THE CFA CONCEPT, A NEW APPROACH TO TRAINER ENGINEERING CHANGES IN THE FIELD

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INTRODUCTION

The practice of modification engineering or engineering change support as performed at NAVTRAEQUIPCEN is based on the premise that trainer service life extension and/or its conversion to a later configuration is an economical and feasible means of avoiding procuring additional trainers and having to pay the full production costs. This concept is similar to that used by NAVAIRSYSCOM in the conversion of aircraft. (Reference 1). Actually, the NAVTRAEQUIPCEN trainer conversion concept is not new. One of the earliest conversions I recall was that of the Device 2F16 F9F-5 OFT to the Device 2F46 F-1E (FJ-4) OFT in the late 1950s. Some of the facets of modification/modernization/ conversion, such as: what are these changes?, what is the magnitude of the program?, how is it being done?, and where is it going? will be covered in this paper. Let us look at the kinds of changes which need to be engineered.

The configuration and performance of the training device in the field and/or in acquisition can be affected by the following types of changes:

a. Trainer unique hardware/software changes: Those changes to the training device only (trainer hardware and/or software) which correct or improve trainer performance or modify trainer capabilities - better maintainability, improved safety, etc.

b. Changes to the operational tactical digital computer program tapes: Those changes to the operational digital computer programs and tapes which affect weapons system performance in such a way that changes to the training devices' performance may be required.

c. Changes to the hardware of the weapons system being simulated: These changes to the weapons system hardware (or conjunctive hardware/software changes) which affect weapon system performance in such a way that changes to the training devices' performance and configuration may be required.

A trainer hardware/software change categorization system is employed by NAVTRAEQUIPCEN in the trainer configuration management process to define the steps that must be followed for any change consideration. Proper categorization of trainer change requests will permit certain types of hardware/software changes to be implemented quickly without undue time delay or cost, while ensuring that changes with significant functional or performance and documentation impact are thoroughly evaluated prior to implementation. All potential changes to a training device may be assigned any one of four categories as defined in the following paragraphs:

a. Category TA - A change to the trainer software which requires a conjunctive change to the trainer hardware.

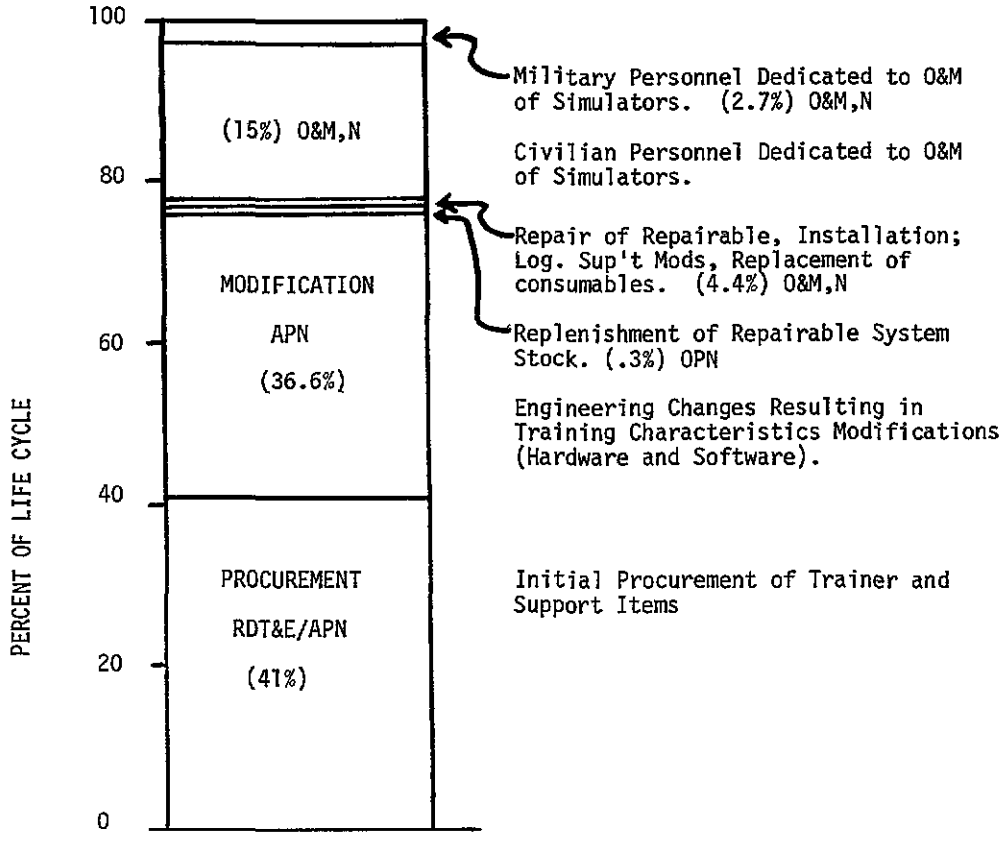
b. Category TB - A change to the trainer software only which affects (1) the functional configuration or performance of the trainer, or (2) requires changes to requirements or user documents such as trainer operator's manuals, training manuals, or trainer maintenance manuals.

c. Category TC - All other trainer software changes. Category TC changes are concerned only with efficient and accurate programming of trainer programs and may require modification of computer program design documentation. Examples of Category TC changes include modifying a computation so that it is performed in a fewer number of steps or so that it requires less storage, and correction of coding errors.

d. Category TD - A change to trainer hardware only which affects (1) functional configuration or performance of the trainer, (2) maintainability/reliability of the trainer, or (3) training improvements/ improved capability/training characteristics.

A second facet of the program is its relative magnitude. Look at the life cycle cost for a highly modified air/warfare class of trainers, the F-4 Aircraft Weapons System Trainers. Figure 1 shows the distribution of trainer costs among initial acquisition, replenishment of repairable supply system stock, operating and maintenance costs and finally the modification costs. The life cycle cost covers the period from about FY 1957 to FY 1982. This end date is not the

obsolescence date for the trainers but the current limit on computation of costs. It can be seen that the initial acquisition cost and that spent on modifications to date are nearly equal (41 versus 36.6%) and that the integrated logistics support and operating costs are about 22% of the life cycle cost to FY 1982. The total life cycle cost from about 1956 to 1982 is estimated at $68¾ million.



NOTE: Funding Identification - O&M,N: Operation and Maintenance, Navy; OPN: Other Procurement, Navy; APN - Aircraft Procurement, Navy: RDT&E: Reasearch, Development, Test and Evaluation, Navy.

Figure 1. Life Cycle Cost of a Highly Modified Air Warfare Trainer (FYs 1957 - 1982 Period).

The next two facets: How is it being done and where is it going will be covered by the balance of the paper.

THE COGNIZANT FIELD ACTIVITY (CFA)CONCEPT

By Department of Defense directives there are three levels of maintenance - organizational, intermediate, and depot. Generally, depot level maintenance organizations are also authorized to perform modifications. The term depot level maintenance would apply equally to an industrial type effort such as that performed by the original equipment manufacturer (OEM) or that performed by an industrial like government activity. The maintenance concept for training devices tends toward two levels - organizational and depot level. This then restricts the level of modifications to two also - the small tasks which do not require special equipment to install the changes or consume more than a few days to install, and the large tasks which require fabrication and assembly of components or changes in digital computer programs beyond the capability of the user or organizational maintenance personnel. The trainer modification engineering project engineer, when investigating a proposed trainer change, must determine the level of resources available to implement the change. Thus, should the change be performed under contract by an industrial concern/software house or by within-the-Navy resources? Pursuing the division of labor further, there is also the question of who has the engineering capability to develop the engineering change and can supply the changes to the integrated logistic support items and to the technical documentation. Further, by directive of the Chief of Naval Education and Training Support (2) specifically assigned levels of authority to perform modification engineering were provided for the efficient use of personnel and resources. These levels are:

Level 1 - Those engineering changes which may be performed by the custodian/using activity providing that the change is less than 40 man-hours (design, debug, installation and documentation); does not affect hardware; does not affect the operational computer programs.

Level 2 - Any change which, through circumstances, cannot be performed by the user as a Level 1 change or which requires hardware, conjunctive hardware/software or operational computer software changes and is less than 1,000 man-hours (design, debug, installation and documentation).

Level 3 - Any change exceeding the limits of Level 2.

In conjunction with these performance levels are the assigned levels for authorizing the changes as follows:

a. Level 1 - At the discretion of the CFA, and in coordination with the custodian/user, approval authority may be assigned to the user to perform those changes defined as Level 1. Changes to be accomplished at this level must be concurred in by the CFA. Documentation developed as a result of a Level 1 change is to be provided to the CFA for coordination with other device users. If coordination dictates no other user requirement for the change, the change can be classified as "local" and may not be incorporated into the baseline documentation by the CFA. Dedicated memory locations will be established by the CFA and utilized for this purpose.

b. Level 2 - All changes exceeding the character and limitations established for a Level 1 change will be submitted in accordance with reference (6). The CFA will provide all services, material, and documentation necessary to perform and support the required changes up to 1,000 man-hours of design, debug documentation and installation. This action will be accomplished within the control parameters established by NAVTRAEQUIPCEN. Changes exceeding 1,000 man-hours may be assigned to the CFA on an exception basis and with CNET SUPPORT concurrence.

c. Level 3 - Those changes exceeding the Level 1 and 2 will be forwarded to the NAVTRAEQUIPCEN for further action in accordance with reference (6). Decisions regarding further implementation will be provided by the NAVTRAEQUIPCEN in conjunction with the appropriate sponsoring agency.

You will notice that this distinction in levels of performance and authority is different from the Naval Air Systems and the former Naval Ordnance Systems Command approach to delegation of engineering effort for service equipment. (References (3) and (4)). For these two Commands, upon completion of equipment production, full engineering responsibility for a specific weapons system is transferred to a field activity; and the field activity performs the same engineering functions and technical coordination that the Assistant Program Manager did at Headquarters. (Reference(5)).

Assignments of limited engineering responsibility of specific trainers were started in 1975 by requesting the CNET SUPPORT field activities to recommend training equipment which, because of geographic location and/or developed experience, can best be assigned to their cognizance. The proposed assignments would provide efficiency in engineering change design effort and would develop organizational expertise in particular units of training equipment. The items included would be characterized by a high-level of complexity and an expected high-incidence rate of engineering changes during its life cycle. The first list of assignments under this concept was issued in July 1977.

Some definitions of terms are now in order so that the concept operation will be easier to follow later on.

a. Engineering Change Support (ECS) or Modification Engineering. The engineering effort necessary to add to or alter the design of an equipment in such a manner or to such an extent as to change its operational capabilities or its design attributes of performance, reliability, maintainability, safety, operability and parts interchangeability or to render it capable of alternative or additional use. The resultant design change includes baseline maintenance of support documentation, computer software, and support material.

b. Cognizant Field Activity (CFA). The field activity of the Naval Education and Training Support Command designated to perform engineering change in support of specifically designated training equipment.

c. Software Support Activity (SSA). An organization designated to perform digital computer software support. Unless specific circumstances require separate consideration, simulator computer software support responsibility is integral to the assignment of CFA responsibility.

d. Computer Software Support. Engineering change support as related to simulator digital computer software, including:

(1) Modifications to computer software as necessary to meet training or logistic support requirements.

(2) Design and development of new computer software as required.

(3) Baseline management of computer software involving the identification, collection, storage, reproduction and distribution of computer programs and associated documentation essential to daily operations.

(4) Computer program housekeeping including assembly/compile operations and those design, development and modification functions concerned with the clarity and efficiency of computer programs.

e. Operational Computer. That portion of the weapons system computer used in training equipment.

ENGINEERING CHANGE SUPPORT AT THE CFA LEVEL

At this point we will focus on the performance of engineering change support which is to be performed at the CFA level. Figure 2 shows the resources available to perform various levels of modification and the relation of the CFA to these levels.

Functions of the CFA. These functions are defined in relation to the deployment date or the Ready-for-Training (RFT) date of a specific training device. Those performed prior to the RFT date are:

a. Assumes assist position to NAVTRAEQUIPCEN during the acquisition process. In this capacity, the CFA will:

(1) Generate and develop the engineering change support plan. This effort is to be accomplished in coordination with the development of the simulator Life Cycle Logistic Support Plan addressed by Reference (7). Details regarding plan format are provided in Volume 1 of the approved outline for the Life Cycle Logistic Support Plan. The Engineering Change Support Plan shall be submitted to CNET SUPPORT via the NAVTRAEQUIPCEN.

(2) Provide inputs in establishing the composition of the data and training required to the NAVTRAEQUIPCEN to ensure inclusion in trainer acquisition budget submissions.

(3) Perform reviews of Training Equipment Change Proposals (TECP) and to provide appropriate comments.

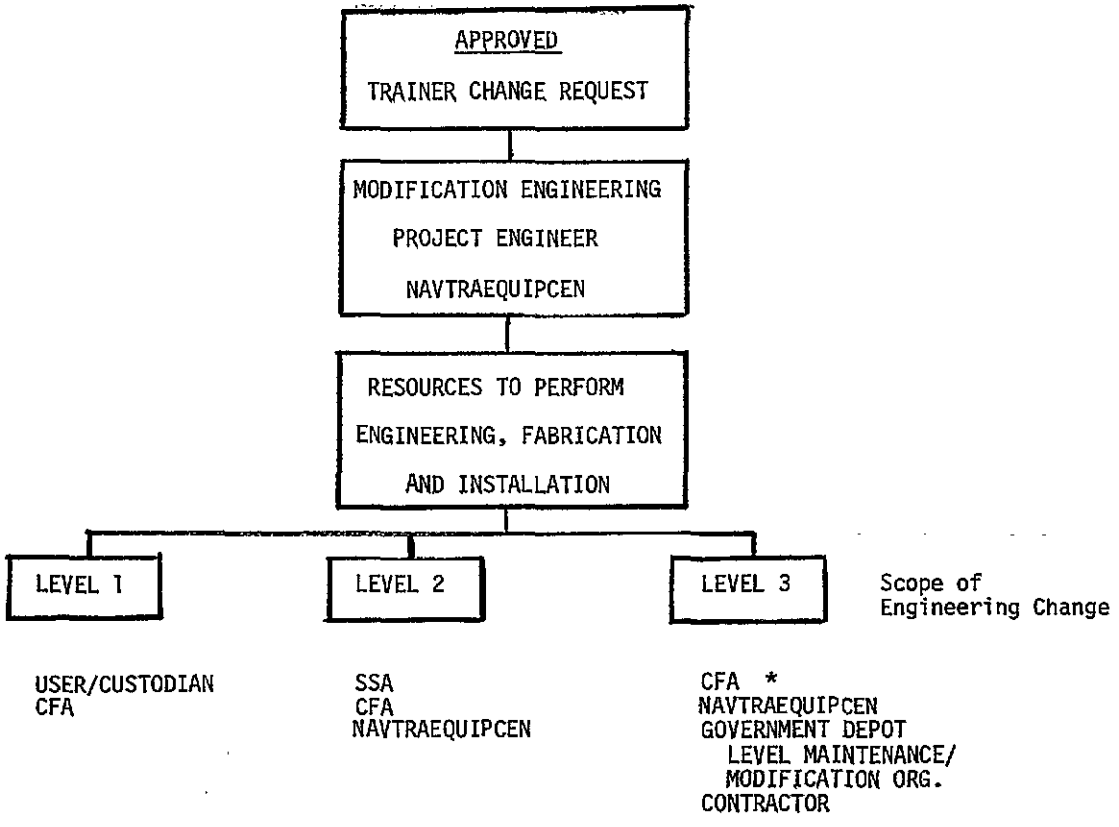
(4) Attend the in-plant test and acceptance of the equipment and may attend design, technical, contract or Fleet Project Team conferences and meetings as requested. Assignment of this responsibility should not be construed as assignment to a specific division/department within the CFA. It would be expected that group travel requirements

are minimized through the use of a single representative to address all interests (Field Engineering Representative support, simulator modifications, etc.) of the field activity whenever possible.

(5) Participate in the configuration Management configuration physical audits.

Those functions performed after the RFT date are:

a. Acts as the single activity for the accomplishment of Level 1 and 2 engineering changes in the field. The changes undertaken are to be performed in accordance with reference (6) and to the limits promulgated by the NAVTRAEQUIPCEN.



* If Authorized

Figure 2. Engineering Change Support Resources

b. Investigates variances in change requirements and recommends appropriate solutions including:

(1) An operational and functional description of the problem and recommeded solutions.

(2) A technical approach to the problem including a definition of the performance effectiveness of the training system with and without the change.

(3) Cost and scheduling information for implementing the change by the CFA.

c. Designs and develops trainer engineering changes with associated revised documentation. (Digital computer programs would be issued as updated iterations of the baseline data.)

d. Maintains the identified baseline reflecting field originated changes and other changes as assigned.

e. Responds to trouble reports related to the engineering change program.

f. Interfaces with user activities in the coordination of change requirements.

NAVTRAEQUIPCEN FUNCTIONS. To assist the CFAs in performing their function the Naval Training Equipment Center will get them involved as soon as practical during the equipment conceptual phase. It is during this phase that necessary planning and direction will take place which will ultimately lead to a successful operationa phase engineering change support program. Assignment of a CNET SUPPORT Field Activity as CFA on a simulator or family of simulators is one which constitutes a commitment of the resources/expertise of the entire activity.

a. Upon issuance of the initial planning documents designating the firm requirement for a new item of training equipment, the NAVTRAEQUIPCEN will recommend the appropriate field activity to serve as the CFA and notify the designated activity by formal correspondence. The letter will be released via CNET SUPPORT.

b. Provide Military Characteristics, Program Master Plans and related procurement documentation to the CFA.

c. Provide the CFA with a list of deliverable data items under the terms of the training equipment contract and place the CFA on automatic (identification on DD Form 1423) distribution of selected data items.

d. Provide the CFA information on program and technical conferences and meetings.

e. Solicit CFA for technical data and training requirements and include requirements in subsequent acquisition planning.

f. Provide the CFA with contractor submitted Trainer Engineering Change Proposals (TECP) for comments and recommendations.

After the trainer RFT date, the Naval Training Equipment Center will:

a. In accordance with its assigned mission, provide overall engineering direction for the implementation and control of the engineering change program.

b. As appropriate, provide the CFA with information regarding non-field originated change requirements (AFC's, ORDALT's, SHIPALT's etc.) for review.

c. Provide contract administration services for contractor engineering support services to supplement the CFA's manpower resources.

Responsibilities of the CFAs. As soon as a CFA is designated for a specific training device or family of trainers it is to plan for the implementation of the hardware/software transition from trainer development contractors to in-service activities through an orderly and systematic approach. To achieve the objective of the task it is necessary to:

a. Establish, train, and maintain a dedicated group of personnel to provide engineering change support services for the assigned trainers.

b. Establish a documentation data base to support the engineering change support task.

c. Review applicable ECP's and prepare TECPs in accordance with MIL-STD-480.

d. Respond to field requested modifications in accordance with reference (6).

e. Implement approved changes resulting from approved cost and lead time estimates.

f. Provide task management/coordination for successful completion of the transition.

The success of the transition schedule hinges heavily on three factors: technical competence, satisfactory baseline documentation, and a realistic, agreed upon development contractor phaseout schedule. As such, transitioning of training device support from development contractor to an in-service facility is predicated on:

a. Requested CFA team training being approved and implemented.

b. Required engineering data/documentation being obtained in a timely manner.

c. Phase out of trainer development contractor being accomplished according to the Navy hardware/software transition schedule.

The phaseout of development contractors will be accomplished according to a three-phase schedule agreed upon by the trainer development contractor, training equipment sponsor, NAVTRAEQUIPCEN, and the CFA. The three phases are:

Phase 0 - (1) Provide and assign personnel to the designated family of trainers and through a coordinated training plan, obtain required weapons system technical expertise, (2) Make provisions for the obtainment of a configuration end item documentation data base, (3) Consolidate training plans into a master training plan to be forwarded to trainer sponsor, (4) Review ECPs and modification requests to be accomplished under an in-service effort, (5) Establish a central trainer documentation data base repository, and (6) Coordinate with development contractors and trainer sponsor for orderly and timely transition.

Phase 1 - This phase is a combined effort involving both the in-service activities and the development contractors. It is during this phase that both the in-service activities and contractors coordinate the incorporation of the current engineering changes. Upon completion of these changes, the baseline will be documented and all data will be delivered to the in-service activities for continuation of the engineering change support program.

Phase 2 - In-service Engineering Change Support Program is established and in operation.

I will now explore one facet of this operation in more detail.

Recording of Engineering Changes and Their Distribution. A central repository for hardware/software documentation data for each trainer is established at the NAVTRAEQUIPCEN. The central repository contains and constitutes the master files for the specific trainer ECS task and, as such, will be under the control of the NAVTRAEQUIPCEN. The central respository is designated as the central point for accounting of all data for the assigned specific training equipment. The CFA will have cognizance of working documentation and will forward revised master reproducibles to the central repository for filing as they are generated.

It must be noted that, prior to the issuance of any hardware or software baseline data to effect a contractor modification effort, the CFA will be consulted by NAVTRAEQUIPCEN. This action is necessary since the repository may not house the most up-to-date data due to in-house ongoing modification efforts, lag time inherent in the documentation chain, etc.

Types of documentation to be stored in the central repository are:

a. Reproducibles of engineering and maintenance drawings.

b. Reproducibles of maintenance handbooks.

c. Historical engineering hardware/software reports such as design reports.

d. Instructional material applicable to on-site and factory training courses.

e. Documentation required for support of computer programs and tape update (i.e., Master Tapes, Listings, Computer Hardware Manuals, etc.).

The CFA has generally identified to NAVTRAEQUIPCEN the documentation required to support its hardware/software efforts. Data requirements for specific trainers can be adjusted when recommended by the CFA acting in consonance with representatives of the users.

To ensure the adequacy of the baseline documentation and to ensure its availability for an in-service effort, the following actions will be taken by the NAVTRAEQUIPCEN:

a. Define certain software data per SECNAV Instruction 3560.1.

b. Establish a review process/cycle for both hardware and software documentation between the NAVTRAEQUIPCEN and the CFA.

c. Include the CFA on the appropriate DD 1423s for automatic receipt of documentation.

d. Establish a firm schedule for documentation delivery.

e. Ensure the adequacy of data procured by use of the CFA review process for specific devices.

f. Ensure that trainer sponsor is aware of documentation procurement efforts and the possible resultant problems if it is not procured due to shortage of funds.

The primary categories of documentation affected by software/hardware changes to the specific trainer are:

a. Requirements documents such as trainer system performance specifications.

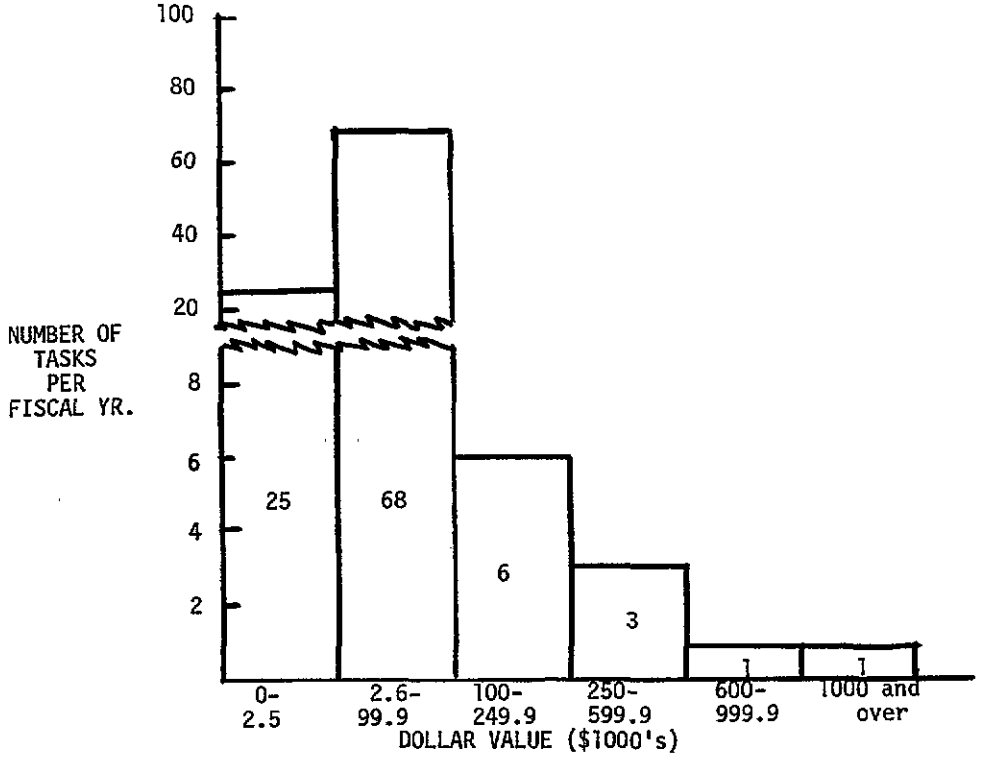
b. Design documents such as computer program performance and design specifications, detailed program and subprogram design documents, design description drawings, trainer program listing, manufacturing and maintenance drawings, Criteria Reports.

c. User documents such as maintenance publications, training manuals, lecture materials and PMS cards.

d. Internal documentation required for the configuration management process.

e. Test plans and procedures.

Maintenance of trainer system specifications will be the responsibility of the NAVTRAEQUIPCEN as provided for in MIL-STD-480. Control of working master design documentation is the responsibility of the CFA. In addition, the CFA will identify and describe the impact of trainer hardware/software design changes on all documentation.



MODIFICATION PROGRAM BY DOLLAR VOLUME OF TASK
(5 YEAR AVERAGE) AS OF FY 77
FOR ALL LEVELS OF EFFORT

Figure 3.

Updating user documentation such as trainer maintenance manuals, training manuals, lecture materials will be the responsibility of the NAVTRAQUIPCEN who is also responsible for integrating software design change information into this user documentation. Test plans and procedures will be developed and updated by the CFA as required to support applicable design, integration, verification and acceptance testing responsibilities. Approval of these documents will be the responsibility of NAVTRAEQUIPCEN. The computer programs will be revised by the CFA to reflect changes made to the program. Patches will not be issued. The revised reassembled computer program will be incorporated into the change kit for distribution. Revised masters will be provided to NAVTRAEQUIPCEN for approval and storage in the master repository.

MODIFICATION WORKLOAD

What is the magnitude of the modification workload? If we take the statistics for a recent year, we can see the distribution of effort. Figure 2 showed the performers by level of effort. The next figures give some specific directions for the effort. Figure 3 shows the distribution of dollar volume of modification effort. Shown is a 5 year average through FY 1977 and indicates that most modification tasks are in the under $100,000 value. The number in this dollar value range is actually larger as modifications costing $5,000 or less for aviation trainers or $20,000 or less for surface and sub-surface trainers may be lumped together and authorized in a group as a single task.

Another way of looking at the workload is by warfare areas. Table 1 shows the numbers of tasks assigned, irrespective of funding levels, to the CFAs. The number of modification tasks performed for aviation trainers greatly exceeds those assigned for all the other warfare areas. This is only natural since presently air warfare trainers represent 77% of all

TABLE 1. MODIFICATION TASKS BY WARFARE AREAS ASSIGNED TO CFAs IN FY 1978

WARFARE AREA	NUMBER OF TASKS
AIR	218
SURFACE	69
SUBSURFACE	28
LAND (MARINE CORPS)	6
TOTAL	321

MODIFICATION TASKS BY WARFARE AREAS ASSIGNED TO CFAs IN FY 1978

trainers in inventory. While no discussion has been presented of the implementation of trainer digital computer program changes, Table 2 shows the distribution of effort in the CFAs between hardware and software changes. This figure shows only the training characteristics modifications (two of the three types described earlier) but these would represent about 90% of all modifications. It can be seen that for air warfare trainers hardware changes still predominate probably due to the nearly constant introduction of weapon system hardware changes while in the surface-subsurface area the software changes are a slight majority. This might be due to the refining of ocean environmental models or SENSOR/TARGET characteristics as well as increasing the capability of the instructor's station and the trainer as a whole. Future trends in workload can be looked at two ways by yearly trends and product mix. Table 3 shows the growth in the total modification engineering program and the in-house or CFA share of the program. Future years funding has not been definitized but it looks like it will grow. Note that the in-house share of program is not increasing as rapidly as the total program. The other way to look at the program is by product mix. Table 4 shows the present distribution of training equipment in use by warfare area and the projected mix in Fiscal Year 1984 based on present acquisition trends. You can see that the total share of nonaviation devices has grown from 23% to 36.5% of total inventory. What does this mean on workload? Table 2 showed that the surface and subsurface trainer modification was software change intensive, thus the conclusion could be that by Fiscal Year 1985 or so the major CFA labor effort will be in software as opposed to the current hardware intensity.

WARFARE AREA	HARDWARE	SOFTWARE
AVIATION	82.3 Man-Years	51.5 Man-Years
SURFACE-SUBSURFACE	9.4	10.8
TOTAL	91.7 Man-Years	62.3 Man-Years

TABLE 2.
TRAINING CHARACTERISTICS MODIFICATIONS ONLY:
DISTRIBUTION OF EFFORT BETWEEN HARDWARE
AND SOFTWARE (FY 78)
ASSIGNED TO CFA's

FISCAL YEAR	DOLLAR VALUE ($1000's)	IN-HOUSE (CFA) SHARE ($1000's)
1978	$15,000 (Approximate)	$3,760 (Approximate)
1977	11,938	3,013
197T (1/4 Year)	1,638	636
1976	5,475	2,742
1975	4,166	2,485

TABLE 3.
TOTAL MODIFICATION ENGINEERING PROGRAM TREND
(ALL LEVELS OF EFFORT)

	EQUIPMENT IN USE FY 77	ANTICIPATED AGGREGATE FY 84
AIR	77.0%	63.5%
SURFACE	15.3%	25.4%
SUBSURFACE	7.7	11.1%

TABLE 4.
DISTRIBUTION OF IN-USE ASSETS BY WARFARE AREA CURRENTLY AND IN FY 84

CONCLUSION

In conclusion, we can make a number of general statements about the Modification Engineering Program and the CFAs. The Modification Engineering Program is an approach used by the NAVTRAEQUIPCEN to extend the life of current training equipment and conform them to the everchanging operational weapons systems they provide training for. On a specific trainer life cycle cost comparison, the modification costs can nearly equal the initial acquisition costs but are spread over a larger time frame. Most modification tasks are under $100,000. The CFAs provide an engineering service to the NAVTRAEQUIPCEN during the acquisition phase and after RFT take on the major engineering change responsibilities for small changes. The CFAs' workload will increase but not at the same rate as that of contractor performed modification tasks. And finally, the CFAs expand the NAVTRAEQUIPCEN in-house engineering labor base.

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