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EVOLUTION OF MAINTENANCE TRAINING

FOR THE

PHALANX MARK 15 CLOSE-IN WEAPONS SYSTEM

Submitted by:

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ABSTRACT

In any organization effective training results when training is properly developed and managed. In many organizations training development is performed through the application of some variant of Instructional Systems Development (ISD) or Systems Approach to Training (SAT) model that contains the following phases: Analysis, Design, Development, Implementation and Evaluation (ADDIE). Training management involves the functions needed to control, plan, manage, and support training. Regardless of the model version, the steps or processes which comprise each ISD/SAT Phase have become quite diverse. In many organizations, training analysts, curriculum developers, and training managers do not have sufficient procedural guidance with which to design, develop and manage training. As a result, training analyses and curricula development activities vary widely in terms of methods and models used to develop training programs. This divergence impacts training effectiveness and in many cases becomes cost prohibitive.

This paper is divided into three segments 1) the Instructional Design Analysis, and 2) the Decision Making Process, and 3) the Financial Analysis. The first segment will briefly describe the activities in the various phases of the ISD Model that the U.S. Navy undertakes in the design of various technical training programs. The second segment will discuss how training system alternatives are created, trade-offs are examined and final decisions are made. The third segment will emphasize the various training program costs that are typically investigated with analysis and cost data over the projected life of the program, utilizing the US Navy PHALANX Mark 15 Close-In Weapons System as an evaluation model.

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INTRODUCTION:

In any organization, whether it is a corporate business, a public agency, or a military entity, effective individual or team performance is paramount in order to be successful. Many of today's organizations are employing the concept of "lean" derived from Total Quality Management. The incorporation of lean into an organization's processes involves numerous things. It is beyond the scope of this paper to detail these various ingredients; however all of the lean concepts involve some type of training. It is important to provide the right type and amount of training at the right time for the concepts of lean to become effective. Numerous organizational development specialists would acknowledge that the desired training results only occur when training is properly developed and managed. Many training developers try to employ an anthropological perspective (Knowles, 1978, 1984) in designing and delivering training in their organizations. Being able to do this in an efficient and cost effective manner is not easy. In many organizations this is performed through the application of the Instructional Systems Development (ISD) model or some derivative of that model. However, from a business perspective, training involves more than just the delivery of the training. It involves the managerial functions needed to control, plan, manage, and support training. Unfortunately, many instructional designers do not have the business background to be able to accurately estimate curriculum design and development costs. Nor do they have the ability to be able to explain how they derived estimates on return on investment (ROI) costs to upper level managers (Seagraves, 2004). Although this paper provides a basic description of the ISD methodology and some examples of how the ISD processes are used in military organizations, its primary purpose is to describe a process for estimating the costs related to developing, delivering and maintaining the training over a period of time. It also describes how the training analyst can determine a ROI for the training and effectively

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communicate these costs to management. This principle is extremely relevant in today's society because as organizations continue to downsize to save costs they are constantly examining ways to cut costs – and training often is one of the first targets.

BACKGROUND:

During the height of the Cold War, the Soviet Union embarked upon a strategic program that would counter the vast NATO shipyard production capabilities and the size and depth of the alliance fleet by engaging surface combatant vessels with Anti-Ship Missiles (ASM) – fired from air, land and sea platforms. The first viable system under this economy of force proliferation was the SSN-2 "Styx" missile which entered service in 1965. The Styx was approximately 6 meters in length and .75 meters in diameter. It possessed inertial guidance and active radar homing with a maximum speed of 1100 km/h packing a 500 kg high-explosive warhead in the mix. Deployed by the Soviets to their navy and those of their allies, the Styx had no effective countermeasure other than the dispersion of chaff to confuse the target acquisition radar. (Scoles, 2005)

Case Study 1:

Just before sunset, on 21 October 1967, the Israeli destroyer *Eliat* was struck by three SSN-2 Styx missiles causing it to sink in the waters of the Mediterranean Sea. What was most disconcerting to Western Naval Intelligence was the fact that the missile platform was a small Egyptian fast attack craft that did not even leave the security of the Alexandria harbor. The success of the attack marked the escalation of the ASM and counter-threat buildup.

A little over four years later, in December 1971, the Pakistani navy, having returned to port after a series of lengthy antisubmarine warfare exercises were deliberately attacked by a surprise

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salvo of four anti-ship missiles, fired by an engagement fleet sent by India. The attackers consisted of one small fast PT-15 missile boat, escorted by two larger frigates who were poised to conduct covering fire. This was the beginning of Operation Trident, a three pronged naval attack on Karachi Harbor. The missiles were initially fired on four contacts – three ships and one coastal installation - sited from a distance of twelve miles. One of the targeted ships, the oilier *PNS Dacca* was moored just outside Karachi harbor due to the recent tidal shifts coupled with its' deep draft. Just after midnight, a sailor posted on watch saw the bright orange objects approaching from the Southern horizon. Assuming it was an air attack, he observed their trails for several minutes until the realization hit that these were ASM missiles launched in the general direction of his vessel and those surrounding Manora anchorage. Alerting the sleeping crew, one sailor promptly assumed his duty station at his gun battery, and upon observing the missile change course, began firing at the incoming missile. He continued to fire up until the point of detonation, when one the gun battery rounds hit the missile causing it to detonate prematurely. The resulting fire and concussion killed the sailor and set the ship ablaze, but the remaining crewmen fought the flames and saved the ship. Upon closer examination, the continuous wall of fire began the genesis of what would later become the PHALANX gun system.

This series of events occurring in different parts of the world often triggers what is known as a mission requirements analysis effort. Government officials reexamine new and emerging threats and reassess the mission requirements of a particular weapons system in order to see if they are current with the developing threats in the world. This is the initial starting point for entering into the Instructional Systems Development process.

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INSTRUCTIONAL SYSTEM DESIGN PROCESS

When undertaking training development the United States military use the basic Instructional System Design (ISD) Process which consists of five phases – analysis, design, development, implementation, and evaluation. Within the US, guidance in using the different phases is provided in MIL-HDBK 29612-2A.

Figure 1 illustrates how the ISD process has been used for the development of a major US Navy training program. The specific example that is illustrated is the PHALANX Mark 15 Close-In Weapons System and its maintenance trainer, the 11G2. In order to appreciate the importance and complexities of the economic cost analysis (that is typically done during the design phase) it is important to be aware of the key

activities that occur in each of the ISD phases. An in depth discussion of the intricacies

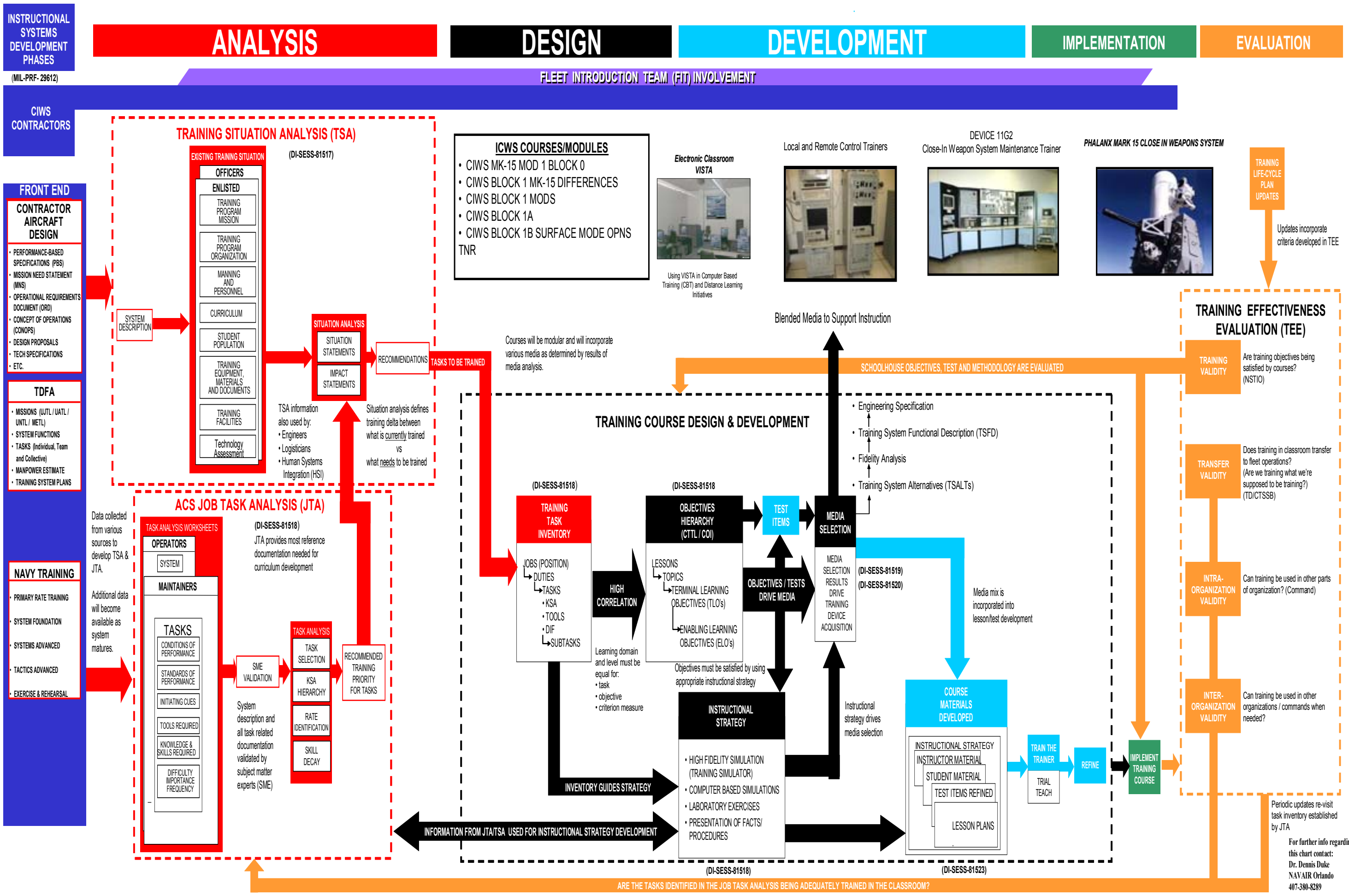
INSTRUCTIONAL SYSTEMS DEVELOPMENT PHASES
(MIL-PRF- 29612)
ANALYSIS
DESIGN
DEVELOPMENT
IMPLEMENTATION
EVALUATION
FLEET INTRODUCTION TEAM (FIT) INVOLVEMENT
CIWS CONTRACTORS
FRONT END
CONTRACTOR AIRCRAFT DESIGN
TDFA
NAVY TRAINING
TRAINING SITUATION ANALYSIS (TSA)
ACS JOB TASK ANALYSIS (JTA)
ICWS COURSES/MODULES
CIWS MK-15 MOD 1 BLOCK 0
CIWS BLOCK 1 MK-15 DIFFERENCES
CIWS BLOCK 1 MODS
CIWS BLOCK 1A
CIWS BLOCK 1B SURFACE MODE OPNS
TNR
Local and Remote Control Trainers
DEVICE 11G2
Close-In Weapon System Maintenance Trainer
PHALANX MARK 15 CLOSE IN WEAPONS SYSTEM
Blended Media to Support Instruction
TRAINING COURSE DESIGN & DEVELOPMENT
TRAINING EFFECTIVENESS EVALUATION (TEE)
SCHOOLHOUSE OBJECTIVES, TEST AND METHODOLOGY ARE EVALUATED
INFORMATION FROM JTA/TSA USED FOR INSTRUCTIONAL STRATEGY DEVELOPMENT
ARE THE TASKS IDENTIFIED IN THE JOB TASK ANALYSIS BEING ADEQUATELY TRAINED IN THE CLASSROOM?
INSTRUCTIONAL STRATEGY
COURSE MATERIALS DEVELOPED
MEDIA SELECTION
For further info regarding this chart contact:
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Figure 1

of the ISD model is beyond the scope of this paper, however, the interested reader may refer to various references that describe the model (Dick & Carey, 1996, Romiszowski, 1990).

In order to appreciate the variables involved in the costing, it is also necessary to be familiar with some of the activities that usually take place prior to the actual start of the ISD model. One of the major activities involves undertaking a Top Down Function Analysis (TDFA) on the weapon system. The TDFA is a process that serves to identify and document four basic elements of the weapons system. These elements are: 1.) the mission requirements of the weapons system, 2.) the various functions that the weapons systems must perform in order to satisfy the mission requirements; 3.) the systems and associated equipment needed to perform these functions; and 4.) the tasks (hardware, software, and human) involved with successfully operating the different equipment. In the TDFA phase of a new acquisition, many of the tasks are usually notional since the weapons system has yet to be developed. In the update of a weapon system (such as with the cases of the CIWS discussed in this paper) the mission requirements are reassessed in terms of any emerging threats that have been discovered. The TDFA can be used in several areas such as systems engineering, logistics, test and evaluation, etc. From a training perspective, the TDFA actually provides an audit trail that illustrates how the tasks (or objectives) that are trained are tied to the actual missions of the weapons system. These tasks initially identified in the TDFA provide a baseline that aligns the missions with the tasks that will be performed by humans on the weapon system.

Phase I - Analysis

The initial phase of the ISD Model is called the Analysis Phase. This phase is usually combined (or uses) the mission requirement information provided by the Top Down Function Analysis (Duke, 2006). In this phase the instructional analyst must critically examine the tasks currently performed by the operator and/or maintainer are adequate to counter the demands posited by the new or emerging threat.

There are two major activities that occur in the Analysis Phase – the Job Task Analysis (JTA) and the Training Situation Analysis (TSA). These activities help to refine the task list developed in the TDFA. They appear in the red color in Figure 1. In the JTA the analyst determines what is actually done on a particular piece of equipment or at a specific work station. Many refer to the JTA as a "bottom-up" analysis done by the contractor who is developing the weapons system. During the ISD process, the contractor identifies several variables that may have an impact on training such as the tasks (actions) that must be performed at a specific workstation or on various pieces of particular equipment (instrumentation) that are located at that workstation. In addition the analyst determined the *conditions* under which the tasks would be usually performed (and the scenarios that must be created to emulate reality), the *standards* by which successful task performance will be measured and other information such as the prerequisite knowledge (theory) required in order to learn these tasks as well as the skills and abilities needed for successful performance of these tasks.

The analyst then selects one of many algorithms to make a determination of what tasks need to be trained and to what extent (Ohio State, 1994, TRADOC, 1995, 1979, 1980, 1990). This analysis resulted in a listing of the tasks that required training and their

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training priority. This information provided an initial identification of the types of things that should be included in the training program. The JTA results in an identification of the specific tasks that require training on individual equipment at each position weapons systems. It also identified the knowledge, skills, attitudes, and abilities (KSAAs) required for successful job/task performance at each station.

Concurrently done with the JTA in the Analysis Phase is the training Situation Analysis (TSA). The TSA is a "snapshot" of the existing training program at a particular point in time. (Beagles & Duke, 1986). A TSA usually provides detailed information on the curriculum that is currently being taught. It identifies such things as the rates (occupational specialty) being trained, the pipeline of prerequisite courses taken prior to entering into this curriculum, the different types of courses being taught, the objectives presented in each of the various courses, the student throughput in the courses on a yearly basis, the equipment, tools and test equipment being trained, a description of the facilities housing the training and the media being used to teach the course. Descriptions of the media (simulators, part task trainers, interactive computer based courseware, etc.) being used to teach the existing course is relevant to this paper, as this comprises one of the major cornerstones of costing.

As illustrated in Figure 1 the analyst undertakes a "gap analysis" to compare the tasks and the KSAAs that the actual jobholder must possess (as determined in the JTA) with the KSAAs already being taught to students in the existing curriculum. The difference between what the students already know and can perform and what the new missions/jobs/tasks will require them to know and be able to perform is what must be

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trained. The result of the Analysis Phase is a training task list. This task list introduces the Design Phase.

Phase II -Design.

Activities in the instructional design phase are based on the results of the analysis phase. These activities appear in black in Figure 1. In the beginning of the Design Phase, the analyst uses the training task list (shown in red) as the foundation for the development of Learning Objectives (LOs) and associated test items. In order for instruction to be successful, the analyst must insure that the domain (cognitive, psychomotor, affective) and level of complexity of the learning objectives and test items correlate to the tasks identified in the list of tasks to be trained (Gagne, 1970, Gagne & Medsker, 1996, Bloom, 1956, Simpson, 1972, Krathwahl,1956) In the design phase, the instructional designer must also determine the instructional strategies, and select optimal media to not only support the strategies but also to meet the cost constraints identified in the training budget. Due to the high cost associated with the development of training media (especially high end simulators) the analyst usually undertakes a critical review of existing instructional materials and media to determine their applicability to the specific instruction under development.

An optimal curriculum usually entails a "blended solution" of media which is a mix of various types of media to present ideas during a course of instruction. This blended solution is illustrated in Figure 1 by the range of media from electronic classroom to part task trainers to full operational simulators to the actual weapons system. The determination of this media mix involves still another model for media selection.

There are several different types of media models that the instructional analyst can choose. Many of them are based upon the identification of attributes (motion, vibration, color density, etc.) deemed necessary for the learning of various tasks (Reiser, et. al, 1981, Krebs, Simpson & Mark 1983, Brabey, Henry, Parrish, & Swope, 1975). The data in the media selection models is generally populated from inputs received from subject matter experts (SMEs) – those who perform the tasks on a routine basis are the ones who know how best to perform the task. They know that when teaching the tasks to a novice there are certain "attributes" that, if present, will enhance an individual's ability to learn the concept. The SMEs input these attributes into the model and then input various types of media into the model. The algorithms in the models rely on the ability of the media to satisfy the attribute in a manner expected by the SME. The SMEs, working with the instructional analysts, determine what attributes must be placed into the model (this depends on what they are intending to train) then input various media candidates into the model. For example, if one were teaching an individual how to repair a part of the CWIS that requires the use of a torque wrench he would expect the individual to be able to "experience" some resistance in training just like he would in reality. Following this premise, a media (such as a simulator) would require an individual to be able to "experience motion" if he were going to learn to fly an aircraft.

It is the purpose of the media selection model to provide an initial list of suitable candidate media for optimally teaching a variety of tasks. However, this list of candidate media does not consider costs – it is based exclusively on the ability of the media to deliver/present the instructional material. It is the responsibility of the analyst to then identify and evaluate candidate Training Systems Alternatives (TSALTs) for incorporation of training media into a curriculum. The TSALTs must consider the training situation from not only a “figure of merit” teaching perspective but also a costing perspective. The figure of merit perspective involves examining characteristics that are important to the community that will be receiving the training. For example, in the CIWS example, the analyst must consider the implications of such things as ability to meet and dispose of current threats. It wills the individual with little benefit if he learns to dismantle a target that is obsolete – no longer used.

The costing perspective involves the consideration of several parameters that affect life cycle cost. Appendix A will describe some of the cost considerations and procedures that are available for determining the optimal mix of training media to effectively train sailors on how to meet the emerging threats.

Within this Design Phase the implementation and evaluation plans for the instructional system are usually developed and a training information management system is designed. Both of these important activities can have a significant impact on the media alternative selected.

Phase III - Develop.

Just as the results of the Analysis Phase are used in the activities in the Design Phase, the Development Phase uses the results of the Design Phase. During the development phase, lesson materials, unit exercises, drills, and other instructional materials for both the student and the instructor are developed. As the title implies, the responsibilities of the instructional analyst turn to developing the actual curriculum. In many cases the individuals working in this phase are specialists in instructional design or

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computer-based-training and possess different skills then the individuals who have undertaken the work in the first two phases (Analysis and Design). The media that were conceptually selected in the design phase will actually be produced or built during the Development Phase.

It is the responsibility of the instructional designers to not only develop but also validate all instructional materials as they are developed. They must incorporate both formative and summative evaluation exercises throughout the developmental effort. An important component of this phase is to develop an implementation plan – that is, they must think through the entire course and develop directions or suggestions on how the course should be taught. This plan involves describing "train-the-trainer" programs and includes other logistics information insuring that all required resources are identified in ample time so as to not affect course schedule or how the course will be taught. It is in this phase that a refinement in the costing model identified in the Phase II – Design stage will be validated.

Phase IV - Implement.

Of all of the phases in the ISD Model the Implementation Phase is by far the most visible to the layman in the general public. Most individuals who are not involved with training on a regular basis or those who have little to no background in training design and development have no idea about all the complex intricacies that serve as prerequisites to this implementation (delivery) phase. This phase involves actually presenting the information to the students – teaching the course. In this phase, the instructional system is fielded following the customer approved Implementation Plan. Historically, it has been this phase that receives the most attention in colleges of education in the United States. The reason for this is that education in most public schools and universities is dictated by state and local school boards. For example, in 2008 students in 9th grade are to be taught introductory algebra. If we compare a 9th grade introductory algebra textbook published in 2008 with one published in 1958 (50 years ago) one would find relatively little difference in content. The basic concepts of algebra do not change! However, one would find significant differences in textbook design and the way algebra is taught to today's 9th graders using technology. The colleges of education expend a considerable amount of time training teachers how to customize their lessons and employ technology in the classroom. Teachers are also taught the basic philosophy of learning and provided with numerous examples of the diversity of learning styles so that they can develop their own teaching style in order to motivate students in the classroom. The general public identifies with these "customized´ ways of teaching and learning because they have experienced them in their own school days or are experiencing them with their children – especially if they home school their children. They have generally assumed that what needs to be trained has already been determined – just as it was throughout their entire school career. Most never even think about all the prerequisites that are involved with determining what needs to be taught! Now think back to the example of the CIWS. Here new threats, which did not exist in the past when the system was originally developed, are now dictating what must be designed into the new system- and ultimately what must be trained on the new system. This is very different from teaching the same algebra principles in 9th grade as we did 50 years ago. These are totally different principles! It is the extensive research that is involved with these new principles that are often the activities that are the most costly – especially if there are relatively inexperienced individuals who are tasked with undertaking this important activity!

Phase V - Evaluate.

Evaluation is a continuous process that starts during the analysis phase and continues throughout the development and life cycle of the instructional system. Feedback from the evaluation process is used to modify the total training program as necessary. To ensure continuing quality of the fielded system, operational evaluations consisting of both internal (schoolhouse) and external (field feedback) evaluations are repeatedly done. The intent of these evaluations is to provide the necessary periodic feedback for the life cycle of the operating system. A key element in evaluation planning is the development of metrics to support the evaluation process. There are three categories of evaluation associated with training:

1) Formative evaluation which involve activities that are conducted while the system (or upgrade) is still being developed,

2) Summative evaluation which is done once the instructional development is complete. This is a "dress rehearsal" using members of the target audience, trained instructors, and actual training equipment.

3) Operational evaluation which is done once the training system is fielded. Organizations undertake periodic checks to ensure that specific systems are updated as scheduled and continue to satisfy the purpose for which they were designed.

Discussion:

As part of the US Navy response to the proliferation of ASM technology and capabilities, a Ship Self Defense System (SSDS) program was initiated in the early 1970's. The first system developed as the "final line of defense" against anti-ship missiles was delivered by General Dynamics to the US Navy and installed for evaluation purposes on the *USS King* in 1973. The weapons system was the PHALANX Mark 15 Close-In Weapons System (CIWS) pronounced "see-whiz". The basis of the technology

PHALANX Mark 15 Close-In Weapons System (CIWS)

was to fit a weapons system capable of throwing up the proverbial wall of lead to counter high-*g* and highly maneuverable 'sea skimmer' anti-ship missiles – which led to the selection of the 20mm M61 Vulcan Gatling-type rotary cannon linked to a tracking and acquisition radar. This self contained system consists of a turret along with an automated fire control system that has continued to evolve as have the threats against it over the past

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30 years. As the system has evolved - in terms of mission parameters, weapons effects, target acquisition, etc - and in order to track these variants of the CIWS – configuration changes became known as "BLOCK", or versions of the system. The CIWS can automatically search, detect, track, engage and confirm kills using its computer controlled

Close-In Weapons System – Maintenance Trainer (CIWS-MT), Training Device 11G2

radar system – since it is self contained, it is ideal for inclusion on platforms such as support ships, which inherently lack the integrated targeting and sensor systems of other surface combatants. Critical to this stand-alone capability, is the requirement for the system to remain fully capable and ready once deployed. This led the US Navy to a massive investment in the training of those sailors charged with maintaining the CIWS.

The initial maintenance training courses set up at the Fleet Combat Training Center –Atlantic, Dam Neck, VA and the Fleet Training Center, San Diego, CA, called for course number A-113-0078 “CIWS MK-15 MOD-1 (BLOCK 0)” – a 201 day program of instruction. The training program consisted of classroom; Simulation Laboratory (SIMLAB) - “mount” training (operational PHALANX systems mounted inside/adjacent to classrooms) and training simulators. The principle differences between the SIMLAB “Mount” trainers and the training simulator is that the “Mount” is an operational CIWS adapted for a static training location. Every aspect of the weapons system, save the installation aboard a surface vessel is exact. The student will have the opportunity to conduct maintenance training, maintenance troubleshooting and repair functions with the system. The negative factors associated with this are legitimate concerns for safety, as the weapons system operates on a high electrical current, utilizes a high pressure hydraulic system, pneumatic air system and can emit microwave radar as part of its tracking and acquisition status. Additionally, each operational CIWS utilized in the training environment, is one less that could have been incorporated to an existing surface combatant. Furthermore, as the weapons system evolved, changes to the TTE “Mount” became extremely expensive to initiate or could not effectively be done – as the addition and/or change of various components would prematurely wear out or break expensive components. In practical terms, configuring an operational system as part of an ever-changing classroom environment, coupled with the extensive student abuse and wear makes this aspect economically prohibitive. Conversely, the implementation of the training simulator – which could safely replicate a variety of system faults, and reinforce the procedures used for maintenance troubleshooting was ideal for this purpose. Initially, the Navy's training requirement called for a "classic" panel type trainer, with removable or reconfigurable panels, called the Close-In Weapons System Maintenance Trainer (CIWS-MT), Training Device 11G2. The CIWS-MT provides an adjunct to 'hands-on' practical experience using actual experience. The complex simulations of the CIWS-MT allow the student to develop signal tracing skills, working deeper into the system from test point to test point to find the source of each malfunction and to take the necessary steps to solve each training problem. With the CIWS-MT students can perform virtually all the maintenance tests and activities that are required in the shipboard environment. Designed to develop and test the student's ability to maintain the CIWS, not his ability to interact with a computer, the CIWS-MT features high-fidelity hands-on simulations of critical CIWS assemblies and support test equipment and a simple, easy-to-use Graphical User Interface. The complex interactions of the ten CIWS subsystems are extensively modeled to simulate both normal and abnormal conditions. Fault insertion is easy and instructors can precisely create, manage and score the training problem desired. By utilizing replacement or removable panels, the instructor could replicate the maintenance and troubleshooting functions associated with the weapons system. This could be done safely – with no risk to the student, instructor, or other adjacent personnel. Upgrades to the simulator were relatively easy to implement – and the costs were low (Millus, 2004). The original systems, delivered in 1982, were contracted for – designed and built by Cubic Corporation, San Diego, CA. In all, over 30 trainers were built – twelve each for

Dam Neck and San Diego, a test bed, and the remainder to allied navies who procured them under various Foreign Military Sales (FMS) cases.

The Navy's investment in facilities, classrooms, curriculum development, training simulators and operational systems ("Mount" trainers) was and remains significant (see Appendix A). All CIWS maintenance training is conducted by classroom – classic lecture and/or self-study, TTE (Tools, Test Equipment) laboratory – where the operational CIWS equipment was utilized as part of the classic "Mount" training; and the SIMLAB (Simulation Laboratory) – where the 11G2 trainer was utilized. In practice, while conducting performance and skill training, each class is normally split into three student groups. Each group will rotate through the TTE laboratory or the SIMLAB to complete Job Sheets, then the classroom for self-study and to complete Assignment or Problem Sheets. Correspondingly, a limited amount of students could be trained per year as instructor availability, course length, availability of SIMLAB systems and the pool of eligible student candidates made this problem a critical one for the US Navy.

In the standard evolution of high tech fielded weapons systems there are normally continuous changes until a representative baseline is established. The CIWS was no different. Over time, a number of BLOCK upgrades occurred, such that the Navy had to implement training course A-113-0095 MK-15 CIWS BLOCK 1 MK-15 DIFFERENCE COURSE, a 68 day program, given at both schoolhouses. This "Difference Course" was designed for previously trained CIWS maintenance personnel, and until they graduated from the course were not operationally deployable as an assignment to a vessel with a system other than BLOCK 0 would render their skill level, vis-à-vis the upgraded system, somewhat limited (Dole 1997). This was later augmented by A-113-0114 MK-15 CIWS

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BLOCK 1, MODS 11-14, an additional 201 day course that ultimately replaced the BLOCK 0 course (A-113-0078). Presently, the BLOCK 0 course is no longer taught, with the basic BLOCK 1, 201 day course the mainstay. The DIFFERENCE course has been cut down to a 15 day program.

Case Study 2:

As NATO began to access this new anti-ship threat, funds were made available to support the research and development required to field their own version. As the United States began development of the Penguin and Harpoon anti-ship missiles, the French applied their own technological approach in the development of the Exocet. Originally designed as a ship launched version in the late 1960's, an air launched version (AM39) became known as the Exocet ("Flying Fish") and was subsequently fielded in the late 1970's.

With the success of air launched surface skimming missiles, such as the Exocet, effective countermeasures were either slow to implement or completely ineffective. During the 1982 Falkland's War between Great Britain and Argentina, two naval engagements became noteworthy. One of Britain's newest ships, the *HMS Sheffield*, had been built to repel such attacks. Part of the ship's self defense array was the Sea Dart System which was designed and fielded in order to successfully counter the proliferation of anti-ship missiles. On the morning of 4 May, an Argentinean tracker plane identified several targets off the Argentine coast that were worthy of interception. Two Super Etendard fighter bombers were dispatched, and consistent with the rehearsals conducted over the previous four weeks, ran their mission on radio silence. Spotting the British destroyer, *HMS Sheffield*, as part of a radar patrol for the British invasion fleet – she was patrolling 40 nautical miles in front of the fleet and 70 nautical miles south-east from Port Stanley. The Argentine Super Etendards fighter bombers maintained their radio silence, and at a distance of 20 miles, released two Exocet missiles, dropped to the sea deck, lit the afterburners and flew a deceptive egress route towards Antarctica before returning to their base at Rio Grande. The Exocets were programmed to fly between two and three meters above the waterline and activated their own homing radars at a distance of 10km. The *HMS Sheffield* had no warning. The first Exocet slammed into the hull about two meters above the waterline but did not explode. The ensuing fire, fed by the missile's unspent fuel, killed 21 and injured over a score more. The second missile homed in on a sister vessel, the *HMS Yarmouth* but missed as a rapid deployment of chaff cluttered and subsequently confused the incoming Exocet's acquisition radar. The *Sheffield* continued to burn despite heroic efforts by the crew. She sank six days later as the burned out hulk was under tow to England. Later in the war, the British merchant ship *Atlantic Conveyor* was also struck by an Argentine launched Exocet. The *Atlantic Conveyor* also sank, losing her precious cargo of aircraft and spare parts – including the loss of twelve seamen and her Captain – Ian North.

Discussion:

In October 1984, the US Navy constituted flag officer representatives from seven major navy commands, convening an Expanded PHALANX Introduction Commitment (EPIC) team. This EPIC team was "intended to enhance PHALANX performance, maintainability and support" and would have a direct bearing on the training and training simulators used to teach those sailor maintainers. Critical to the purpose of the EPIC team, was recognition of the value in having highly trained fire control maintenance technicians. The EPIC team charged the PHALANX Program Office, General Dynamics and Cubic to "maintain as a configuration model, the Device 11G2 currently at (the) Pomona, CA" General Dynamics facility. (NAVSEA 1984) The plan called for the trainer to be used by the Navy PHALANX Training Unit for curriculum updates, and designated Cubic Corporation as the Design Agent for the trainer.

Case Study 3:

While closely observing the effects of anti-ship missile technology in the various naval engagements of the Falklands' War, the United States Navy initiated its own countermeasure – the PHALANX Mark 15 Close-In Weapons System (CIWS). The system is comprised of a self-contained, highly automated tracking and acquisition radar, coupled with a fire control system spewing out 20mm shells at the rate of 3000 per minute. The prevailing thought, conceptually speaking, was to put up a proverbial 'wall of lead' to counter the speed and elusiveness of the incoming ASM. If nothing else, the targeted missile, should it prove too difficult to track and engage, would fly *into* the protective rounds that were fired. Naturally, this was all predicated on a system that was well maintained and operationally effective. In May 1987, a United States frigate, *USS Stark* was on patrol duty in the Persian Gulf. At approximately 2000 hours, a Saudi Arabian AWACS plane detected an Iraqi Mirage F-1 fighter as it proceeded south over the Persian Gulf near the Saudi coastline. A message was sent out over the Naval Tactical Data System and the radar operators on the *Stark* picked up the Mirage at a range of 200nm at 5000 feet. At 2210 hours the Mirage banked sharply and then proceeded on a northerly track back up the coast into Iraq. What the sensor operators about the AWACS and *Stark* failed to notice that while performing this banking maneuver the Mirage had launched two air-to-surface ASM missiles one minute apart. Launched from a distance of 22 nautical miles, the AM-39 Exocets found their target despite the sophistication of the ship's self defense system. The first Exocet slammed into the port hull and ripped into the crew's quarters and exploded. The second hit the frigate's superstructure, but did not explode. The heroism and dedication of the crew were instrumental in controlling the raging fires – that otherwise would have consumed the *USS Stark* for a total loss. The cost to the US Navy was 37 sailors killed, 21 wounded and the cost to repair the Start was $142 million.

In the aftermath of the *Stark* review, a Naval Board of Inquiry found that despite the inclusion of highly sophisticated warning systems and counter threat weapons designed to prevent this occurrence, it was found that the sensors did not identify the incoming missiles nor engage the threat. The *Stark's* PHALANX Mark 15 Close-In Weapons System – despite the capability to automatically track and engage the incoming Exocets, stood idly by and the missiles impacted the ship. The board found that a week before the catastrophe the CIWS had developed an "Air Ready No-Go" condition that indicated a fault in the track antenna positioning circuits. The maintenance crew was unable to isolate the fault – later deemed to be caused by an intermittent failure in a wire harness that sent signals to the track antenna positioning circuits. Furthermore, the system casualty reporting (CASREP) process was not followed – possibly resulting in the *Stark* being withdrawn from hostile waters until the problem had been corrected. Clearly, the lack of command leadership, maintenance troubleshooting and assessment, and proper reporting procedures contributed significantly to this tragedy. Caught with her defenses down, the *Stark* and her crew, much like the *Sheffield*, suffered horribly. In hindsight, had the *Stark* been able to offensively render a chaff screen or taken evasive maneuvers, it may have dodged the first Exocet, but not the second. Had the CIWS on the *Stark* been operational it may have acquired the missiles with its J-band radar and incapacitated both of them before impact (Scoles, 2005).

Discussion:

By the mid-1990's the fleet of BLOCK 0 operational systems were diminishing as the Fleet-installed BLOCK 0 CIWS equipped ships were being retired or upgraded to BLOCK 1 CIWS. Consequently, the Navy directed the consolidation of all BLOCK 0 training into the Fleet Training Center San Diego, and would continue to do so until the BLOCK 0 system was retired. In the "DIFFERENCES" and BLOCK 1 courses, every module of training, as called out by the curriculum, was at one point or another conducted using both the TTE and Device 11G2. This was significant because the CIWS Program Office, PEO TAD (Program Executive Office Theater Air Defense) in a series of budgetary decrements, had reduced the funding necessary to upgrade the 11G2, as well as the project team engineering support required to maintain quality configuration control. The subsequent training analysis indicated that "in the near term, student throughput will not be immediately affected by either the loss of the project team in support of the training or the decision to not provide configuration upgrades to the existing 11G2 inventory. However, as the number of BLOCK 1 Baseline 2B and BLOCK 1A upgrades appear in the Fleet, there will be a significant impact to student throughput as SIMLAB time will have to be restructured or other mounts procured and upgraded. Without the upgraded mounts to support the lack of upgraded 11G2s, there would be some maintenance personnel who may not have had an opportunity to conduct maintenance

CIWS-MT, Training Device 11G2 with latest BLOCK 1B Upgrade

trouble shooting techniques on the latest configuration of the CIWS PHALANX until reporting aboard ship! Fielding of the BLOCK 1A systems has begun. Consequently, the lack of capability in the existing suite of 11G2s makes this deficiency more acute. The throughput affects could be felt as early as late FY97. In addition, the lack of a configuration "match" between the 11G2 and BLOCK 1A Baseline may degrade student

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technical training and performance by more than fifteen percent! Follow-on upgrades would greatly compound this training deficiency and most certainly drive a new requirement for an entirely new course, or at least another "DIFFERENCES" course, along with the funding costs of additional TTE or the costs associated with modifying the existing TTE. Upgrading the devices and using them to train skill and performance factors would more than hold the line of providing "Trained, Proficient Sailors to the Fleet" – and at a much lower cost." (Dole 1997)

Discussion:

As a result of the training analysis, PEO TAD (currently PEO Integrated Warfare Systems) rectified the funding decrement to the CIWS-MT/11G2 project team. This was coupled with support from a number of allied navies who participated in the effort as part of their respective FMS cases. Since the 11G2 could be adapted into any configuration of the CIWS, while simulating all of the embedded functional elements in all of the subsystems, it became incumbent upon the Program Office to support this aspect of schoolhouse training. The depth of the trainer simulation model is such that there is virtually no difference between the simulator and the operational equipment interfaces. The trainer operator receives accurate and realistic responses from various control panels and information subsystems – exactly as he receives it on the CIWS. Critical to the support of the CIWS-MT was the transfer of project knowledge – by 1995, 'ownership' of the CIWS-MT database was under US Navy cognizance – with US Navy civilian personnel solely comprising membership in the CIWS-MT project team. This limited support costs to labor, limited material procurement and travel costs. Furthermore, innovative approaches to solving complex operational problems became the hallmark of the Navy team. In 1997, the engineering team devised a way to simulate "Klystron Tuning" on the trainer. This maintenance aspect was formerly done on the TTE "Mount" – depleting the Fleet's inventory of klystron's as their service life was shortened in the "Mount" training process. On this one innovation alone, the team was able to document a savings of over $1.0 million. Despite these achievements, there were some negative aspects, mostly perception, but nonetheless associated with the11G2. Those included the inability of training more than one student at a time per trainer, and the maintenance costs associated with keeping the training fully operational. Although these costs were reduced to virtually nil, they were validated costs none-the-less. With the increased emphasis on desktop simulation, the Navy, in concert with subordinate warfare commands – directed that all simulation efforts for CIWS be phased out in favor of a Lockheed-Martin Canada initiative called VISTA. This decision was tied to an overall effort to standardize much of the Navy's classroom training such that one generic desktop system could be used to support a variety of training specialties. The investment would be in the realism and functionality of the software, with the student manipulating a mouse/cursor to affect decisions/actions in the training environment. Notionally, VISTA has great potential, but when directly compared with the 11G2 the differences are startling. While VISTA can currently emulate several hundred faults, the 11G2 model can engage 3620 modeled test points, 540 insertable casualties, 34 unique student warning messages, 28 unique student actions, 650 replaceable circuit cards or components, 600 still photographs, etc. It is estimated that VISTA can currently emulate approximately fifteen percent of the simulation modeled in the 11G2 – with the additional simulation requirements being pushed over to the TTE "Mount" – further increasing the maintenance costs on that system.

FACTORS IMPACTING CIWS TRAINING DECISIONS

Based on the knowledge and skills needed by technicians to operate and maintain CIWS, a 600-hour training program was developed with 360 hours of theory and 240 hours of hands-on exercises. The theory is delivered through a traditional instructor-led format at two schools (Dam Neck, VA and San Diego, CA) with 6:1 student to instructor ratio (12 students/2 instructors). From 1982 to 2005, 120 hours of the hands-on format was delivered through the 11G2 Training Device and another 120 hours on 6 "Mount" Trainers – operational PHALANX systems mounted inside/adjacent to classrooms.

In 2005, the VISTA Desktop Trainer was adopted as a replacement for the 11G2 Training Device. As indicated above, a number of reasons led to this decision including: 11G2's inability of training more than one student at a time, time needed by instructors to set-up scenarios for the 11G2 as well as the desire to migrate towards Desktop Trainers. Although the VISTA Desktop Trainer successfully addressed the above issues, its ability to generate scenarios needed by technicians to develop the desired skills was very limited – only 15% of required scenarios can be generated. To graduate CIWS technicians with the same level of preparedness, more training (102 hours = 120 hours x 85%) would have to be shifted to the "Mount" Trainers. As a result, the added benefits gained from increasing students to instructor ratio and reducing the instructor setup time are countered by the additional costs needed to operate the "Mount" Trainer. Given this reality, a new alternative is being proposed by the project engineering team that involves porting the 11G2 capabilities to a Desktop Trainer format.

Given the advantages and limitation of these three alternatives, how do we determine the most effective and efficient blend of delivery options? By instituting a Training Cost Analysis Model provided as part of Appendix A, which includes a direct "apples to apples" comparison of all training systems, as well as projected costs – and savings – over an expected thirty year weapons system lifecycle.

SUMMARY AND CONCLUSIONS

Although selecting the right blend of delivery options can significantly impact training costs, employees' productivity and organizational goals, in most instances, analysts do not have access to financial data, tools or support needed to assess the financial implication of their recommendation. As a result, decisions are being based on either soft instructional design factors that can significantly increase costs while minimizing productivity and performance, or worse on financial analysis that does not ensure the transfer of knowledge and skills needed to attain business goals. To select the most effective and economical blend of delivery options, the analysis should proceed as follows:

1st Step: Instructional Design Analysis. Identify plausible delivery options that meet learners, learning and organizational needs.

2nd Step: Financial Analysis. Estimate the financial impact of plausible delivery options on training program's costs, employees' productivity and organizational goals.

3rd Step: Make Decision. Select the most favorable blend of delivery option by considering the effectiveness, cost and impact on various alternatives.

Of course, each training program is unique. Your development and compression ratios may be different then industry averages and other factors can influence the results. The key point however is: by utilizing common measures such as hourly rates of developers, instructors, administrators, managers and support staff; average time needed to develop, administer, manage and support courses with different levels of complexity, average trainee's per diem and travel costs; daily equipment and facility costs; and so on; you can significantly improve training efficiency by easily and accurately forecasting the costs of plausible delivery options for any training program; identify and duplicate programs that are running efficiently; correct problem areas as well as carry out multiple what if scenarios to help you uncover other venues for improving training efficiency. And if you are overwhelmed by this level of detail, don't despair tools such as ADVISOR Enterprise (http://www.bnhexpertsoft.com/english/products/advent/overview.htm) are available to help you.

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A POSSIBLE FUTURE:

Currently, the United States Navy is conducting upgrades to the entire operational inventory of PHALANX, with the ultimate intent of fielding the BLOCK 1B variant only. BLOCK 1B improvements include Optimized Gun Barrels (OGB) and a new integrated forward looking infrared system (FLIR). The OGB will be electrically controlled, pneumatically driven and fire the new Enhanced Lethality Cartridge (ELC). The PHALANX FLIR provides increased capability to search, track and engage coastal warfare threats as well as provide ASM defense. There is a manual control capability, such that a Fire Control (FC) technician can engage a variety of targets – given the latest threat assessments. As of February 2007, approximately 900 PHALANX systems have been built and deployed worldwide (www.navweaps.com). Despite the Navy's decision to forego continued training on the 11G2 in favor of VISTA, the CIWS-MT/11G2 project team continued to improve the simulation model, as well as the functionality of the trainer. These efforts, funded as a part of several on-going FMS cases, resulted in the completed model associated with BLOCK 1B. Additionally, the effort resulted in the successful fielding of a new Surface Mode Operator Trainer. This new software will allow a newly assigned student - or even a seasoned CIWS FC operator – with the ability to track, acquire, identify and manually engage targets that threaten his vessel utilizing the same procedures as he would aboard ship, all from a desktop or laptop computer.

Ultimately, the consensus of the CIWS-MT/11G2 engineering team is that a desktop configuration of the 11G2 can be refined and ported into a laptop computer. The possibility of increasing the training effectiveness with reduced cost and providing those graduating FC maintenance students with a tool that they can train and deploy with is considered the training communities “Holy Grail”. The notion that an FC maintenance student would report to his respective schoolhouse, be issued a laptop with the entire 11G2 simulation resident on it – where the student could use the laptop to take his engineering notes, load drawings and other data, and upon graduation bring that laptop aboard ship to assist him in maintaining, troubleshooting and supporting his ships’ own “Last Line of Defense” is noteworthy. Consider that the Navy’s Material Readiness Database for fiscal years 1997 through 1999 showed the PHALANX (all mods) had an availability rate of between 72% and 81% for this time period. Clearly, the training community can and should do a better job (www.navweaps.com).

Even more remarkable, the entire 11G2 simulation model can be ported to a desktop version within a six-month window of appropriate funding. The software will be designed to work with any existing classroom desktop configuration – assuming certain

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CPU/RAM specifications – and can run equally well on the existing VISTA dedicated desktops. The estimated cost to transition from the existing CIWS-MT/11G2 to a desktop model and ultimately to the laptop version is less than $600,000.00 With that investment, the United States Navy could have classrooms fitted with a desktop version of the 11G2 Trainer and in-turn increase training efficiency by approximately $100 million over 30 year and reduce trainee's cost by over 29 % as illustrated in Appendix A.

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APPENDIX A

TRAINING COST ANALYSIS MODEL

Three primary issues should be taken into consideration when selecting the most effective and efficient blend of delivery options, namely:

- Cost Avoidance – can we accomplish the same training objectives at lower costs.
- Productivity Gains – can we reduce time needed for training.
- Organizational Benefits – the impact of reducing time to competency.

The impact of each on the CIWS training program will be presented in the following sections.

a. Cost Avoidance

To find out whether one option is more economical then others, the costs of plausible delivery options over the life of the training program should be computed and compared.

In general, the costs may include one or more of the following items (Allen 1996; Bahlis 1995 & 1998; Barksdale & Lund 1996; Brandit 1987; Foreman 1994; Hall 1995 & 2001; Head 1987 and Phillips 1997):

Development Costs:	includes development/purchase/licensing of training
Hardware/Equipment Costs:	includes equipment purchase, upgrade & operation
Software Costs:	includes software purchase, licensing &update
Instructor Costs	includes delivery/preparation time
Travel & Per Diem Costs	includes trainees & instructors travel/per diem costs
Facilities Costs	includes facilities setup, maintenance & update
Transmission Costs	includes internet/audio/video transmission costs
Administrative Costs	includes time needed to register students, etc.
Management Costs	includes time needed to coordinate development/ delivery/maintenance/support of training program
Support Costs	includes technical/equipment support
Material Costs	includes the costs of training material, CD, etc.
Miscellaneous Costs	includes all other cost not accounted for above

CIWS Development Costs

The training material for CIWS has already been developed, and in-turn has minimal impact on the three options under consideration. However, since the CIWS weapon system is continuously evolving it is estimated that 15% of the training content would have to be updated each year. By ignoring inflation, the cost of updating the training material over the 30-year life of CIWS can be estimated as follows:

Initial Development Costs: $4.2 million
Annual Training Material Update Cost: $630,000 per year ($4.2 million x 15%)
Material Update Cost [over life]: $18.9 million ($630,000 x 30 years)

What About Alternatives

The 360-hour theory segment of the CIWS course can be converted and delivered in a computer based training (CBT) format. The initial development cost for the CBT version can be estimated as follows:

Instructor-led Initial Development Costs: $2.52 million ($4.2 x 360/600)
Instructor-led Initial Development Time: 7,200 hrs ($2.52 m / $350 per day)
Instructor-led Development Hours per hour: 20 hrs ($7,200 hrs / 360 hrs)

Based on industry averages, the effort needed to develop the theory segment of the CIWS course can be categorized as "low" and the corresponding development hours per hour for an equivalent CBT course would approximately be 100. Moreover, the average time needed to complete the CBT course can be compressed by 30% to 252 hours (360 hours x 70%) (Bahlis and Corneau 1994; Bunderson 1984; Ketner 1982; Kimberlin 1982; Miller 1990; Reeves 1988; Reeves & Marlino 1989; Weinstein 1987; and Wright 1983). With this data in hand and assuming that the hourly rate of the CBT development teams is similar to instructor-led (i.e., $350 per day), we can accurately estimate the development and maintenance costs of the equivalent CBT course as follows:

Initial Development Costs: $8.820 million (252 hrs x 100 hrs/hr x $350 /day)
Annual Material Update Cost: $1.323 million/yr ($8.82 million x 15%)
Material Update Cost [over life]: $39.69 million ($1.323 m x 30 years)
Total Development Costs: $48.51 million

Although at first glance, the computer based training option does not appear to be advantageous – $48.51 million in development cost compared to $11.34 million ($18.9 million x 360 / 600) for the instructor-led option – keep in mind that computer based training can be delivered in a self study mode thereby minimizing the need for instructors during the theory portion of the CIWS program.

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CIWS Hardware/Equipment/Software Costs

Three alternatives will be examined:

- Option #1: Original 11G2 Training Device with "Mount" Trainers
- Option #2: VISTA Desktop Trainer with Mount Trainers
- Option #3: Proposed 11G2 Desktop Trainer with Mount Trainers

The computations below are based on the following assumptions:

- To graduate CIWS technicians with the same level of preparedness, we may use:
  - 120 hours of hands-on training on the original 11G2 Training Device plus 120 hours on "Mount" Trainers;
  - 18 hours of hands-on training on the VISTA Desktop Trainer plus 222 hours on "Mount" Trainers;
  - 120 hours of hands-on training on the proposed 11G2 Desktop Trainer plus 120 hours on "Mount" Trainers;

- The hourly operating costs of the three alternatives are as follows:
  - Original 11G2 Training Device: $92 per trainee per hour
  - VISTA Desktop Trainer: $0.12 per trainee per hour
  - Proposed 11G2 Desktop Trainer: $0.12 per trainee per hour
  - "Mount" Trainer: $122 per trainee per hour

<u>Option #1: Original 11G2 Training Device with "Mount" Trainers</u>

11G2 Purchase/Develop Costs:	$2.100 million ($1.3 million + $0.8 million updates)
11G2 Operation Cost per class:	$132,480 (12 Stud./class x 120 hrs/class x $92/hr)
11G2 Operation Cost per year:	$2.252 million ($132,480 x 17 classes per year)
11G2 Operation Cost over life:	$67.56 million ($2.252 million x 30 years)
11G2 Total Hardware Costs:	$69.66 million ($2.1 million + $67.56 million)

Mount Purchase/Develop Costs:	$40.80 million ($6.8 million/mount x 6 mounts)
Mount Operation Cost per class:	$175,680 (12 Stud./class x 120 hrs/class x $122/hr)
Mount Operation Cost per year:	$2.987 million ($175,680 x 17 classes per year)
Mount Operation Cost over life:	$89.60 million ($2.987 x 30 years)
Mount Total Hardware Costs:	$130.4 million ($40.8 million + $89.60 million)

11G2 + Mount Total Hardware Costs: $200.06 million ($69.66 m + $130.40 m)

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Option #2: VISTA Desktop Trainer with "Mount" Trainers

VISTA Purchase/Develop Costs: $2.40 million ($1.6 million + $0.8 million install)
VISTA Operation Cost per class: $26 (12 Stud./class x 18 hrs/class x $0.12/hr)
VISTA Operation Cost per year: $441 ($26 x 17 classes per year)
VISTA Operation Cost over life: $13,219 ($441 x 30 years)
VISTA Total Hardware Costs: $2.413 million ($2.4 million + $13,219)

Mount Purchase/Develop Costs: $40.80 million ($6.8 million/mount x 6 mounts)
Mount Operation Cost per class: $325,008 (12 Stud./class x 222 hrs/class x $122/hr)
Mount Operation Cost per year: $5.525 million ($325,008 x 17 classes per year)
Mount Operation Cost over life: $165.8 million ($5.525 x 30 years)
Mount Total Hardware Costs: $206.6 million ($40.8 million + $165.75 million)

VISTA + Mount Total Hardware Costs: $208.97 million ($2.413 m + $206.554 m)

Option #3: 11G2 Desktop Trainer with "Mount" Trainers

11G2 DT Purchase/Develop Costs: $2.700 million ($1.3 m + $0.8 m + 0.6 m update)
11G2 DT Operation Cost per class: $173 (12 Stud./class x 120 hrs/class x $0.12/hr)
11G2 DT Operation Cost per year: $2,938 ($173 x 17 classes per year)
11G2 DT Operation Cost over life: $88,128 ($2,938 x 30 years)
11G2 DT Total Hardware Costs: $2.788 million ($2.7 million + $88,128)

Mount Purchase/Develop Costs: $40.80 million ($6.8 million/mount x 6 mounts)
Mount Operation Cost per class: $175,680 (12 Stud./class x 120 hrs/class x $122/hr)
Mount Operation Cost per year: $2.987 million ($175,680 x 17 classes per year)
Mount Operation Cost over life: $89.60 million ($2.987 x 30 years)
Mount Total Hardware Costs: $130.4 million ($40.8 million + $89.60 million)

11G2 DT + Mount Total Hardware Costs: $133.19 million ($2.788 m + $130.4 m)

CIWS Instructor Costs

Since the student to instructor ratios for the Theory and the Hands-on segments of the course are different, they should be computed separately as follows:

Theory
Instructor Costs per Class: $33,300 (360 hrs/8 hrs x $370/day x 2 instructors)
Instructor Costs per year: $566,100 ($33,300 x 17 classes per year)
Instructor Costs over life: $16.983 million ($566,100 x 30 years)

For self-study computer based training, instructors are not required. We may support CBT with instructors while reducing costs by increasing students to instructor ratio.
Hands-On

The computations below are based on the following students to instructor ratios:
- Original 11G2 Training Device: 1 student per 1 instructor
- VISTA Desktop Trainer: 12 students per 2 instructors
- Proposed 11G2 Desktop Trainer: 12 students per 2 instructors
- "Mount" Trainer: 1 student per 1 instructor

Option #1: Original 11G2 Training Device with "Mount" Trainers

11G2 Instructor Costs per class: $66,600 (120 hrs/8 hrs x $370/day x 12 instructors)
11G2 Instructor Costs per year: $1.132 million ($66,600 x 17 classes per year)
11G2 Instructor Costs over life: $33.966 million ($1.132 million x 30 years)

Mount Instructor Costs per class: $66,600 (120 hrs/8 hrs x $370/day x 12 instructor)
Mount Instructor Costs per year: $1.132 million ($66,600 x 17 classes per year)
Mount Instructor Costs over life: $33.966 million ($1.132 million x 30 years)

11G2 + Mount Total Instructor Costs: $67.932 million ($33.966 m + $33.966 m)

Option #2: VISTA Desktop Trainer with "Mount" Trainers

VISTA Instructor Costs per class: $1,665 (18 hrs/8 hrs x $370/day x 2 instructor)
VISTA Instructor Costs per year: $28,305 ($1,665 x 17 classes per year)
VISTA Instructor Costs over life: $0.849 million ($28,305 x 30 years)

Mount Instructor Costs per class: $123,210 (222 hrs/8 hrs x $370/day x 12 instruct.)
Mount Instructor Costs per year: $2.095 million ($123,210 x 17 classes per year)
Mount Instructor Costs over life: $62.837 million ($2.095 million x 30 years)

VISTA + Mount Total Instructor Costs: $63.686 million ($0.849 m + $62.837 m)

Option #3: 11G2 Desktop Trainer with "Mount" Trainers

11G2 DT Instructor Costs per class: $11,100 (120 hrs/8 hrs x $370/day x 2 instruct.)
11G2 DT Instructor Costs per year: $188,700 ($11,100 x 17 classes per year)
11G2 DT Instructor Costs over life: $5.661 million ($188,700 x 30 years)

Mount Instructor Costs per class: $66,600 (120 hrs/8 hrs x $370/day x 12 instructor)
Mount Instructor Costs per year: $1.132 million ($66,600 x 17 classes per year)
Mount Instructor Costs over life: $33.966 million ($1.132 million x 30 years)

11G2 DT + Mount Total Instructor Costs: $39.627 million ($5.661 m + $33.966 m)

CIWS Instructor Travel Costs

On average, instructors travel to only 1 out of the 17 classes. Since travel is not expected to change regardless of method used for delivery the training, it is will have minimal impact. However, to gain clearer insight of CIWS technicians training costs, travel cost are estimated as follows:

Instructor Travel Costs per year: $13,000 ($6,500 per individual x 2 instructors)
Instructor per Diem Costs per yr: $27,510 (600 hrs/8 hrs x 7/5 x $131/day x 2 inst)
Total Instructor Travel Costs per yr: $40,510 ($13,000 + $27,510)
Total Instructor Travel Costs over life: $1.215 million ($40,510 x 30 years)

CIWS Facilities Costs

Facilities costs are not expected to change regardless of method used for the delivery of training. However, to gain clearer insight of CIWS technicians training costs, facilities costs are estimated as follows:

Facilities Costs per year: $208,000 (5,200 ft^2 x $20 per ft^2 x 2 facilities)
Facilities Costs over life: $6.24 million ($208,000 x 30 years)

CIWS Administrative Costs

Administrative costs are not expected to change regardless of method used for the delivery of training. Once again, to gain clearer insight of CIWS technicians training costs, administrative costs are estimated as follows:

Administrative Costs per year: $150,000 ($75,000 per individual x 2 staff)
Administrative Costs over life: $4.5 million ($150,000 x 30 years)

CIWS Management Costs

Management costs are not expected to change regardless of method used for the delivery of training. However, to gain clearer insight of CIWS technicians training costs, management costs are estimated as follows:

Management Costs per year: $210,000 ($105,000 per individual x 2 staff)
Management Costs over life: $6.3 million ($210,000 x 30 years)

CIWS Support Costs

Support costs are not expected to change regardless of method used for the delivery of training. To gain clearer insight of CIWS technicians training costs, support costs are estimated as follows:

Support Costs per year: $550,000 ($55,000 per individual x 10 staff)
Support Costs over life: $16.5 million ($550,000 x 30 years)

CIWS Material Costs

Material costs are not expected to change regardless of method used for delivery of training. To gain clearer insight of CIWS technicians training costs, material costs are estimated as follows:

Material Costs per year: $5,000 ($25 per individual x 200 trainees)
Material Costs over life: $150,000 ($5,000 x 30 years)

CIWS Total Costs

By adding and comparing the costs of the three plausible delivery options over the 30-year life cycle, it is easy to foresee how the 11G2 Desktop Trainer can increase training efficiency by approximately $100 million over 30 year ($343.44 - $243.61) and reduce trainee's cost by over 29 % - $16,313 ($56,118 - $39,805).

	11G2	**VISTA**	**11G2 DT**
Development & Update Costs	$18.9 m	$18.9 m	$18.9 m
Hardware/Equipment Costs	$200.06 m	$208.97 m	$133.19 m
Instructor Costs	$84.915 m	$80.669 m	$56.61 m
Instructor Travel Costs	$1.215 m	$1.215 m	$1.215 m
Facility Costs	$6.24 m	$6.24 m	$6.24 m
Administrative Costs	$4.5 m	$4.5 m	$4.5 m
Management Costs	$6.3 m	$6.3 m	$6.3 m
Support Costs	$16.5 m	$16.5 m	$16.5 m
Material Costs	$0.15 m	$0.15 m	$0.15 m
Total Costs	**$338.78 m**	**$343.44 m**	**$243.61 m**
Number of Trainees	6,120	6,120	6,120
Cost per Trainee	**$55,356**	**$56,118**	**$39,805**

A closer examination of the table above reveals that potential savings are generated from Equipment Operation as well as Instructors Costs since the 11G2 Desktop Trainers minimize the time needed on the "Mount" Trainer which is far more expensive to operate and requires more instructor time.

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b. Productivity Gain

Since some delivery options can minimize time away from the job – by eliminating travel as well as compressing time needed to acquire the desired knowledge and skills – productivity gains can be computed as follows:

(Average Hourly Salary of Trainees [Employees] + Lost Productivity) x Reduction in Time Away from the Job x Number of Individuals Affected

For the CIWS training program under investigation, the computer based training option can reduce training time for the theory segment of the course by 108 hours (360 hours x 30%) or 13.5 days. Assuming the average annual salary of technicians to be $40,000 implies a daily cost of $174 ($40,000 / 230 working days per year). As a result, productivity gains can be computed as follows:

Productivity Gains per year: $479,196 ($174 per day x 13.5 days x 204 trainees)
Productivity Gains over life: $14.376 million ($479,196 x 30 years)

c. Organizational Benefits

Since the primary objectives of a training program is to develop skills, competencies and/or attitudes needed to attain business goals – i.e., resolve problems, create new opportunities increase competitive advantage, etc. – achieving goals quicker may have a significant impact on the organization's bottom line. The impact is computed by considering reduction in time to competency, as follows:

Anticipated Benefits per Day * Reduction in Time to Competency

Since the CIWS in the final line of defense, adequately operating, maintaining and troubleshooting the system (i.e., ensuring that it is fully operational) is the primary objective of the CIWS training program. Allowing technicians to bring the 11G2 Desktop Trainers on board ships will minimize the time needed to troubleshoot the equipment and minimize future risks.

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