the following near-, mid-, and long-term ASW mission requirements.   Near term requirements: Improve ASW crew proficiency by increasing **training.**

Entry #503
Missile Risk Reduction Underway But System Production Plans Need to be Reexamined

1998

Joint

AIM-9X, Sidewinder

NSIAD-98-45

In commenting on a draft of this report, DOD stated that the projected range and sensor tracking capability of AIM-9X without the helmet-mounted cueing system is equivalent to the capability of the AA-11 threat missile in azimuth and exceeds the capability of the AA-11 in range. DOD's position is based on using the fighter aircraft radar to cue the AIM-9X missile to the target of interest when it is beyond the view of the aircraft's heads-up display. Using the radar to cue the missile, however, will take more time and be less certain than with the helmet and will require DOD to **train** pilots in yet to be developed procedures and tactics that would be considerably different than current practices for aerial combat.

Entry #504
Advanced Concept Technology Demonstration
1998
Air Force
Predator
NSIAD-99-4

In the early operational assessment of the Predator's ACTD demonstration, the Director, Operational Test and Evaluation, did not make a determination of the system's potential operational effectiveness or suitability. However, the system was found to be deficient in several areas, including mission reliability, documentation, and pilot **training**. The assessment also noted that the ACTD demonstration was not designed to evaluate several other areas such as system survivability, supportability, target location accuracy, **training**, and staffing requirements.

Entry #505
Acquisition Plans for Training Aircraft Should Be Reevaluated
1997
General

NSIAD-97-172

DOD is proceeding with plans to procure a fleet of JPATS aircraft that may exceed the quantity needed to meet **training** requirements. Until inconsistencies in the data used to calculate JPATS requirements are resolved, it is unclear how many aircraft should be procured. Furthermore, DOD's schedule for procuring the aircraft does not take advantage of the most economical approach that would allow it to save money and permit more time for operational testing.

Entry #506
Acquisition Cost Estimates
1993
Air Force
B-2

The estimated support costs, which included those of data, **training**, peculiar support equipment, and software support, were not based on a comprehensive analysis by the Air Force. Justification provided by the Air Force for the costs was incomplete, based on other weapon systems, or preliminary in nature. B-2 program officials stated that the cost estimate for support of the B-2 is not firm because the overall support concept for the 20 aircraft program has not yet been decided. They stated that a more accurate estimate of support cost will be available when the 1994 President's budget is announced.   The peculiar support cost element includes $1.266 billion associated with the support of the production aircraft and simulators, procurement of technical data, and procurement of items for maintenance **training** equipment.

Entry #507
Selected Aspects of the Army's Forward Area Air Defense System
1990

Army

FAADS

NSIAD-90-191

The DIVAD program, however, was terminated by the Secretary of Defense in August 1985 because it could not handle the stand-off attack helicopter threat. Army analysis and **training** had revealed that the projected air threat could strike ground forces from distances beyond the range of current frontline missile systems and the DIVAD.

Entry #508

Acquisition Issues Facing the Army Battle Command, Brigade and Below Program

1998

Army

FBCB2

NSIAD-98-140

The oversight effort was conducted in partnership with the Army's Operational Test and Evaluation Command, in recognition of the unique nature of the experiment (as distinct from an operational test). The Director's report also identified a lack of (1) adequate digital connectivity; (2) maturity of the Applique and the Tactical Internet; (3) adequate tactics, techniques, and procedures for operations with digital equipment; and (4) tactical skills resulting from inadequate unit collective **training**.

Entry #509

Progress of the F-22 and F/A-18E/F Engineering and Manufacturing Development Programs

1999

Air Force

F-22

T-NSIAD-99-113

Our review showed that the Navy's statements about the performance of the E/F reflect the performance of the Emodel aircraft, not the less capable F model. Also, the statements reflect the projected aircraft performance, not the actual performance being demonstrated in flight tests. Specifically, the Navy.s performance values include anticipated, but not yet demonstrated, range improvements. If these values are not included in the performance estimates, the F model aircraft will be 33 nautical miles short of meeting its interdiction range requirement. This is significant because (1) the F model, which was originally planned to be used as a **trainer** aircraft and therefore made up only about 20 percent of the total buy, now comprises about 56 percent of the total buy and (2) increased range over the current C/D aircraft was critical to justifying the decision to buy the F/A-18E/F.

Entry #510

Progress Made, but Significant Challenges Remain

1998

Joint

JCCS

NSIAD/AIMD-98-257

DOD has experienced a mixture of successes and problems in implementing Global Command and Control System. For example, users like some of the additional features it provides compared to the old system and found them productive. These features include mission-related communications by e-mail, internet-like web pages, and on-line discussion groups. Users also like the idea of being provided situational awareness of the battlefield. However, some key capabilities, such as the system's operational planning function and the situational awareness function, have experienced problems and are performing less effectively than expected. Also, operator **training** is deficient, data exchange procedures with coalition partner have not been defined, and the system is at risk of failure because year 2000 problems have not been fully resolved.

Entry #511
Successful Application to Weapon Acquisitions Requires Changes in DOD's Environment
1998

Army

Javelin

NSIAD-98-56

The Javelin is designed to significantly improve the Army's antitank capability. This capability is limited by the weather, the gunner's distance from the target, and the gunner's **training**. However, there are some questions as to whether **training** will be adequate to prepare the soldier to (1) acquire valid targets and (2) identify friend from foe without additional equipment, which is not yet developed. We discussed the Javelin's ability to identify friend from foe with officials from the Office of the Deputy Chief of Staff for Operations and Plans, Washington D.C.; and the Javelin Project Office. We also discussed the **training** aspects of this issue and reviewed documents from the U.S. Army Infantry School, Fort Benning, Georgia; Center for Night Vision and Electra-Optics, Fort Belvoir, Virginia; and the Javelin Project Office. Training officials at the U.S. Army Infantry School consider the currently planned Javelin gunner **training** inadequate in the areas of recognition and identification. In their opinion, the **training** will not adequately teach gunners to use the Javelin's infrared optics to recognize tanks from wheeled vehicles or identify friendly tanks from enemy tanks. A Javelin logistics official said the Javelin **training** will teach gunners to use the system--that is, turn it on, lock-on to targets, and fire the missile. In addition, an Army Infantry School official said gunners will be taught general thermal recognition and identification. However, both said the gunners will not be taught to recognize or identify thermal images as seen through the Javelin optics. According to an Army research psychologist, the current **training** software will not teach gunners to recognize (1) moving targets, (2) targets with approximately the same temperature as that of their background, or (3) targets whose image is degraded by electronic noise --as the Javelin's images frequently are.

Entry #512
Javelin Is Not Ready for Multiyear Procurement
1999

Army

Javelin

NSIAD-96-199

Javelin's Chief of Logistics said the Army cannot afford to maintain both the low-rate production and redesigned launch unit configurations. He said that if soldiers were given different launch units, the Army would have to maintain inventory and **train** personnel to repair both configurations. In addition, the Army would have to develop and produce test equipment for the low-rate production configuration because it will not have built-in-test equipment to diagnose system failures.

Entry #513

Accelerated Joint STARS Ground Station *Acquisition* Strategy Is Risky

1996

Army

JSTARS

NSIAD-96-71

In some instances, problems were attributed to shortfalls in operator **training** or another non-materiel cause. The majority of deficiencies involved software fixes, not major hardware redesign. The Army has also gained experience operating the GSMs assigned to the III Corps and XVIII Airborne Corps and in **training** and preparation for multi-service OT&E. In November 1995, the Program Executive Officer for Joint STARS certified the system ready for OT&E, which attests to the developer's confidence in system maturity.

Entry #514

Concerns With Milstar's Support to Strategic and Tactical Forces

1998

Army

MILSTAR

NSIAD-99-2

This upgrade effort, while compatible with the Army's terminal testing schedule, will require the Army to reconfigure its equipment and software and **retrain** its forces when the automated communications management system becomes available at a future date. Military Strategic and Tactical Relay (AF manages).

Entry #515

Evaluation of the Navy's 1999 Naval Surface Fire Support Assessment

1999

Navy

Navy Surface Fire Support

NSIAD-99-225

The estimated cost cited for reactivating the U.S.S. Wisconsin was $209.4 million and for the U.S.S. Iowa, was $221.3 million, including repair of the damaged turret. To accomplish the reactivation, the Navy estimated 14 months for industrial support and 3 to 6 months for modernization and **training** on and certification of newly installed equipment.

Entry #516

Navy's Aviation Logistics System Not Ready for Deployment

1990

Navy

Aviation Logistics

IMTEC-90-11

Additionally, the program manager told us that existing documentation will be augmented by word-of-mouth and on-the-job **training**. In our opinion, this approach is not adequate for a system as large and important as NALCOMIS. Although system maintenance may be possible without a manual, it will undoubtedly be more difficult and costly than necessary.

Entry #517
A Rare Opportunity for Lasting Change
1992
General

NSIAD-93-15

The desire of program sponsors to keep cost estimates as low as possible and to present attractive milestone schedules has encouraged the use of unreasonable assumptions about the pace and magnitude of the technical effort, material costs, production rates, savings from competition, and other factors. In some cases, acquisition cost estimates have been kept low by excluding relevant program costs-such as the cost of **training** equipment-which should be included in program cost estimates.   Successful performance of missions, assuming well trained operators and reliable equipment, requires a weapon system that is operationally effective. "Effectiveness" generally refers to the ability of a weapon to successfully engage the enemy. For a majority of weapons, that means the ability to reach the target area, find targets, and destroy or disable them with munitions such as missiles or torpedoes.   In a 1983 classified report on the Army's Patriot air defense system, we reported that the diagnostic software used with the system's built-in test equipment had successfully identified faulty components only 50 to 60 percent of the time. To address these problems, the Army upgraded the software, added another level of maintenance, and increased maintenance training. Initial investment costs for these changes was about $94 million.

Entry #518
Status of Selected Programs
1990
General

NSIAD-90-159

The initial operational evaluation tests were conducted from November 1988 to September 1989. The tests included (1) captive flight tests to armor targets, (2) a force development test and experiments to investigate tactics, **training**, and crew performance, and (3) actual missile firings to demonstrate capability against helicopters and armored vehicles.

Entry #519
The Special Operations Forces Aircrew Training System at One Year
1992
Air Force

NSIAD-92-52

There has been a 2-month schedule slippage because problems in preliminary software design, development of in-class **training** curricula and materials, and cockpit configuration changes require more work than anticipated. The prime contractor is working with the subcontractors to develop and implement a new schedule for some tasks to meet all major milestones.

Entry #520
Commercial Components Used Extensively in Tactical Trucks
1994
Army

NSIAD-94-240

The Army requires that its vehicles be fielded with detailed technical manuals and other documentation covering the operation and maintenance of the vehicle. The Army requires specialized manuals because (1) Army drivers and mechanics generally are not as well **trained** as commercial drivers and mechanics.

Entry #521
Defense Weapons Systems Acquisition
1997
General

HR-93-7

The desire of program sponsors to keep cost estimates as low as possible and to present attractive milestone schedules has encouraged the use of unreasonable assumptions about the pace and magnitude of the technical effort, material costs, production rates, savings from competition, and other factors. In some cases, acquisition cost estimates have been kept low by excluding relevant program costs-such as the cost of **training** equipment-which should be included in program cost estimates.

Entry #522
Issues Concerning Acquisition of THAAD Prototype System
1996
Army
THAAD
NSIAD-96-136

The remaining 30 UOES interceptors were to be used in operational suitability tests that did not involve firing interceptors. However, the purposes of those tests can be accomplished with **training** rounds or with the backup demonstration and validation phase interceptors.   The Army also plans to conduct a 7-week limited user test after completing the 14 demonstration and validation flight tests. The limited user test will build on the results of the demonstration and validation flight tests and focus on operational effectiveness and suitability issues, including mission performance and system supportability. The primary events to be conducted during the limited user test will be field training exercises, command post exercises, modeling and simulations, and a flight test using an interceptor already under contract. Results from the limited user test are not scheduled to be available until early 1998.

Entry #523

THAAD Restructure Addresses Problems But Limits Early Capability

1999

Army

THAAD

NSIAD-99-142

To identify underlying reasons for the program's difficulties, we reviewed pertinent government and contractor documentation, including contract files, audit reports, schedules, briefings, cost reports, integrated product team minutes, and contractor resolution plans and **training** plans. We also reviewed independent studies and discussed the studies' findings with knowledgeable officials. We compared the results of our review to the findings of the independent studies.

Entry #524

Comprehensive Strategy Needed to Improve Ship Cruise Missile Defense

2000

Navy

GAO/NSIAD-00-149

Impediments to Availability: SLQ-32 Electronic Warfare System V2 0.72 0.70 0.69 High cost of parts, lack of funding for parts and upgrades, parts failure, lack of technician experience, and **training**; SPS-48E Radar System 0.73 0.81 0.77 Inadequate **training** of shipboard technicians, lack of technical schematics

Entry #525

Actions Needed to Enhance Success of Reengineering Initiatives

2000

Joint

GAO/NSIAD-00-89

Logistics support personnel from the Joint Chiefs of Staff and combat commands in the United States and Europe voiced a number of concerns about the potential effects that some reengineering efforts could have on their operational capability. These concerns involved the presence of increasing numbers of contractor personnel on or near the battlefield, the ability of contractors to meet "surge requirements", the potential reduction of rotational positions to meet **training** requirements

Entry #526

Chemical and Biological Defense: Units Better Equipped, but Training and Readiness Reporting Problems Remain

2000

Joint

GAO-01-27

Many units were inadequately trained in basic tasks critical to surviving and operating in a chemical or biological environment.   Our current and prior work as well as the work of DOD's Office of the Inspector General found that commanders were not integrating chemical and biological defense into unit exercises and the **training** was not always realistic in terms of how units would operate in war. For example, we were told by Marine Corps officers responsible for chemical and biological defense training at the unit we reviewed that commanders are not fully integrating chemical and biological defense into unit exercises, as required by Marine Corps policies, because operating in protective equipment is difficult and time consuming   In September 1999, we reported that the Army's combat **training** centers were restricting the simulated use of chemical weapons against the units being trained because units were arriving at the centers with lower levels of proficiency in chemical and biological defense than in the past Officials at the units we reviewed stated that chemical and biological defense **training** is being adversely impacted by (1) a shortage of chemical and biological defense specialists and (2) specialists being assigned multiple responsibilities unrelated to their specialties

Entry #527
Actions to Improve Navy SPAWAR Low-Rate Initial Production Decisions

Navy

Info Tech

GAO-01-735

A suitability problem involves a system not satisfactorily meeting one or more requirements, including reliability, maintainability, logistics support, or **training.** These problems may delay progress in achieving the Navy's vision for using information technology to attain and maintain network-centric warfighting knowledge and decision-making superiority.   The Pacific Fleet experienced 46 problems with the NavyExtremely High Frequency Satellite Communications System from 1995 to 2000. The problems involved hardware and software, interoperability, and **training.**   The Pacific Fleet also experienced problems with the High Frequency Radio Group, mainly due to system performance problems and **training** shortfalls. For example, on a ship visit in October 2000, ship communications personnel said that the system had broken down several times for a duration of 1 week to 1 month at a time. They said that, when it breaks down, the operators must tune in the radio frequency manually, but ship operators have not been **trained** to do this because they were used to relying on the system to tune into a particular frequency automatically.

Entry #528
Presentation To The V-22 Blue Ribbon Panel

2001

Navy

V-22

GAO-01-369R

Quote from JAG report: "Aircraft performance envelopes are developed, and procedures and guidance published (NATOPS) to prevent pilots from putting an aircraft in a situation that would exceed safe parameters. The MV-22 performance envelope may be one that fleet pilots can operate within, but given the rigors of combat, real world operations, and realistic **training** for both, the consequences of exceeding this particular envelope appears to be excessively grave (departure from controlled flight with no warning)."

Entry #529
TACTICAL AIRCRAFT Modernization Plans Will Not Reduce Average Age of Aircraft

2001

Joint

All tactical aircraft

GAO-01-163

DOD has stated that as aircraft age, they tend to break more often, take longer to inspect and maintain, and are less available for operations and **training.**

Entry #530
Assessments of Major Weapon Programs

2003

Joint

JPATS PAC-3

JPATS: They also reported that the full JPATS had not yet been tested due to uncorrected deficiencies in the aircraft and the immaturity of the software-intensive **training** information management system (p. 48).   PAC-3: However, the contractor must increase production earlier than planned because DOD decided to accelerate deliveries. This decision may present new production challenges because the contractor must find and **train** additional personnel. (p. 55)

Entry #531
DOD Needs to Better Manage Automatic Test Equipment Modernization

2003

Joint

Consolidated Automated Support System

GAO-03-451

Counterexample: The Navy reports that the replacement of these testers with CASS (Consolidated Automated Support System) stations, when complete, will reduce the number of test-related enlisted occupational specialties from 32 to 4, thus reducing **training** requirements.

Entry #532
TACTICAL AIRCRAFT Status of the F/A-22 and Joint Strike Fighter Programs

2004

Joint

 F/A-22 and Joint Strike Fighter

If the Air Force fails to improve the F/A-22's reliability before fielding the aircraft, the high failure rates will result in higher operational and support costs to keep the aircraft available for **training** or combat use

Entry #533

MILITARY AIRCRAFT DOD Needs to Determine Its Aerial Refueling Aircraft Requirements

2004

Air Force

KC-135

GAO-04-349

At times, Air Force refueling aircraft have not been available to support Navy **training** due to the lower priority placed on Navy training by the Air Force, and sometimes training plans changed on relatively short-notice

Entry #534

DEFENSE ACQUISITIONS Assessments of Selected Weapon Programs

2011

Joint

GAO-11-233SP

The Air Force's C-130 AMP will standardize the cockpit and avionics for three combat configurations of the C-130 fleet.   In February 2010 the program reported a Nunn-McCurdy unit cost breach of the significant cost growth threshold, which it attributed to factors such as the omission of **training** devices and adequate spares from initial estimates, and delays in the production decision. The program has been restructured and planned dates for key events have been pushed back by more than 1 year. (p. 51)   WIN-T is the Army's high-speed and high-capacity backbone communications network.   The test results showed that WIN-T Increment 2 did not meet its operational reliability requirements. DOD's Director, Operational Test and Evaluation, recommended that the Army improve performance and **training** to address these deficiencies and ensure success during initial operational test, which is scheduled for early fiscal year 2012. (p. 127)

Entry #535

Realizing Savings under Different Littoral Combat Ship Acquisition Strategies Depends on Successful Management of Risks

2010

Navy

LCS

GAO-11-277T

Navy officials expressed confidence that their cost estimate supporting the dual award provides details on the costs to operate and support both designs. However, since little actual LCS operating and support data are available to date, the Navy's estimates for these costs are currently based on data from other ships and could change as actual cost data become more available. These estimates are also based on new operational concepts for personnel, **training**, and maintenance that have not been fully developed, tested, and implemented. For example, the Navy has not yet implemented a comprehensive training plan, and it is possible that the plan could cost more or less than the **training** costs currently accounted for by the Navy. (p. 7)

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