UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Utilization of test and evaluation results in weapons system acquisition process as applied to naval surface ship systems		5. TYPE OF REPORT & PERIOD COVERED Final - Oct. '76 - June '77
		6. PERFORMING ORG. REPORT NUMBER W-78-N204-2
7. AUTHOR(s) Richard E. Foster, Richard L. Cochrane, William H. Pattillo, Charles G. Stephens		8. CONTRACT OR GRANT NUMBER(s) N00014-76-C-1156
9. PERFORMING ORGANIZATION NAME AND ADDRESS Wheeler Industries, Inc. 1120 - 19th Street, N.W. Washington, D.C. 20036		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS 031112
11. CONTROLLING OFFICE NAME AND ADDRESS Commander Operational Test and Evaluation Force U.S. Naval Base Norfolk, Virginia 23511		12. REPORT DATE 30 December 1977
		13. NUMBER OF PAGES 77
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office) Office of Naval Research Code 230 800 North Quincy Street Arlington, Virginia 22217		15. SECURITY CLASS. (of this report) UNCLASSIFIED
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE Not Applicable

16. DISTRIBUTION STATEMENT (of this Report)

Distribution unlimited

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Test and Evaluation
Gas Turbine Propulsion
Sonar Systems
Gun Fire Control Systems
Combat System Integration
Ship Acquisition
System Development

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report documents the results of a comprehensive review of four surface ship subsystem developments, acquisition, test and evaluation, with emphasis on the use of test and evaluation results in the acquisition process decisions. The systems studied: (1) DD 963 Class Propulsion System; (2) CGN-36 Class and CGN-38 Class Combat System Integration Effort; (3) MK-86 Gun Fire Control System; and (4) SQS-56 Sonar.

FINAL TECHNICAL REPORT
W-78-N204-2
30 DECEMBER 1977

UTILIZATION OF TEST AND EVALUATION RESULTS IN WEAPONS SYSTEM ACQUISITION PROCESS AS APPLIED TO NAVAL SURFACE SHIP SYSTEMS

Prepared for
Commander, Operational Test and Evaluation Force

under
ONR Contract
N00014-76-C-1156

WHEELER INDUSTRIES, INC.
1129 Twentieth Street, N.W.
Washington, D.C. 20036
(202) 659-1867

FINAL TECHNICAL REPORT
W-78-N204-2
30 DECEMBER 1977

UTILIZATION OF TEST AND EVALUATION RESULTS IN WEAPONS SYSTEM ACQUISITION PROCESS AS APPLIED TO NAVAL SURFACE SHIP SYSTEMS

Prepared for
Commander, Operational Test and Evaluation Force

under
ONR Contract
N00014-76-C-1156

WHEELER INDUSTRIES, INC.
1129 Twentieth Street, N.W.
Washington, D.C. 20036
(202) 659-1867

TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

TABLE OF CONTENTS (continued)

TABLE OF CONTENTS (continued)

TABLE OF CONTENTS (continued)

LIST OF FIGURES AND TABLE

UTILIZATION OF TEST AND EVALUATION RESULTS
IN WEAPON SYSTEM ACQUISITION PROCESS
AS APPLIED TO
NAVAL SURFACE SHIP SYSTEMS

EXECUTIVE SUMMARY

Testing is one of management's key controls in the complex process of acquiring major systems for the Navy. Information obtained from testing provide some of the first clues to potential equipment problems and serious cost growth. With inadequate or invalid testing, or by disregarding failures or problems indicated by the tests, management is depriving itself of a prime tool for promptly and efficiently developing effective systems. Deficiencies discovered and corrected during testing can reduce costly retrofit or redesign problems and costly delays in the scheduled delivery of weapon systems.

The four Test and Evaluation Case Studies in naval surface ship systems illustrate the diversity of development and acquisition programs and a wide variation in the problems encountered, actions taken, and results achieved. Case Study #1 - DD963 Gas Turbine Propulsion System is a classic case of a new naval propulsion system committed to a large ship acquisition program without the benefit of prototype installation tests at sea in a Navy ship and before the research and development results were fully available. Case Study #2 - the SQS-56 Sonar, developed under the latest defense system acquisition policies, illustrates those developments that continue on a fixed schedule despite major problems and a low probability of success. Case Study #3 - the Mark 86 Gun Fire Control System - had a long development cycle with major capabilities added during development, as well as concurrency of development and production. Case Study #4 -Combat System Integration of CGN-36 and CGN-38 - provides an example of "before" and "after" in which the experience in the CGN-36 provided solutions for the combat system integration in the CGN-38. Also the results of partially implementing DOD 5000 series of directives are evident in the CGN-38 integration effort.

The Case Studies are documented as of June 1977 at which time a draft report was submitted to the Commander, Operational Test and Evaluation Force (COMOPTEVFOR). This final report dated 30 December 1977 revises the draft report based on comments received from the Navy Material Commands and COMOPTEVFOR. No attempt has been made to update the case studies beyond June 1977.

CASE STUDY #1 - DD963 PROPULSION SYSTEM

Litton was awarded the contract for the detail design and construction of the 30-ship DD963 Class in June 1970 under a single package procurement. The Pratt and Whitney FT-4A gas turbine propulsion system with controllable pitch propellers was specified. The propulsion system had not been tested at-sea in a Navy ship with a Navy crew. However, the FT-4A was a fully developed gas turbine having operated in the MSC ADM CALLAHAN for over 20,000 engine hours. Controllable Pitch Propellers (CPP) in the 40,000 hp size had not been produced although two designs were scheduled for sea tests in 1971. During the time that the DD963 was in the Contract Definition phase of design, the Ocean Escort Program (one experimental ship) was in the budget (FY69) and would have provided early prototype propulsion testing. The Ocean Escort program was subsequently cancelled.

Litton's Test and Evaluation (T&E) Plan called for integration tests of one-half ship set of propulsion at NAVSEC, Philadelphia. However, the scheduled completion of the Builder's Trials of the DD963 was 2 months before completion of the 1,000-hour integration test at Philadelphia.

Based on successful operations of the LM2500 gas turbine in the ADM CALLAHAN and a savings of $28 million in acquisition cost and an estimated $120 million in fuel savings, a change order was approved in December 1970 for installation of the LM2500 gas turbine vice the FT-4A. In this instance, T&E results, indicating improved performance and lower cost, had a significant effect on an acquisition program.

Despite delays in the CPP development program and apprehension in the CNO that the Navy's gas turbine development program needed acceleration,(9) funds were committed for the FY72 seven-ship increment.

Tests of the one-half ship set of propulsion at NAVSEC Philadelphia were delayed and extensive redesign and field modification of the control system were required. As a consequence, training, technical documentation, supply support, and operational problems developed. The propulsion control system would have caused serious delays in the DD963 program had the program not been delayed due to other ship production problems.

The catastrophic failure of the developmental CPP in the BARBEY (FF-1088) in August 1974 promptly led to a reanalysis of the DD963 propeller. Full-scale trials of the BARBEY and the SPRUANCE (DD963) were conducted to verify CPP design criteria. In retrospect, it is evident that the technology base for propeller design had not advanced far enough to simply scale up CPPs to 40,000 hp without supporting DT&E.

Low level RDT&E funding for non-nuclear propulsion in the 1960 decade did not permit development of a gas turbine propulsion system in frigate/destroyer power range. Lack of success in earlier attempts to receive authorization for gas turbine propelled ship design and construction contributed to the problems developed in the DD963 Program.

CASE STUDY #2 - AN/SQS-56 SONAR

In June 1971 CNO selected the SQQ-23 as the FFG-7 Class sonar, and approved the Advanced Procurement Plan for the SQQ-23 in January 1972. To meet the cost and size constraint CNO decided in May 1972 to specify a "Generic SQS-505" for the FFG-7 Class. The SQS-505 was considered a low risk sonar since it had been approved for service use in the Canadian Navy. No sonar operational requirements were formally approved by CNO during the development of the FFG-7 sonar.

NAVSHIPS proposed that a Request for Proposal (RFP) be let to four sonar candidates, to select two sonars for prototype development and determine the FFG-7 Class sonar by competitive T&E. The SQS-505 was the lowest risk of the four candidate sonars. The CNO found the competitive approach unsuitable for the lead ship and requested that action be taken to procure the SQS-505 sonar from Westinghouse Canada for the lead ship and competitively select the sonar for the follow ships.

It was decided to procure the SQS-505 from Westinghouse Canada for the lead ship and competitive procurements for the follow ship. However, the Office of the Secretary of the Navy in November 1972 denied the exception to "Buy America."

Competitive procurement was initiated and three proposals were received by 3 February 1973. Raytheon's DE-1160 (subsequently designated AN/SQS-56 (XN-1)) sonar was selected as the FFG-7 Class sonar. The Technical Development Evaluation (TECHEVAL) was concluded in April 1975. Because of the construction schedule of the ship, NAVSEA, in order to meet this schedule, certified that the sonar was ready for OPEVAL with identified deficiencies and on the basis of requesting Provisional ASU. This was done over the objection of OPTEVFOR. Another concern of the SHAPM and of CNO was that a failure to have a sonar ready for OPEVAL might jeopardize a DSARC III decision for follow-on FFG-7 ships.

The sonar OPEVAL was completed in August 1975 and evaluated as not operationally effective and not recommended for service use. Virtually every problem area reported in TECHEVAL was still present during OPEVAL. Despite the fact that the sonar was not approved for service use the follow-ship production was approved.

The failure to define rational operational performance thresholds early in the SQS-56 development cycle which correlated with the technical thresholds established by NAVSEA's interpretation of CNO's requirements, ultimately resulted in poorly defined T&E procedures and subsequently contributed to the sonar's failure in OPEVAL. Decisions were primarily based on cost and schedule as opposed to performance and test results.

CASE STUDY #3 - MARK 86 GUN FIRE CONTROL SYSTEM

The Mark 86 system is a dual purpose gunfire control system capable of multiple target tracking and engagement of targets. The newer classes of LHA, DD, and CGN types have the system installed as a component of their combat systems.

The developmental period has been greater than a decade. The initial system had only a surface capability and, as the program developed, an AA capability was added. In some modifications the system was provided with additional capability to control a standard missile.

The system has received three comprehensive concurrent TECHEVAL/OPEVAL evaluations. Each one reported the system to have a sound design and to demonstrate promising capability toward satisfying the currently specified Operational Requirements. Each evaluation also reported major problem areas that required resolution.

The study analyzes the major Decision Points in the program development. The T&E impacts are considered at each Decision Point. Successive design reviews associated with each Decision Point reported minimal technical risks in the system and recommended that the program should continue. The three evaluation programs reported severe problem areas that required resolution.

OPTEVFOR had no task assignment to participate in the program until the testing began for the first OPEVAL on the USS BARRY.

Following the third OPEVAL, the CNO approved the system for service use, provided certain conditions were met by NAVORD.

The study concludes that (1) Technical risks had existed in greater degree than reported by the review groups; (2) Concurrency of development and procurement was too great as revealed by T&E; and (3) T&E inputs during initial development efforts are necessary to provide early risk identification and orderly progress.

CASE STUDY #4 - COMBAT SYSTEM INTEGRATION CGN-36 and CGN-38

The failure of the Integrated Combat System of the USS CALIFORNIA (CGN-36), during her Acceptance Trials on 3-4 Jan 1974, caused a comprehensive introspective review, by the Chief of Naval Material, of the Navy's management practices in the acquisition of ships with modern sophisticated Combat Systems. The details of individual areas of deficiency in the case of CALIFORNIA have been clearly developed, and are discussed in the body of the report with respect to their impact on changes made in the management of CGN-38 Class acquisition. It is important to note in the study of these deficiencies that, by and large, the errors were errors of management. Although problems did surface in the areas of hardware, software, and inadequate testing, it was the management of these areas that was deficient.

The Chief of Naval Material stated that, as early as June 1968, the Navy recognized that the combat systems of the CGN-36 Class represented a quantum increase in complexity over previous designs.[77] Specific testing requirements were imposed on the Contractor by amendment to the contract,[57] by providing a Combat System Test Plan (CSTP) including an Integrated Test Package (ITP) to be used by the Shipbuilder to identify and correct problems as they occurred. Nonetheless, it is evident from a study of the evolution of the ship, that few people recognized the total magnitude of the task in the integration of the Combat System of CGN-36. In short, none of the management echelons with responsibilities in the acquisition program had a full appreciation of the risk involved in the integration effort.

The Ship's Characteristic document was promulgated by CNO in 1964. Change #1 to this document, issued in August 1965,[74] specified the GFCS Mk 86 and MFCS Mk 74-4. Preliminary and Contract designs were completed in 1965 and 1967 respectively. Even at this time there was a general lack of understanding of real-time computer programming and of conceptual Combat System Integration. As a result, there was no Total Combat System Performance Specification written or developed in any contractual document.

CNM, through the SHAPM, had a partial awareness of the problem; however the responsibility for the integration of weapon systems was not vested in any single overall management office. Individual PARMs were expected to cooperatively solve their interface problems with each other and it was expected that the total system would then be refined during COT Tests and OPFCO. In actuality, each of the PARMs was so involved in solving problems internal to his own systems, that there was little or no time for an integration effort.

The Combat Systems Test Development Manager and the test team which resulted were established and funded by the SHAPM in recognition that a total system test requirement existed.[75] However the effectiveness of this team was seriously reduced by the lack of line management authority of the TDM to direct and enforce the test program.[59]

The problems in CALIFORNIA occurred as a result of a loss of test discipline by the SHAPM and virtually all of the participating managers. Contributing to this breakdown were higher than anticipated failures in Government-furnished hardware and software and Contractor inexperience in sophisticated combat system requirements. The PCO Reports gave a continuous monthly summary of unsatisfactory documentation, progressive slippage of the test program, material failures, and software computer program deficiencies (Tab B). In August 1973, it was recognized that an "extremis" situation existed and on 22 August, in the offices of CNO, a decision was made to accept the ship on completion of the Contractor's work and for the Government to complete the work required post-delivery. This was documented in SUPSHIPS Code 154 Memo of 27 Aug 1973.(56) OPFCO and COT were conducted as scheduled, knowing that the ship was not ready. Waivers were requested by NAVSHIPS 221821Z of Dec 73, approved by CNO 2714582Z of Dec 73, and the ship was presented to INSURV on 2-3 Jan 1974.

The results of the Acceptance Trials were as anticipated. The Board of Inspection and Survey (INSURV) found the Combat System not ready for an operational test due to numerous hardware and software problems.(55)

The CALIFORNIA experience provided a wealth of "lessons learned" which greatly improved the management procedures in the acquisition of modern Combat Systems. Many were implemented immediately and were fruitful in the CGN-37 and CGN-38 programs. The establishment of a centralized overall Combat System Manager within the office of the SHAPM provided a single management responsibility. A reorganization and strengthening of the SUPSHIPS combat systems personnel and an improved discipline for the configuration control of hardware and software elements of the Combat System made the flow of work, particularly the T&E program for CGN-37 and 38, more effective than with CGN-36.

Of equal significance in the case of VIRGINIA was the implementation of the DOD 5000 series of Directives. Beginning in mid-1971, a series of new policies, procedures, and responsibilities were promulgated to govern the acquisition process. T&E was emphasized and each DOD component was charged with responsibilities to insure that T&E requirements were met. DOD Directive 5000.3, issued in January 1973, established specific direction for T&E and its governing impact on program milestone developments. Prior to this, a DEPSECDEF memo to SECNAV dated 13 Oct. 1972(64) established these same T&E concepts specifically for VIRGINIA except for the requirements of Initial Operational Test and Evaluation and the use of the results therefrom in the program approval process.

While the advent of DOD 5000.3 was too late for application in the CGN-36 acquisition, it was applicable to CGN-38 Class ships. Unwittingly, the Navy was thereby providing two similar programs, inevitably for comparison purposes, one of which was to conform to the 5000.3 Directive and one which did not.

Although OPNAVINST 3960.10 which implemented these new policies in detail was not promulgated until Oct 1975, the context and content were well known early in the year. The T&E program for VIRGINIA was modified to conform; and even though a Test and Evaluation Master Plan (TEMP) for the

CGN-38 was not officially signed until after ship delivery, the plan was effective in context for all later phases of the T&E effort. The great significance of 3960.10 is the early inclusion of OPTEVFOR responsibilities in the acquisition cycle. It enforces a liaison between the Development Agency and OPTEVFOR and an exchange of T&E data and planning that permits an overall TEMP, a single document to cover the T&E requirements of all participating managers.

A major effort was undertaken by NAVSEA and NAVMAT to improve the ship acquisition management of the CGN-38 program to correct the deficiencies that became apparent in the CGN-36 program. There is little doubt and it is universally recognized that the early inclusion of OPTEVFOR in the T&E planning development was significant in the improved readiness condition of CGN-38 at delivery. However, it was with considerable reluctance that the DA accepted this concept until after the problems with CGN-36 were recognized in late 1973 and demonstrated in January 1974 during her Acceptance Trials. The original OT&E Plan for the CGN-38 Combat System[65] included OPTEVFOR only to the extent that their involvement would not change the basic plan, and not as a major participant or as an independent test agency. This was the specific subject of a 31 Jan 1973 letter from COMOPTEVFOR to CNO.[66] As late as February 1975, the SHAPM had no planned or funded program for OT&E by OPTEVFOR.[76] After an exchange of messages in the spring of 1975, CNO did assign project F/S38[68] which included an OpAppraisal of the Combat System and formed the basis for the development of the final TEMP.

There would undoubtedly have been many problems with CALIFORNIA in any case, however if a strong centralized overall Combat System Manager had been assigned and a comprehensive TEMP including those elements of total operational performance had been in existence, there would not have been the loss of T&E discipline which occurred in the program.

UTILIZATION OF TEST AND EVALUATION RESULTS
IN WEAPON SYSTEM ACQUISITION PROCESS
AS APPLIED TO
NAVAL SURFACE SHIP SYSTEMS

I. CASE STUDY #1 - DD963 GAS TURBINE PROPULSION SYSTEM

1. INTRODUCTION

The DX (later DD963 Class) development was initiated under the single package procurement concept. Competitive Concept Formulation (CF)/Contract Definition (CD), beginning in December 1966, produced essentially ship contract designs from three shipbuilders: Litton, Bath, and General Dynamics.

Until the contract was awarded in June 1970 for the detail design and construction of the 30-ship DD963 program, the Navy did not reach a final decision on the type of propulsion system to power the ships.

The DD963 Class Acquisition Program resulted in a multi-year contract to Litton in June 1970 under a total procurement package. The Navy was almost totally precluded from any test and evaluation prior to ship delivery. Thus, the entire DD963 program was affected only slightly by the changes in DOD T&E policies that were taking place in the early 70s. Although substantial development testing was performed in the propulsion system, no initial operational test and evaluation was performed as is specified in OPNAV 3960.10. Current "approval for service use" policies and procedures are also not evident in the DD963 propulsion program.

Independent of the DD963 program, as well as other ship programs, the Navy carries out a continuing research and development program in the ship gas turbine propulsion field. This RDT&E program and the DD963 program complement each other. The DD963 Propulsion System Chronology including allied events in associated RDT&E programs is shown in Tab A.

2. DECISION POINT NO. 1 - MAY 1970

The initial decision point in the DD963 gas turbine propulsion system was the decision to commence detail design and construction of the DD963 Class leading to the award of the contract for the 30-ship program to Litton. Preparatory to the contract award, a Defense System Acquisition Review Council (DSARC) meeting was held in May 1970, equivalent to DSARC III under current procedures.

2.1 DEVELOPMENT STATUS OF GAS TURBINE PROPULSION SYSTEMS

The Pratt and Whitney FT-4A gas turbine had been under Navy development since 1961. By May 1970, two FT-4A gas turbines were operating in the Military Sea Command Ship ADM CALLAGHAN and had accumulated many thousands of hours of operations.

The second generation of marine gas turbines in the 20,000 hp regime is the LM2500, developed by General Electric. The Navy purchased two development engines. By May 1970, one LM2500 engine had accumulated approximately 3,000 hours of operations, having replaced one of the two FT-4A engines in CALLAGHAN. However, tests of the second LM2500 engine at NAVSEC Philadelphia had not yet started.

The Controllable Pitch Propeller (CPP), a vital component of a ship gas turbine propulsion system, provides the means of propulsion reversing. The Navy had studied CPPs in power ratings up to 40,000 shp. Designs had evolved, models were tested, and plans prepared for full scale testing.

The Baldwin-Lima-Hamilton (BLH) Corporation was under contract to the U.S. Navy to produce a 35,000 hp BLH/Navy design CPP to be installed in a 1052 Class frigate for operational test and evaluation. OPTEVFOR tests were scheduled for 1971.(1)

In November 1968, a second 35,000 hp CPP was contracted to Propulsion Systems, Inc. (PSI), originally as part of a complete FT-4A gas turbine propulsion system for the Ocean Escort program. The PSI propeller was scheduled to be installed in a frigate in early 1972 for OT&E to complete in mid 1973.

2.2 PREVIOUS SHIP PROGRAMS WITH GAS TURBINE PROPULSION

Prior to May 1970, three separate U.S. destroyer/frigate ship acquisition programs with gas turbine systems had gone through various stages of design during the previous decade. Each suffered the same fate, cancellation during the budget cycle. The first ship program was the SEAHAWK program (one ship) in FY64; the second, the DDG program (two ships) in FY67 and again in FY68; and the third, the Ocean Escort (one ship) in FY69. All three programs included the FT-4A gas turbine in their propulsion systems. The Ocean Escort Program was in the FY69 budget at the same time that the DD963 program was in the Contract Definition (CD) phase of design.

During the hearings on Military Posture in March 1969, DOD Secretary Laird announced the Navy's proposal to cancel the Ocean Escort Program in order to finance cost overruns in the Shipbuilding Program.(2) He stated: "The Ocean Escort was to be an experimental vessel powered by a gas turbine engine. Since it now appears that the new DD963 Class destroyer (formerly the DX) will have a gas turbine propulsion system, there is no longer any need to build that DE."

2.3 DD963 ACQUISITION PROGRAM STATUS - MAY 1970

After considering steam, diesel, gas turbine, and combination plants, all three DD963 Contract Definition (CD) contractors recommended gas turbine propulsion. The three CD contractors specified the LM2500 rather than the FT-4A gas turbine primarily because of economy of operation, the LM2500 being of a later design.

When the contractors submitted their proposals in April 1969, there was considerable discussion concerning the propulsion system, the risks involved in gas turbine propulsion, and the rumors that the Navy and DOD influenced the contractors to select gas turbines. Secretary of Defense Laird and Dr. Foster, Director of Defense R&D, were questioned at length on the DD963 propulsion system in May 1969 during the military posture hearings in Congress.[3]

While there may be some basis in fact for the rumors that the Navy and DOD preferred gas turbine propulsion, the trade-off analyses by the contractors clearly favored gas turbine propulsion.

From the Navy's position at that stage, a gas turbine propulsion system was consistent with the Navy's destroyer/escort designs during the preceding 5 years. Furthermore, under the single package procurement, Litton is to bear the responsibility for the satisfactory operation of the propulsion system and for the ship meeting the performance objectives which are cited in the Top Level Specification.

However, the Navy did direct Litton to price out the ship using the FT-4A gas turbine since the risks involved in the LM2500 gas turbine were considered too high.

2.3.1 Litton's Test and Evaluation (T&E) Plan

The T&E Plan provided for the validation of the performance. Since the contractor guaranteed that the ship will meet the specified performance and the T&E Plan provides for validation of performance, the plan in its entirety became the Technical Risk Management Plan for Litton.

The T&E Plan specified a structured system comprising test networks, test outlines, test procedures, trial agendas, and trouble and failure reports. Rigid qualification tests were specified for components of the propulsion system.

A prototype land-based integration test of one-half ship set of propulsion equipment was also specified in the T&E Plan. In a contract between Litton and NAVSEC Philadelphia, one-half ship set of propulsion equipment with a waterbreak in place of the actual propeller was to be tested for a minimum of 1,000 hours.

Operational Testing was restricted to demonstrating at-sea the contractor's compliance with the performance requirement prior to Final Contract Trials.

2.4 DSARC REVIEW - MAY 28, 1970

The DSARC review on May 28, 1970, prior to the contract award to Litton for detail design and construction of the 30-Ship DD963 Class included the following presentation by the Ship Acquisition Project Manager: "As you know, our program is essentially one of production using service equipment already in production. For this reason, we have only three risk items which are scheduled rather than cost-oriented with low degree of risk."

"Controllable reversible pitch propellers of the type required for the DD963 have been operated in the U.S. Navy and Coast Guard ships for some time. The largest of these is approximately 3/4 the size and 1/2 the horsepower of the DD963 propellers. The Navy will begin testing propellers of the size and power required in 1971. Based on the experience to date and industry's plans for high power merchant ship propellers, we are convinced of the technical soundness of the larger designs. We show them as a schedule risk only because they have not yet been tested at sea."

"The last risk item is using the new distillate fuel in the gas turbine engines (referring to the FT-4A gas turbine). The Navy conducted 1,000 hours of preliminary testing using a reference fuel. The engine has already demonstrated many thousands of hours of satisfactory operation on diesel fuel."

The technical milestones presented to the DSARC are shown in Figure 1.

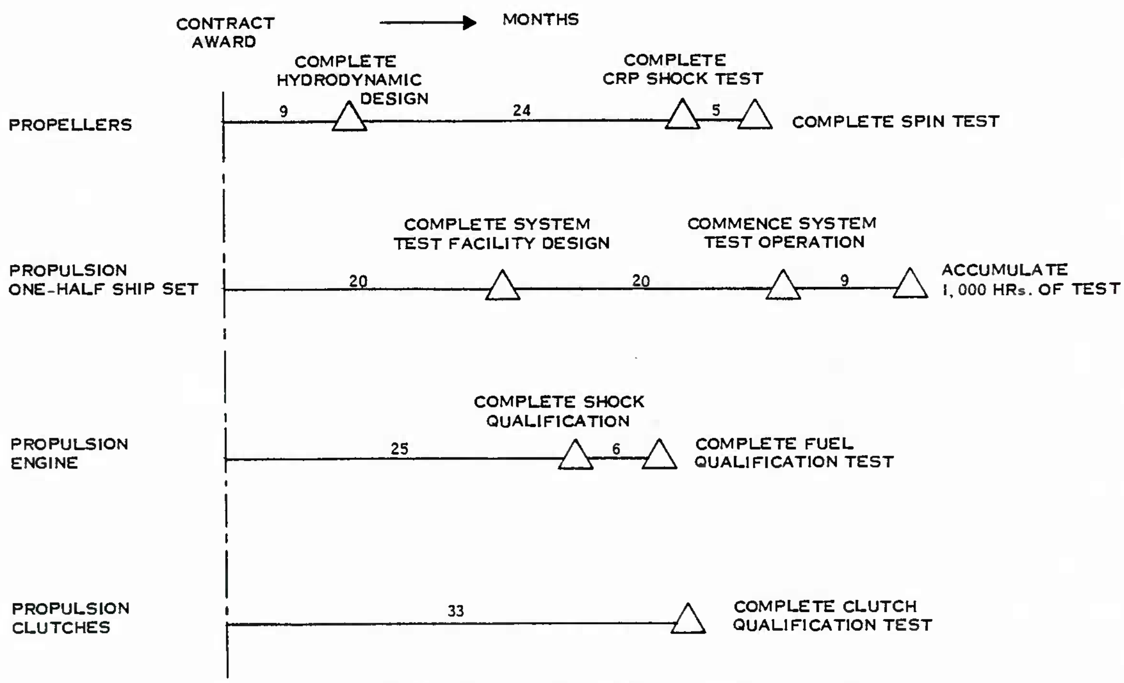

Figure 1. TECHNICAL MILESTONES DD963 PROGRAM

The propulsion system milestones also presented at DSARC are expanded in Figure 2.

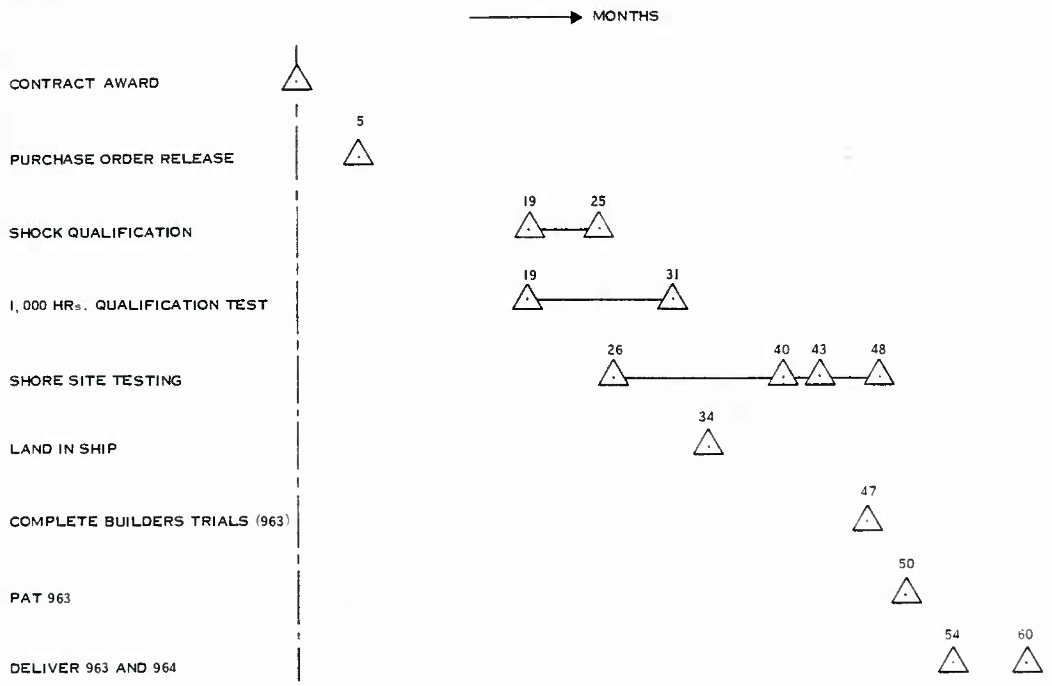

Figure 2. PROPULSION ENGINE MILESTONES

It is noted that the schedule completion of the DD963 Builder's Trials is 2 months prior to the completion of 1,000 hours of testing the one-half ship set of propulsion system. This matter will be discussed later in the study.

2.5 DECISION

The Deputy Secretary of Defense, Mr. Packard, on 23 June 1970, authorized award of the 30-ship destroyer program, three in FY70, six in FY71, and seven in each program year FY72 through FY74.[4]

2.6 OBSERVATIONS

2.6.1 Gas Turbine Propulsion Development

The DD963 contract for detail design and construction of a 30-ship program was signed, specifying a new propulsion system that hadn't been to sea in a Navy ship operated by a Navy crew. However, the FT-4A was a fully developed gas turbine having operated at sea in the ADM CALLAGHAN for over 20,000 engine hours in 2-1/2 years. Other navies and the U.S. Coast Guard had ships using the FT-4A as boost propulsion. On the other hand, the controllable pitch propellers in the 40,000 hp size had not been produced, let alone tested ashore or at-sea.

2.6.2 Non-Nuclear Propulsion RDT&E Funding

Prior to June 1969, it is estimated that only $10 million per year was being spent on ship non-nuclear propulsion plant R&D, less test and evaluation expense.[5] Table 1 shows the expenditures by fiscal years for gas turbine development and associated equipment and technology programs, including CPPs.

Table 1. GAS TURBINE PROGRAM RDT&E EXPENDITURES (Millions of Dollars)

PROGRAM	FY63 THRU FY68	FY69	FY70	FY71	FY72	FY73
GAS TURBINES (Programs S4622, S624, and 0379)	1.150 Average Per Year	6.000	3.686	3.143	6.576	12.257

The meager RDT&E funding level in FY68 and prior years for gas turbine development was completely inadequate to provide a destroyer-type propulsion system for test and evaluation and service approval. The influence of the DD963 Program in reducing the RDT&E effort is clear as indicated by the significant reduction in the RDT&E Program in FY71 from $5 million as programmed in November 1970 to $3.143 million actually expended. Other ship programs have shown similar influences in the RDT&E programs, since some concurrent development has normally occurred during ship production and been funded by the Ship Construction Navy (SCN) appropriation rather than RDT&E appropriations.

2.6.3 Previous Ship Programs

Three previous attempts to receive authorization to construct destroyer/frigate type ships with gas turbine propulsion system had failed due to budget restrictions. As originally programmed at least 5 years of operational testing of a gas turbine propulsion system in a destroyer/frigate size could have been available prior to the scheduled delivery of the DD963 of March 1975.

2.6.4 Risk Assessment

The risks involved in the DD963 propulsion system, while modestly treated in the DSARC Review in May 1970, were discussed in somewhat more depth in Congressional Hearings as previously mentioned. Mr. Blandford, Chief Counsel of the House Committee on Armed Services, questioned whether the Navy should build an experimental ship and not authorize any additional DXs and delay the whole program two years. Dr. Foster replied: "I believe that there has been adequate demonstration in the gas turbine field to be able to put power plants in the DX ships with confidence."[2]

2.6.5 DD963 T&E Program

The integration testing planned to be conducted at NAVSEC Philadelphia was "scheduled" or "success oriented", leaving insufficient time to correct defects found and still adhere to the construction schedule. The iterative, feedback nature of testing was not appreciated. Fortunately, from the T&E position, the builder's trials were actually delayed 8 months due to delays in the DD963 construction schedule. Thus, some added time was available for correcting problems encountered at the LBTS. DOD 5000.3 recognizes the distinctive nature of ship nonnuclear propulsion development by requiring T&E of prototype systems be completed prior to the first major production decision on follow ships. Obviously, the DD963 prototype tests were much later than current policy would dictate.

3. DECISION POINT NO. 2 - DECEMBER 1970

In December 1970, the Navy approved an Engineering Change Proposal (ECP), permitting the use of either the FT-4A or the LM2500 gas turbines for main propulsion in the DD963 Class. Subsequently, in the same month, the Navy consented to a subcontract to General Electric by Litton for LM2500 gas turbines. No change in the DD963 or the propulsion systems test schedules were required as a result of the ECP.

3.1 PROPULSION SYSTEM DEVELOPMENT STATUS - DECEMBER 1970

a. Gas Turbines. The LM2500 gas turbine had been operating satisfactorily in the ADM CALLAGHAN since installation in December 1969, accumulating approximately 6,000 hours of at-sea operations.

Meanwhile, in July 1970, NAVSEC Philadelphia had started testing the second LM2500 that had been delivered to the U.S. Navy as part of the Navy's RDT&E program. The unit experienced smoke problems and limited life of 40 hours on the igniters. The test program was terminated in October 1970 after 120 hours of operations.

b. Controllable Pitch Propellers. The BLH CPP encountered a further delay of about 6 months since May 1970 as a result of deficiencies found during spin tests. The schedule as of December 1970 was:

Complete Spin Test	1 Feb 1970
Complete Shipping of Service Unit	15 Mar 1971
Commence Restricted Availability (RAV) of USS PATTERSON (DE 1061)	Mar 1971

3.2 DD963 ACQUISITION PROGRAM STATUS - DECEMBER 1970

The DD963 Class Destroyer Development Concept Paper (DCP) was issued on 28 July 1970.[6] Extracts from the DCP applicable to the propulsion system are:

"Risk varies from low with the FT-4 to low-to-moderate with the LM2500."

"Final selection can be made up to 18 months after D&P contract award without adversely affecting the program provided the test program is continued." ... "Clutch risk is low ... Risk of 40,000 shp CPP is low. Controllable pitch propellers up to 30,000 shp are in use today, and two units up to 40,000 shp will be evaluated at-sea prior to the critical decision point." (By 12/71)

The milestones in the DCP for the propulsion system are the same as shown in the DD963 T&E Plan, Figures 2 and 3.

3.3 SELECTED ACQUISITION REPORT (SAR)

The Selected Acquisition Report (SAR)[7] reported the above contract change, adding:

"Testing of the LM2500 on the MSC Ship CALLAGHAN continues to progress satisfactorily. The Military Sealift Command (MSC) signed a contract with General Electric for an additional two years of operational use of the LM2500 to power one shaft in the MSC Ship CALLAGHAN. This is expected to add an additional 12,000 hours of operational testing of the LM2500 gas turbine."

3.4 OBSERVATIONS

The successful test thus far at sea in the CALLAGHAN provided added confidence for Litton to recommend, and the Navy to approve, the shift to the more advanced gas turbine in the DD963 program. Because of the LM2500's decreased fuel consumption, particularly at partial loads, the DD963 endurance requirements could be met with less complication and at a cost savings. As a consequence, a reduced cost change order was negotiated for $28,153,000. Additionally, an estimated 20-year fuel cost savings of $120 million would be realized based on 1974 fuel costs.

In this instance, T&E results had a significant effect on a large acquisition program: improved performance and reduced cost. The decision was made well in advance of the decision point of 18 months after the DD963 contract award without affecting the program as noted in the DCP.

The 6-month delay in delivery of the BLH propeller for installation and operational testing was recognized but had no noticeable effect on the DD963 program.

4. DECISION POINT NO. 3 - JANUARY 1972

The third decision point in the DD963 program was a DSARC review on January 13, 1972 of the program prior to committing funds for the FY72 increment of seven ships. The review was made in order to assure the Secretary of Defense regarding the propriety of committing the FY72 funds in view of publicity of potential cost growth and possible schedule slippage of the program. Also, the substantial personnel and organizational changes at Litton suggested possible adverse impact on the program. The minutes of the meeting of the DSARC made no mention of the propulsion system.[8]

However, on 17 December 1971, the CNO, meeting with the Sea Control Panel of the CNO Executive Board (CEB), reviewed the DD963 program and provided the following guidance and decision among others:

"Propulsion R&D. In view of our extensive commitment to gas turbine technology and large controllable pitch propellers in the DD963, CHNAVMAT is requested to review the Navy's RDT&E efforts in these areas and recommend urgent augmentation, if needed."[9]

4.1 PROPULSION SYSTEM DEVELOPMENT STATUS - JANUARY 1972

The LM2500 gas turbine in the MSC ADM CALLAGHAN had accumulated over 12,000 hours of at-sea operation. The BLH CPP program encountered production problems and delays as a result of deficiencies found on spin tests. Nevertheless, the BLH CPP was being installed in the PATTERSON and scheduled to start operational tests at completion of the RAV in March 1972, nearly 2 years later than originally scheduled and 15 months later than predicted at the DD963 production decision in mid-1970.

The PSI CPP schedule published in December 1971 had also encountered schedule slippage. The propeller was scheduled to be delivered in September 1972 for installation, which amounted to a 9-month delay from the schedule as of May 1970 when the DD963 production decision was made.

4.2 DD963 ACQUISITION PROGRAM STATUS - JANUARY 1972

The DD963 gas turbine propulsion system was progressing on schedule. The following technical milestones were reported to have been completed on schedule: (1) Complete the baseline propeller design, and (2) Subcontract awarded for construction phase of the land based test sight at NAVSEC Philadelphia. Factory tests of the first LM2500 Propulsion G/T Module was well underway.

4.2.1 Special Study on DD963 Program

The Secretary of the Navy, John Chafee, requested a special study of the DD963 in May 1971 "to assess, in relation to the tactical situation of the next 10 years, the appropriateness of the mix of offensive, defensive, and control equipments planned for the new DD963 destroyer." The study was undertaken under the aegis of the National Research Council of the National Academy of Sciences. In November 1971, further specific questions were raised by Secretary Chafee. One of the questions resulted in the Council studying the DD963 gas turbine propulsion systems, i.e., "Have reliability and maintainability been given sufficient emphasis in the DD963 program?"

The influence of the study group's deliberations on the decision of Assistant Secretary of Defense to obligate funds for seven more DD963 Class is not evident.

4.3 DECISION - JANUARY 1972

The Assistant Secretary of Defense memorandum of 13 January 1972 to the Secretary of Defense reported on the DSARC meeting and stated that the Navy plans to proceed with the obligation of funds for the next seven ships by 15 January 1972.

4.4 OBSERVATIONS

Although the decision was made to request funding for seven more DD963 Class, some apprehension was evident in the CNO that our gas turbine and CPP development program needed acceleration. The delays incurred in the past year and a half in the 40,000 shp CPP development program contributed to the concern as did the cessation of further LM2500 gas turbine R&D program efforts.

However, the propulsion test program established by Litton for the DD963 was proceeding on schedule and the initial technical milestones were being met. No effect on the DD963 program was evident from the delays being encountered in the two CPP development programs despite the fact that the CPP development was recognized as one of the DD963 risk items.

5. IMPOSED DECISION

There were no other clearly identified DD963 program decision points after the DSARC review on January 13, 1972. With the authorization of seven ships in the FY72 SCN program, the program was well underway with 16 ships under contract.

Subsequently, however, two significant problems arose during T&E of the propulsion system that affected the DD963 program. The first problem became evident in the testing of the one-half ship set of the propulsion system at NAVSEC Philadelphia starting in October 1973. The control system required extensive redesign and field modification in order to properly integrate the components of the propulsion system.

The second major problem arose on August 31, 1974, when the BARBEY (FF 1088) reported a catastrophic failure in the PSI CPP during operational testing.

5.1 PROPULSION CONTROL SYSTEM PROBLEM

The control system accumulated a total of 264 deficiency reports while the one-half ship set of propulsion system was operated at NAVSEC, Philadelphia.[(10)] The high frequency of failure indicated a major shipboard reliability concern.

COMOPTEVFOR was allowed only to observe these integration tests under the operational assist project X/S 31, assigned in November 1973. COMOPTEVFOR pointed out his concern for the DD963 propulsion control system as demonstrated at the LBTS in a letter to CNO in August 1974.[(11)]

5.1.1 <u>DD963 Program Implications</u>

The result of the control system problems noted during prototype testing generated training, technical documentation, and supply support problems as well as many operational problems in the ships long after the prototype testing was completed.

a. <u>Training</u>. The propulsion control system, operational and maintenance training for all ships was originally scheduled to be conducted at Great Lakes on a Singer-built training simulator. However, due to propulsion control problems, Litton's control system contractor was delayed in providing control panels and the ready-for-training date was not met. Training for the DD963 propulsion crew had to be carried out in the DD963 which contributed to accepting ship delivery on August 12, 1975 and delaying commissioning approximately 5 weeks until September 20, 1975. The shipbuilder was not responsible for either the simulator or this portion of the training.

b. <u>Technical Documentation</u>. The technical documentation for troubleshooting the propulsion control system at the LBTS was deficient. The complexity of the control system requires troubleshooting logic flow diagrams and procedures to assist in identifying a fault source. Since delivery of the DD963, North Island Naval Air Station has been tasked to develop single fault isolation diagrams at an estimated cost of $150 thousand. The initial maintenance concept was based on logic boards being throwaways. However, the escalated cost for many of these boards, coupled with the higher than predicted failure rate, made it desirable to develop a repair capability. This requires additional documentation not previously specified.

c. Supply Support. The late design changes required on the propulsion control system, still being made in late 1976, generated a supply support problem. The late Class-2 design changes created a configuration problem in that the internal components in the control system boards were not documented. Spare boards in the supply system have been in short supply.

North Island Naval Air Station has been set up as a repair facility for the control system boards for both the DD963 and FFG-7 Classes. The cost to the DD963 program is $1.4 million.

d. Operations. Trials and operations of the earlier ships of the program were unsatisfactory because of the propulsion control system problems. For example, it was not until the retrial of the fourth ship in the program that a full power trial was run with a clear control board.

5.1.2 Observations

Without a well-engineered and component-tested control system, integration testing of a propulsion system at an LBTS takes additional time and resources, and may result in casualties to the system. Lack of IOT&E and the early involvement of a typical Navy crew and OPTEVFOR in land-based tests prevents an early evaluation of the operability and supportability of the system.

In a ship program it is necessary to freeze the design early enough for the training and the provisioning systems to take effect. When control deficiencies are carried from land-based tests into the ships, trials are unsatisfactory, delivery of the ships jeopardized, with possible reduced operational readiness.

The propulsion control system would have caused serious delays in the DD963 program had the program not been delayed due to shipbuilding production problems.

5.2 CONTROLLABLE PITCH PROPELLER FAILURES

a. BLH CPP in PATTERSON (FF-1061)

At-sea trials of the BLH CPP commenced in September 1972 in the PATTERSON (FF-1061) over 2 years later than originally planned. In June 1964, the PATTERSON suffered a casualty, having completed 6,500 hours of CPP operation. The failure was in a rod coupling subjected to low stress and high cycle fatigue. Since improved threaded connection joints are used in the DD963 CPP, no redesign or extensive investigation was indicated.

b. PSI CPP in BARBEY (FF-1088)

The BARBEY (FF-1088), with PSI CPP installed, commenced trials in December 1973, 18 months later than the original scheduled date.

By February 1974, the BARBEY completed the CPP trials and commenced a one-year operational evaluation. On August 31, 1974, the PSI propeller in the BARBEY suffered a catastrophic failure. The blades fell off the crank discs to which the propeller blades are bolted.

Since the Bird-Johnson DD963 propeller, ordered in July 1971, is similar in design to the PSI CPP, the BARBEY failure promptly led to a thorough reanalysis of the DD963 CPP. The state-of-the-art in design criteria for propeller loading during transient conditions was generally lacking.

As a direct result of the BARBEY propeller failure, RDT&E efforts were mounted with additional RDT&E funds reprogrammed through FY80 of $5.4 million. Subsequently, the BARBEY was instrumented and tested to obtain full scale loading data.

The DD963 Bird-Johnson propeller is considered stronger than the PSI propeller, but concern did exist because of inconsistent stress analyses, questionable stress concentration areas, and load analysis of the BARBEY trials. Therefore, the SPRUANCE (DD963) was instrumented with over 200 channels of data and trials conducted 2-6 August 1976. Among the findings were that alternating stresses are much higher than predicted, ship turns produce higher stresses than crash ahead or crash back maneuvers.[12] Program costs for the investigations, trials, and resulting modifications are estimated at $5 million in DD963 SCN funds.

Operational restrictions placed on each DD963 Class ship in September 1976 as a result of the analysis of the BARBEY failure will remain until the ship receives a propeller modification either during construction or at next regular drydocking.

5.2.1 Observations

In retrospect, it is evident that the technology base for propeller design had not advanced far enough to scale up CPPs to 40,000 shp without greater assurance of the design criteria required. Whereas the propeller in the DD963 program was considered low risk with assurance of successful operations depending on two full-scale trials of similar CPPs, the propeller was in fact a high risk component requiring more extensive full-scale instrumented trials to provide validation of design criteria and correlation with predictions and model testing.

The schedules for the BLH and PSI CPP development were over ambitious and the significant delays were experienced. The propeller casualty in BARBEY occurred nearly 6 years after the contract was awarded for the design of the propeller and 9 months after installation.

The delays in the propeller operational evaluations had no effect on the DD963 program until the BARBEY CPP catastrophic failure. Confidence in the DD963 Bird-Johnson propeller, as well as the low technical and schedule risk designation given to the CPP no doubt contributed to the continuation of the DD963 program without change until the BARBEY failure. Fortunately, the BARBEY failure accelerated the RDT&E program in CPPs and the resulting efforts produced what is hoped to be fixes in the DD963 program.

6. STATUS AS OF MAY 1977

OPTEVFOR is currently conducting an "Operational Appraisal of the DD963 Class Power Plant" in accordance with reference (13). The Operational Appraisal constitutes Follow-On Test and Evaluation.

II. CASE STUDY #2 AN/SQS56 SONAR

1. INTRODUCTION

The SQS-56 (XN-1) Sonar Program is one of the first weapon systems developed using the new Management Test and Evaluation (T&E) Directives and Instructions currently in effect. The program had high visibility.(14) It employed current planning documents, including the early involvement of OPTEVFOR, and identified the program risks early.

Two program constraints by CNO adversely affected the sonar development. The first, design-to-cost, was translated to mean design-to-economic constraint (as opposed to design-to-required performance). The second constraint was the compressed schedule.(14) The sonar development schedule was force-fitted to the FFG-7 Class schedule in an attempt to obtain approval for service use before the Ship Defense System Acquisition Review Council (DSARC) III decision point.

1.1 SCOPE

The scope of the study includes both the advanced development of the sonar which corresponds to the validation phase of the weapons development cycle, and the engineering development of the sonar which corresponds to the full-scale development phase. Since the sonar development was somewhat unique in that the contractor, Raytheon, used company funds to accomplish both advanced development and engineering development, the phases of the normal DOD development cycle are not easily distinguished. It is clear, however, that the bulk of the sonar development included in the validation and full-scale development phases was conducted between the DSARC I/II and DSARC III ship decision points.(15)

It is important to determine what impact T&E results had on the decisions made at the various decision points of the program. Four major sonar decision points will be discussed along with the basis for the resulting decisions, with particular emphasis on how OT&E and OPTEVFOR influenced the decision.

2. DECISION POINT NO. 1 - MAY 1972

The initial decision point of the sonar program was CNO's decision in May 1972 (just prior to the ship DSARC I/II decision) that the FFG-7 Class sonar would be a "Generic SQS-505."(16) The decision to go with the Canadian SQS-505 at such a late point in the program was a departure from existing plans.

CNO had selected the SQQ-23 as the FFG-7 Class sonar in June of 1971.[17] Sonar studies conducted in early 1971 had shown that while the Canadian SQS-505 possessed the advantages of small size, most recent technology and low cost, the SQQ-23 offered substantially greater direct path detection performance.[18] As late as January 1972, CNM approved the Advanced Procurement Plan (APP) for the SQQ-23.

Later in the spring of 1972, CNO chose to reduce the ASW performance requirement and selected the SQS-505 in order to meet ship cost and size constraints of $45 million and 3400 tons.[16] The SQS-505 was considered a low risk acquisition because it was already approved for service use in the Canadian Navy.[18]

The technical basis for this decision was the Antisubmarine Warfare Destroyer Model Computer Studies which assessed the effectiveness of a mixed screen of FFG-7s and DD963s.[19] The principal measure of effectiveness was the number of ships surviving a North Atlantic transit. The results of this computer simulation represented the performance of the mixed Fleet and showed little improvement in effectiveness whether the FFG-7s ASW sonar was an SQS-23 or an SQS-505.[20]

COMOPTEVFOR's participation in this decision was limited to attendance at briefings. The Canadian SQS-505 Operational Evaluation (OPEVAL) Report provided the T&E results from which performance and risk were determined at this decision point.

3. DECISION POINT NO. 2 - APRIL 1973

The results of several parallel efforts by different activities in the Navy culminated in a decision in April 1973 to award a contract to Raytheon for the DE-1160 (subsequently designated AN/SQS-56 (XN-1)) sonar to be installed in the FFG-7 Class. The problem was complicated by the lack of specific FFG mission requirements. The best guidance was the CNO decision of May 1972 for a Generic SQS-505 for the ship.

3.1 NAVSHIPS SONAR STUDY

NAVSHIPS had been requested to provide a selection rationale on candidate duct sonars by 10 June 1972 and, in the absence of definitive Operational Requirements, they updated a previous Naval Underwater Systems Center (NUSC) Study which compared six candidate sonars. They did a comparative analysis between the active detection ranges, cost and risk, and recommended that a Request for Proposal (RFP) be let to the top four sonar candidates. The intention was to select two sonars for prototype development and determine the FFG sonar via competitive T&E. It is interesting to note that the DE-1160 ranked number one in active detection range, 10 percent greater than the second candidate, the Canadian SQS-505. In risk, however, the DE-1160's probability of success was the lowest of all candidates. The DE-1160's performance per dollar was 32 percent higher than the SQS-505. Since the overall selection rated performance and cost of greater significance than probability of success, the SQS-56 was ranked the best candidate.[21] In a 7 July 1972 letter from CNO to CNM, the CNO found the prototype development procurement approach not suitable for the lead ship for the following reasons:

a. The FFG-7 program was not funded to provide for the development and test effort required by competitive development.

b. The approach left unanswered too long which sonar will be installed on Lead FFG-7, complicating the design process. Sonar interface data for the lead ship was required no later than 1 Oct 72.

c. It would result in extensive concurrency of development with the FFG-7 lead ship. This is counter to requirements of DOD and SECNAV Dir 5000.1, and ASN (I&L) desires.[22]

3.2 OPERATIONAL TEST AND EVALUATION FORCE (OPTEVFOR) TASK

After the CNO decision for a Generic 505, OPTEVFOR was tasked to review the Canadian tests of the SQS-505, and to provide CNO, by December 1972, with their appraisal of the status of the sonar with regard to its Operational Test and Evaluation (OT&E) and FFG-7 installation suitability. OPTEVFOR was further requested to find the minimum additional testing required for OT&E to support a production decision by CNO and the DSARC.[21]

3.3 SQS-505 SONAR FOR LEAD SHIP

On 7 July 1972, recognizing the difficulties in competitive sonar development for the lead ship, the decision was made, and CNO concurred, to procure the SQS-505 from Westinghouse Canada for the lead ship, and to utilize a competitive procurement for the follow-on ships.[23]

In the meantime, the Office of the Assistant Secretary of the Navy OASN (R&D), in August 1972, conducted an informal survey of NAVSEA, OPNAV, and OPTEVFOR, and found that none seemed to have much information about the SQS-505. The ASN Memo indicated awareness of the OPTEVFOR and OPNAV controversy over the lack of precise minimum acceptable requirements to describe the sonar.[24]

The SHAPM attempted, by achieving a sole-source procurement to Westinghouse Canada SQS-505, to go with the minimal risk item. But in November 1972, in a Memo from ASN (I&L) to NAVSEA, the request for an exception to "Buy American" was denied; thus the sonar program was forced to an open procurement.[25] Consequently, the problem of selecting a sonar for the FFG-7 Class lead ship remained.

3.4 ADVANCED PROCUREMENT PLAN (APP)

By 6 December 1972, NAVSEA submitted to NAVMAT an Advanced Procurement Plan (APP), based on competitive qualification testing of the SQS-505 and several other prototype American systems. Based on factory tests, one or more would be selected for at-sea tests. Final selection was to be determined by successful at-sea performance and production price.[26]

The following excerpt from the APP shows that the procurement objective was to obtain optimum performance in system design within program costs and schedule constraints: "A system that meets technical and schedule requirements and is reproducible in lots of 25 at $700 thousand per copy is the ultimate objective."

3.5 OPTEVFOR REPORT

On 29 December 1972, OPTEVFOR submitted its assessment of the SQS-505 sonar system.[27] The results of this report show that the mean initial detection range was one-half the Canadian staff range requirement for active detection of submarine contacts. CNO had based the performance requirements for the FFG-7 Class on the performance of the SQS-505 as recorded in the Canadian Test Reports. Thus, OPTEVFOR recommended that, if the degraded performance reported still satisfied the performance requirements of the FFG-7, the SQS-505 should be further subjected to a full-scale TECHEVAL/OPEVAL in the system configuration. This report had high visibility including the Assistant Secretary of the Navy (ASN) (I&L).[28]

The OPTEVFOR assessment delayed the Secretary of the Navy's approval of the Request for Authority to Negotiate (RAN) for the prototype sonar. After a month delay, the approval was conditionally granted. The conditions set down required the final approval of the ASN (I&L) in the selection of the prototype sonar.

3.6 SONAR PROGRAM MANAGER'S ASSESSMENT

Based on the OPTEVFOR assessment and the ASN's conditional approval, the Sonar Program Manager issued a point paper assessing the procurement program.[29]

The NAVSHIPS program to select the FFG sonar is based on the following rationale:

a. There are several systems which meet CNO's requirement.

b. Bottom up development of a new system to meet this requirement is untenable from both cost and schedule considerations.

c. Industry gave strong high-level indications they would welcome an opportunity to put their hardware in competition with the CNO prescribed standard, at their own expense.

d. Navy sponsorship of the program is reasonable in view of the potentially large U.S. and foreign market.

Among the conclusions reached from this rationale were:

a. Selection of a system superior to the SQS-505, as reported by COMOPTEVFOR, is highly likely because: (1) Except for the SQS-38A, the lowest performance of anticipated offers will be the SQS-505 and (2) Selection criteria place performance ahead of cost, given that all costs be below ceiling.

b. The COMOPTEVFOR appraisal results do not change performance requirements for the FFG sonar, nor do they lessen our high confidence that a modern direct-path sonar, which meets this performance requirement, can be procured within the funding estimates now budgeted in the FFG program. The required sonar performance used in the FFG ASW effectiveness evaluation remains unchanged.

3.7 FINAL SONAR SELECTION

The RFP was released on 22 January 1973, and three proposals were received by 2 February 1973. On 26 February 1973, the Contract Award Review Panel decided to release the multi-source production option of the RFP because: (1) Funds were not available to support more than one test program, and (2) The risks involved were sufficiently low to make retention of a back-up system through parallel test programs of questionable necessity.[30]

The rationale for not awarding two test programs was: (1) In the judgment of the Technical Evaluation Board (TEB), one of the three offered systems was very clearly superior to both of the other systems from a technical/operational viewpoint, and (2) The Contract Award Review Panel concurred with the findings of the TEB that parallel testing was unwarranted.

On 20 April 1973, ASN concurred with the selection of one source for the factory test phase. On 24 April 1973, Raytheon's DE-1160 Sonar was selected as the FFG-7 Class Sonar.

4. DECISION POINT NO. 3 - APRIL 1975

The technical development of the sonar was concluded in April 1975 with the completion of TECHEVAL, and with NAVSEA certifying the SQS-56 (XN-1) Prototype ready for OPEVAL with the intention of requesting provisional approval for service use, with final approval contingent on satisfactory completion of environmental tests and reliability/maintainability demonstrations.[31]

This was a critical sonar decision point, as both the Naval Underwater Center (NUC) and OPTEVFOR recommended that the sonar not be certified ready for OPEVAL.[32,33] This is a clear-cut example of program management overruling the results of T&E, and the recommendations of its technical and operational advisors, thus allowing the schedule, requiring OPEVAL, to override all other factors. The driving force behind the strict adherence to schedule was the desire to successfully achieve a DSARC III approval for the FFG-7 Class. The fact that the SQS-56 was not approved for service use was considered to be a stumbling block in the way of a DSARC III approval for the ship program, since it was the only ship weapon system which was not approved for service use.

The pressures brought to bear to minimize risk at DSARC decision points is a major contributor to the schedule orientation as opposed to performance orientation of DOD programs. The sonar is a case in point. In the opinion of a Manager Antisubmarine Warfare Project (MASWP) representative interviewed, "The decision to certify the sonar ready for OPEVAL may have been a poor technical decision but it was a reasonably good management decision. The possibility of success, even though small, compelled the Manager to certify the sonar ready for OPEVAL. If the sonar had successfully completed OPEVAL, it would have been a definite plus; if it failed OPEVAL it would be considered no worse than failing TECHEVAL."[34]

4.1 SQS-56 SONAR DEVELOPMENT PROGRAM

It is important to trace the program to determine how the Program Manager arrived at such a low-probability-of-success situation.

The SQS-56 began as a Raytheon-funded internal development program which resulted in the commercial sonar, the DE 1160, which was considered an advanced development model. The development of the SQS-56 (XN-1), the Navy's prototype sonar, was carried out between April 1973 and April 1975. During this period, Raytheon developed and manufactured the sonar from commercial components, performed factory tests, then loaned the Navy the equipment for dockside and at-sea tests which culminated in a formal TECHEVAL.

The intent during this phase was to test and evaluate a full-scale development model sonar. By the strict definition, what NAVSEA specified was a prototype model which fell somewhere between an advanced development model and a full-scale development model.

The sonar specifications (NAVSHIP 1041) allowed certain deviations for the prototype.[35] Quoting from the Specification, "The prototype sonar system shall include fault sensors and automatic fault indication programs sufficient to demonstrate operational feasibility and to support an IOT&E Program, but need not include all elements proposed for the product baseline and production systems."

Thus, fault isolation and fault localization abilities were not designed into the prototype system. Additionally, excerpting from a September 1973 Test and Evaluation Master Plan (TEMP), "Reliability and maintainability factors (quantitative thresholds) cannot be applied directly to the prototype system because it contains commercial grade components."

From the initial specifications for the prototype equipment, limitations in the reliability and maintainability were such that (from the inception of the program) the probability of completing a successful OPEVAL which would meet approval for service use, was low.

However, in a Memo to MASWP, in May 1973, the Sonar Program Manager optimistically predicted that, "The sonar is functionally equivalent to production units and considered adequate for IOT&E purposes such that the performance results of IOT&E will provide a valid basis for a production decision (approval for service use)."[36] Thus we have a basic conflict resulting from original objectives (1972) being overtaken by evolving T&E policy and changing emphasis that culminated in OPNAVINST 3960.10 in 1975. Based on the requirements of OPNAVINST 3960.10, the best that the Sonar Program Manager could strive for would be conditional service approval. The scope of the original T&E program objectives were not upgraded to be consistent with OPNAVINST 3960.10.

4.2 TECHNICAL EVALUATION

During the engineering development phase, NUC was the primary laboratory for providing technical support. In addition, the laboratory was charged with the responsibility of developing the preliminary operating doctrine for at-sea testing, and of the detailed planning, execution, and reporting for the TECHEVAL phase.[37]

The engineering reports of the factory test phase showed that, in general, the individual subsystems met the performance requirements of NAVSHIPS 1041.[38] However, when the system was put together in an at-sea operational environment, numerous deficiencies were found and a major system design change had to be initiated before TECHEVAL could be conducted.

Throughout TECHEVAL, the number of technical problems steadily increased and quick-fix solutions to correct basic system design problems were not entirely successful.[39] At the conclusion of TECHEVAL, the OPTEVFOR observation team evaluated the operational performance as severely degraded from its performance at the start. NUC, as stated in the TECHEVAL final report, found the Fault Detection/Fault Localization (FD/FL) Subsystem of the sonar unacceptable. The detection range, however, exceeded all expectations of performance.

A sonar design review, conducted in February 1975, determined that except for the FD/FL Subsystem, essentially all of the technical problems were found to have solutions that were feasible, with low technical risk and correctable within a reasonable time. The Design Review Report also stated that the SQS-56 (XN-1) System FD/FL Subsystem was found unsatisfactory and would not pass OPEVAL.[32]

4.3 DECISION

NAVSEA chose to implement those changes to the prototype sonar which were considered absolutely essential to have a meaningful OPEVAL (NAVSEA's interpretation being to evaluate performance capability). NAVSEA further planned to correct the unsatisfactory reliability/maintainability performance of the sonar in the production systems.[40] Thus, on the strength of the excellent range performance and in spite of the numerous deficiencies, NAVSEA certified the sonar ready for OPEVAL.

5. DECISION POINT NO. 4 - AUGUST 1975

The sonar OPEVAL was started in April 1975 and, after the first at-sea period, it was suspended pending modification of the system. OPEVAL was resumed in June 1975 and concluded in August 1975. The SQS-56 (XN-1) was evaluated as not operationally effective because there was too great a percentage of "no-detections" within the sonar's detection envelope. The observed detection ranges were well below all SQS-505 detection baselines. At this time the sonar specification, the TEMPS, and the TECHEVAL Final Report each reflected conflicting detection performance thresholds.[39] In any case, the OPEVAL detection range was approximately one-half that observed in TECHEVAL. The sonar was evaluated as not operationally suitable because the computer and power supply unit were not reliable and the FD/FL Subsystem was incomplete. OPTEVFOR recommended that the SQS-56 in its present configuration not be recommended for service use.[40]

5.1 DECISION

The sonar's failure to pass OPEVAL had an immediate impact on the sonar program. DCP-97, used in the FFG-7 DSARC III Decision, stated that: "As a result of COMOPTEVFOR's findings an improvement program has been undertaken to correct the sonar deficiencies." DT&E and OT&E of the improved sonar will be conducted at-sea in the latter part of 1977.[42]

5.2 OBSERVATIONS

The fact that the sonar was not approved for service use had virtually no effect at the ship's DSARC III Decision Point. The follow-ship production was approved by the CNO Executive Board without a formal DSARC.[43] The problems encountered with the SQS-56 did point up the limitations in the FFG's ASW capability and directly influenced the decision memo to correct these limitations by funding LAMPS III and TACTASS.

Virtually every problem area reported in TECHEVAL was still present during OPEVAL. Furthermore, nearly every one of these problems are traceable via monthly reports since early in the development phase.(44) Although testing disclosed problems early, the sonar continued through development and, at the strong objection of OPTEVFOR, into OPEVAL although solutions to problems had not been found.

A controversial issue which has not been entirely resolved to this day is the wide difference in measured detection ranges between TECHEVAL and OPEVAL. An excerpt from the NAVSEA "Goldberg Report" summarizes this issue.(15) "The differences in measured detection ranges during TECHEVAL and OPEVAL could be due wholly or in part to more highly variable propagation conditions during OPEVAL tests. Certainly when combined with the burden placed upon the sonar operator as a result of poor video and audio display quality, the detection range differences against in-layer targets are neither unusual nor uncommon."

6. CONCLUSIONS

The Sonar Program showed weakness in planning, conducting, in reporting the development testing, and in the use made of the test results. For example:

a. CNO did not define clear operational requirements at the outset of the program.

b. Differences in technical and operational thresholds were not resolved prior to testing.

c. Although management ascertained risks early, and testing disclosed problems early, the sonar continued through development and, at the strong objection of OPTEVFOR, into OPEVAL although solutions to problems had not been found.

d. Decisions were primarily based on cost and schedule as opposed to performance and testing.

e. The impact of technical inputs (reports, tests, recommendations) was lost or reduced as the information filtered up to the decision-making level.

7. LESSONS LEARNED

It is important to recognize that no sonar operational requirements were formally approved by CNO at any time during the development of the sonar. At the inception of the sonar program, some basic rules of development were broken which ultimately resulted in ill-defined T&E thresholds. Sonar development is a function of the direct correlation between operational requirements, operational thresholds, technical thresholds, cost, and the major variable, the erratic path losses due to changes in the environment.

Consider the ideal sonar development process. operational requirements are translated into an operational performance range. Then, using the basic sonar equation this performance range is used to determine the equipment Figure of Merit (FOM) required to overcome the path propagation losses for a probability of detection of 50 percent. Numerous iterations of the sonar equation are necessary to determine the FOMs needed to satisfy the wide variation in path losses encountered due to changes in the environment. The FOM is then translated into hardware performance parameters which in turn correlate directly to cost. Thus, once CNO selected the cost ceiling, the sonar performance was uniquely described by the number of decibels (db) which could be bought for a given dollar. Since CNO selected the minimum dollar ASW option, the resulting performance was extremely vulnerable to environmental degradation. The failure early in the development cycle to define rational operational performance thresholds which correlated with the technical thresholds established by NAVSEA's intepretation of CNO's requirements ultimately resulted in poorly defined T&E procedures and subsequently contributed to the sonar's failure in OPEVAL.

While it is easy to say "define rational quantitative operational thresholds," it is extremely difficult to accomplish particularly in a sonar system. The problem is the extreme difficulty experienced in making real-time measurements of the environment which accurately predict variations in range during at-sea tests. The technical community, acutely aware of this limitation, is adamant that range should not be a criteria for pass/fail performance in an OPEVAL. OPTEVFOR, on the other hand, must have quantitative operational range thresholds to perform a meaningful OPEVAL.

Thus, two lessons have been learned from these differences. They are: (1) The resolution of the differences in operational and technical performance thresholds, and (2) The development of a new TEMP which correlates the technical capability via measured environmental parameters with operational requirements.[32,33,45,46]

III. CASE STUDY #3 - MK86 GUN FIRE CONTROL SYSTEM

1. INTRODUCTION

The most evaluated Gun Fire Control System (GFCS) in recent history is the Mk 86 system. Three times in the past 10 years, the system has been subjected to successive TECHEVALS and OPEVALS and yet continues to have support problems. The Specific Operational Requirement (SOR) of 1962 stated a requirement for a lightweight gunfire control system; however, the program concept goes back to the late 1950s when a General Operating Requirement (GOR) stated the requirement for a more effective defense of an amphibious task force in the amphibious objective area. Thus, the system has been nearly two decades in development and has gone through several iterations, increasing its operational capability as the state-of-the-art and the threat have changed.

2. SCOPE

The scope of the study includes a history of the program and a review of the decisions which were made during the course of this acquisition program. The T&E program will be reviewed to determine its adequacy or inadequacy in light of present day deficiencies with the system as it operates at sea.

3. BACKGROUND

From its inception, the Mk 86 system included techniques that were innovative to gun control systems. Track-While-Scan (TWS) features and a general purpose digital computer were in the system to develop multi-target track and engagement capabilities. The first system produced was a prototype designed with a surface capability. The second system produced was also a prototype and had an AA capability added. Subsequent production models had Continuous Wave Injection (CWI) for in-flight control of the standard missile.

4. PRODUCTION SUMMARY

This dual purpose system is installed in the LHA, CGN, DD963 procurement programs. Forty-six systems will have been delivered by mid-year when the fourth system is made available to the Iranian Government. The distribution of systems includes 6 in the CGN, 5 in the LHA and 30 in the DD963 Classes and 1 at land site. Plans are made to upgrade 23 DDG-2 Class ships. Germany plans to purchase three this year (1977) for their Guided Missile Destroyer (DDG) program.

5. DECISION POINTS

5.1 SOR - JUNE 1962

The CNO issued Specific Operational Requirement No. 12-04 in mid-1962. This SOR had been supported by recommendations and studies made by the Bureau of Naval Weapons (BUWEPS). A system with a surface capability was specified.

5.2 TECHNICAL DEVELOPMENT PLAN OF MARCH 1963

The program plans and the design approach were approved in the Technical Development Plan (TDP) of March 1963. Two prototype, or preproduction, systems were to be procured whose design would include the TWS multi-track feature in which central processing and computations would be performed by a general purpose digital computer. Three factors are evident: A surface only capability is envisaged; the risk assessment of this design was found to be minimal in the TDP; a contract would be let to procure two prototype systems.

5.3 REVIEW OF THE DESIGN - MARCH 1965

In early 1965 the program consisted of paper studies plus the major components of the first of the two prototype systems at the contractor's plant. A review of the design was conducted by NAVORD (BUWEPS) in March 1965 and the results of this review were:

a. An analysis estimating minimal risk in the design
b. A decision to proceed with development; and
c. A decision to initiate procurement of production systems.

It should be noted that, at this stage in the program development, OPTEVFOR has had no Mk 86 task assignment nor has it had opportunity for any participation or impact on the program. With the IOT&E license and authority now prescribed in the DOD 5000.3 series of instructions and in OPNAV3960.1 COTF would have at least had the opportunity to question the SOR and the design concept of a surface-only system. In hindsight, inclusions of the AA capability at an early stage of the system development would have saved the time, and money and evaluation effort which was devoted to the Mk 86-0 system. As it happened, the decision to include the AA capability was delayed by 5 years.

5.4 TECHEVAL-OPEVAL C/S45 - DECEMBER 1966

The first prototype system was delivered by the Manufacturer, Lockheed Electronics, Inc. (LEC) in June 1966. NAVORD requested a technical evaluation. The CNO assigned the task to COTF and it evolved into concurrent TECHEVAL and OPEVAL C/S45. C/S45 was conducted on board the USS BARRY and terminated in December 1966.

The major discrepancies of the system as they were revealed in C/S45 were incomplete debugging of the TWS program and unsatisfactory performance in the beacon mode. The report also stated that the allocation of scheduled ship time was inadequate to complete the evaluation.

In spite of these major discrepancies, the results of C/S45 demonstrated that the basic design was sound, that the digital computer provided unmatched flexibility over analog computers, and that the system was capable of delivering accurate effective fire on two shore targets or on two surface targets during high speed maneuvers.

In general, C/S45 found the Mk 86 Mod. 0 system to be suitable for installation on board ships after correction of major discrepancies.

5.5 AA CAPABILITY ADDED-CNO LTR OF 6/2/67

The CNO, in the SOR of 6/27/67, increased the requirement for the Mk 86 system to include a capability against airborne threats. The capability would include control of AA gunfire and a Standard Missile. A complete redesign was not required but extensive modifications would be necessary. To acquire the added characteristics, the system would need: an extensive revision of the software program; a pulse doppler radar as an AA sensor with CWI as a target illuminator for the missile; the redesign of major components; and, the design and inclusion of several new components.

As a result of the SOR, NAVORDSYSCOM (NOSC) held a review of the design to evaluate the revised system capability and to assess the technical risk. The basic conclusions of the review group were that the dual-purpose design was sound; it presented minimal risk; and, the Navy should proceed with the development of the AA-Capable Mk 86 system.

Preproduction System No. 2 which was modified during 1968 to receive the added capability was designated Mk 86 Mod. 2. Plans were made to start testing it early in 1969.

5.6 SECOND CONCURRENT EVALUATION C/S58 - 1969-71

A concurrent TECHEVAL and OPEVAL was performed on board Norton Sound. Throughout the OPEVAL phase the system was plagued with problems that were reliability related.(47) These problems remained so severe that, after twelve weeks of testing, COTF terminated the OPEVAL phase on

20 August 1970, noting that major problem areas had remained unresolved.[47] The In-Depth Review (IDR) was in progress during this same period and the results were unofficially known by OPTEVFOR.

NSMSES continued the TECHEVAL to completion; however, during a 2-month period within the evaluation schedule a test moratorium was invoked by NOSC and a program review was held to determine the future of the Mk 86 GFCS. TECHEVAL conclusions were that the system, when operating, was satisfactory and that the program should continue.

During this timeframe, a decision was made to authorize limited production in advance of service approval and a letter contract was signed on December 30, 1969.

5.7 IN-DEPTH REVIEW (IDR) JULY 15-SEPTEMBER 15, 1970

The In-Depth Review (IDR) was held under the direction of NSMSES. It consisted of representatives from all the activities associated with the Mk 86 program. The IDR group rigorously examined every functional area involved in the program, particularly the areas of system design, system performance, and quality assurance. Special efforts and emphasis were made to appraise the prime contractor's ability to fabricate and assemble the equipment in a manner which would retain the designed-in quality.

The IDR Group reaffirmed the soundness of the conceptual design of the system, identified a range of problems and their solutions, and proposed a continuance of the program. Their extensive findings and recommendations were documented in their report, TR147.

5.8 TR147 - OCTOBER 15, 1970

The problems reported in TR147 fell into three categories; the first two being of a major or crucial nature. They were:

a. Production problems;
b. Required operational improvements; and,
c. Other recommended improvements.

Solutions to the first group were mandated for accomplishment. The second group were improvements or changes required for the proper performance and operation of the system. The third group were other recommended improvements required for optimal performance of the system.

The IDR group developed detailed solutions to the problems reported in TR147 and, in some instances, a range of solutions were presented in the findings.

Generally, solutions to the first two categories of problems were accomplished in a short time. Many were installed on the AVM-1 prior to completion of TECHEVAL. To the greatest extent practicable, the lessons learned in the first two categories were incorporated in Production Serial No. 3 being readied for DLGN 36. This was done after acceptance and then backfitting prior to delivery to the shipbuilder.

Solutions to the third category of problems were either incorporated into the production systems or ORDALTed after delivery; or, in the less important items, not yet approved due to funding decisions.

The results reported in TR147 are, considered in retrospect, the most crucial milestone of the total Mk 86 program. The professional direction and emphasis demonstrated by NSMSES throughout the IDR produced a thorough understanding of the problem areas as they related to system performance and the industrial engineering practices of the contractor.

5.9 THIRD CONCURRENT EVALUATION C/S79 MAY 1-JULY 28, 1972

The third and last evaluation was performed on System No. 4, the second production system. The conclusions of TECHEVAL were that the system should be capable of adequate performance and satisfactory reliability. There were findings that specified modifications and safeguards be implemented.

TECHEVAL results also indicated the system was capable in its surface, air, and shore modes. The problem areas found to require remedial actions were grouped into two categories, essential and desirable.[48] The essential category related to safety, system performance, and system reliability. The desirable category related to those items desirable to enhance equipment performance, maintainability, operability, and reliability.

Safety items were incorporated in production systems and backfitted into the one production system already delivered. Similar actions were taken on the more important reliability- and performance-related items. The remainder are in the ORDALT process or in the limbo of funding decisions. The minor ones may never be accomplished.

During OPEVAL, COTF found deficiencies. The SPG-60 radar lacked capabilities in an ECM environment.[49] He found poor performance against high speed surface targets and during counterbattery operations. He also questioned the reliability of the SPQ-9 modulator and identified human factors problems involving safety and functional arrangements.

COTF's recommendation to the CNO was against a major procurement.

5.10 CNO APPROVAL FOR SERVICE USE JANUARY 2, 1973

The CNO reviewed the results of C/S79[50] and indicated that, when the electro-optical package was available, the Mk 86 system would meet or exceed the SOR. Marginal or poor performance exhibited during OPEVAL was compared to similar but satisfactory performance during TECHEVAL and a judgment was made. Approval for service use was made, provided three conditions were met by NAVORD.(51) They were to:

a. Eliminate in production models certain safety items identified by COTF;

b. Install in production models a more reliable modulator in the SPG-9 Radar; and,

c. Install after production, the electro-optical package being developed separately.

6. RELIABILITY

Reliability was a serious performance deficiency of the Mk 86 systems. The MTBF specified by weapon system Specification 13559 for each major equipment group of the system is 100 hours. The demonstrated reliability has varied from a low of 2.7 hours during C/S58 to 104 hours derived from fully operational history provided by California and South Carolina over 13 months. Data from other ships are excluded because they were not fully operational. The quality assurance controls decreed during C/S58 and the IDR began to exert positive impacts on the reliability of the systems being produced. Circuit boards, modules, and components began to meet specs.

One of the most confusing situations which the Fleet encountered was an apparent lack of configuration control. Fixes were accomplished in two ways. They were incorporated into the production line where possible or were backfitted by means of ORDALT into those systems already delivered. The result was the appearance in the Fleet of Mk 86 systems of the same Mod but with different histories of ORDALT accomplishment. There is no doubt that some ORDALTs were late in accomplishment because of contractual considerations with individual shipbuilding yards. The management solution has been to establish a series of production serial number baselines. For example, all serial numbers prior to No. 18 will be ORDALTed to No. 18 baseline and all serial numbers 18 and above will have those ORDALTS accomplished at the prime contractor's plant. In actuality the configuration of each installation is under control and its alteration status is carefully monitored by the program office and by LEC.

7. AVAILABILITY

Qualitative data representing meaningful system availability are now beginning to appear in the program. Data from the prototype system during C/S58 were limited; however, availability was unsatisfactory ... C/S58 in its various phases lasted over 2 years. Availability had made some improvement during C/S79. That evaluation required 3 months. Operational data did not yet exist.

The best availability experience on the system to date is provided by the combined California-South Carolina operational experience and evaluated by the Fleet analysis center in TM 841 - 1471. Availability was 91 percent over a 13-month period and the MTBF had increased considerably above the 100 hour requirement.[52] The current availability trend is downward while the MTBF increases.[53] This situation is due principally to lack of supply support in range and depth on board ship and in the supply system.

The downward trend noted above was recently substantiated by COTF during PAT&E trials of SPRUANCE. He noted that the Mk 86 GFCS was the least available and most troublesome of the subsystems on board and found lack of supply support the most significant causative factor. He identified an inadequate range of supply support, citing the CGN level of support to be about three times that for the DD963 Class. Both classes have identical systems.[54]

8. CONCLUSIONS

During each evaluation program, T&E results indicated that technical risks had existed to a degree greater than reported, especially in the first two programs.

Concurrency of development, testing, and production is risky under ideal programming. The decision to procure initial production hardware prior to thorough testing by OPTEVFOR was premature.

T&E inputs at the initial stages of a developmental effort are most beneficial to a program. The early discovery of risk areas resulting from T&E contributes to a more orderly and less costly process. The present policies governing T&E greatly contribute to such a process.

IV. CASE STUDY #4-COMBAT SYSTEM INTEGRATION, CGN-36 AND CGN-38

1. INTRODUCTION

1.1 PURPOSE

The purpose of the study of the integration of the combat systems of the CGN-36 and the CGN-38 is to determine what impact Test and Evaluation had on the acquisition programs of these ships. Emphasis on T&E, as a major pacing factor on acquisition programs, was directed in DOD Directives of the 5000 series beginning in mid 1971. Detailed responsibilities were promulgated in DOD 5000.3 in 1973. These T&E policies became effective too late to be included in the CGN-36 program or the early phases of the CGN-38 program, but they were effective in time to govern the later testing phase of the CGN-38 program. The study of the two programs permits an easy assessment of the effect of the 5000.3 directives on Navy acquisition of modern Combat Systems. In addition, the study develops those lessons learned during the CGN-36 program and describes how these lessons were applied to the CGN-38 Class acquisitions.

1.2 SCOPE

Test and Evaluation in this study includes that done by the Development Agency (DT&E) and that done by OPTEVFOR (OT&E). While there were many problems in both CGN-36 and CGN-38 programs occurring internally within individual weapons systems, the scope of this study is restricted to those which affected the overall Combat System Integration only. It was in the management of T&E programs involving the total ship capability that the greatest number of lessons were learned.

2. CGN-36 CASE HISTORY

2.1 BACKGROUND

The combat system of the CGN-36 was not fully tested nor ready to support INSURV Acceptance Trials when it was presented on 2-3 Jan 1974.[59] The Navy accepted delivery of the ship in an incomplete status on 7 Feb 1974 and undertook a concerted effort of about 6 months duration post-delivery to bring the combat system to a complete and operational status.

The T&E program for the Integrated Combat System of the CALIFORNIA was not adequate. For a variety of reasons, the early T&E plans were not fully implemented nor did they fully appreciate the magnitude of the task. Many indicators were available to management during the construction period which should have caused concern, however they were largely ignored or underestimated. PCO Reports (Tab B) gave a continuous record of late accomplishment of scheduled events, of test deficiencies, and of hardware and software problems. During the summer of 1973, an awareness of crisis began to be appreciated; and in August 1973, the Navy recognized a state of "extremis"[56] which led to the decision to accept the ship in an incomplete status. With only 4 months remaining until scheduled delivery of the ship, there probably was no other reasonable alternative; however throughout these last months, it was the event schedule that was the driving function, not the readiness of the ship to accomplish a particular event. In December 1973, waivers were requested and approved pertaining to Acceptance Trials of the Combat System and the ship was presented to the Board of Inspection and Survey on 2-3 Jan 1974. A chronology of significant CGN-36 Combat System events is presented in Tab C.

2.2 DISCUSSION OF SPECIFIC PROBLEMS IN CGN-36 PROGRAM

2.2.1 SHAPM and CSM

Many problems existed on both the side of the Shipbuilder and of the Government. There was no single strong centralized authority with management responsibility for the overall Combat System Test Program. Consequently, test discipline seriously eroded. Test schedules slipped without recovery and test deficiencies frequently were uncorrected. Because of the lack of an overall Combat System Manager, the test effort, for the most part, consisted of a parochial fractionalization of effort by the individual PARMs involved. There were more than enough problems internal to their own subsystems to preclude overall System Integration Testing.

2.2.2 Shipbuilder

The Shipbuilder had major cost, schedule, and personnel problems. The delivery date of the ship had slipped by over a year. It had been a number of years since he had undertaken to deliver a modern surface warship and the combat system of CALIFORNIA was an order of magnitude more complex than any other in his experience. His work force was inexperienced and sufficient talent to augment this inexperience was not available for hiring. A Combat System Test Plan (CSTP) was provided to him contractually in June of 1970[57] but its implementation was not made mandatory nor was it used by him to full advantage. As late as May 1973, with a significant number of combat system tests still not satisfied, he was predicting an optimistic completion and readiness for COT, BT, and AT.[58] In fact OPFCO, COT, BT, and AT all were conducted knowing that the ship was not ready. (Tab B)

2.2.3 Shipbuilding Contract

The Contract Design of CALIFORNIA was completed in 1967, and the ship construction contract with Newport News Shipbuilding and Dry Dock Co. was executed in July 1968. The original contract gave the contractor the responsibility for delivery of a fully operational combat system. This included the requirement to develop all tests, subject to the approval of the Supervisor of Shipbuilding, and to be based on ODs, OPs and other data to be provided by the Government.

The test guidance in the contract was recognized by the SHAPM to be inadequate and he chartered the Philadelphia Naval Shipyard as the Test Development Manager in September 1969 expressly, among other things, to provide the contractor with the Combat System Tests to be used in lieu of the test requirements then specified in the contract. The CSTP, including an Integrated Test Package (ITP), resulted; and it was invoked as a contract modification (FMR-142) in June 1970. The ITP was to be administered by SUPSHIPS.

There were no definitive specifications on combat system interfaces, or on testing discipline and fault correction, in the original contract. A general lack of understanding of the term "Integrated Combat System," even by the Navy, made the writing of integration specifications of various subsystems difficult at best.[(59)]

2.2.4 Technical Publications

The subjects of inadequate and late arrival of Technical Publications and of deficiencies in the Shipbuilder-maintenance of Government furnished material were items of continuing concern to the PCO and were reported by him as matters of urgency. (Tab B). Inadequate procedures in GFE/GFI management contributed to the lack of overall discipline in the control of this portion of the Government's responsibility. Individual PARMs took action when deficiencies were reported with varying degrees of response. A part of the problem in this area was the lack of configuration control over both hardware and software. Changes were made in both, however the resulting updates of test procedures, of maintenance requirements, and of the records of computer program changes lagged far behind the actual accomplishment of the changes in configuration. A comprehensive Configuration Status Accounting Document (CSAD) was needed. What did exist was not kept sufficiently current to be fully useful.

2.2.5 SUPSHIPS

Combat System Integration was not fully understood by the SUPSHIPS any better than it was by the Shipbuilder. The SUPSHIP staff was inadequate in both number and experience to properly discipline the testing of the Combat System. Although the contract did provide for the witness of tests by the Government, the test discipline exercised by SUPSHIPS was sporadic and of a quality assurance nature only.[(60)] The Interface Requirement Document was issued in April 1970, but it consisted of generalizations which had been long since outdated by equipment and software requirement changes. NAVSEC developed a Combat System Integration Test Program which was used for all Integration Tests, however there was no Specification Tree for the Combat System starting with an overall Performance Specification with an error budget assigned to lower level specs and including analog, digital, and facility interfaces.[59] The Operational Combat Systems program was being built by FCDSSA. The revised version of the program did not arrive aboard ship until the day before Acceptance Trials; this version had not been proofed.

There were attempts to run some programs jointly at both Mare Island and Dam Neck. At Mare Island, on a "not-to-interfere-with-training" basis, and using the NAVSEC NTDS Test Tape, the NTDS/TARTAR D programs were run together. Simulation of inputs and outputs was attempted in lieu of major equipments. These tests did indeed uncover problems in both programs. However, the tests conducted were single thread tests and the systems were never saturated or tested in an operational sense.[59] Development problems in systems, subsystems, and computer programs continued, many of which still existed when the programs and the equipments were delivered aboard ship. At Dam Neck, the NTDS Test Program/Mk 86 interfaces were tested with considerably more success. However, many problems were evident in all three programs when software and hardware met aboard ship in September 1973.

It is significant to note that the MFCS Mk 74-4 was not an Approved for Service Use system. It was still in the development phase and the lack of configuration control of both hardware and software made it virtually impossible to stabilize the computer programs. During the TARTAR test period in the summer of 1973 there were 35 program patches made in a one month period and three major program changes made in the last months before delivery.[61] A strong centralized management authority, definitive interface specifications, and a comprehensive acceptance test for the integrated system were needed. None of these requirements existed.

2.2.6 Test Schedule

The DLGN-36 Combat System Test Schedule, as originally planned by the Shipbuilder, was optimistic. It was apparent from reviewing the PERT networks, that the Shipbuilder intended to complete individual subsystem testing (AAW System, Search Radar, GFCS) prior to starting any integrated system testing (AAW/NTDS, Search Radar/NTDS, and NTDS/OPFCO). Despite early slippages in the DLGN-36 delivery dates, the Shipbuilder did not expand his schedule for higher-level testing. This decision by the Shipbuilder contributed to the testing problems later in the program.

Testing on DLGN-36 continued at a very slow pace. It appeared that the time required to test a system was at least twice what the TDM, TDD, and TDAs anticipated.[60] Among the reasons for delays were problems with spare parts, equipment, systems, and personnel. Included in this was the Shipbuilder's failure to properly use the Government expertise that was available within the Supervisor's Office. One prime example was the Mk 13 GMLS. The Test Development organization estimated it would take 6 weeks to complete Stage 3 testing; the Shipbuilder allocated 20 weeks for completion. The actual time for completion of the forward system alone was 47 weeks. During this time close to 50 Combat System Problem Reports (CSPRs) were issued against the TPs and the equipments for the forward and after system.[60] The result was a general lack of credibility in the overall ITP.

2.3 T&E IMPACT ON THE CGN-36 PROGRAM

2.3.1 Test Documentation Development

The documentation controlling the test program was developed both by the Government and the Shipbuilder. The Shipbuilder used his existing TPs and was expected, where necessary, to demonstrate compliance with contract specification, and to develop additional tests. In June 1970, as a result of the TDM (PNSY) effort, a modification to the Contract was invoked which provided an ITP. The intent of this first attempt to implement the ITP concept was to provide the Shipbuilder with a contractual set of tests that would demonstrate the combat system progressively through Acceptance Trials. It was deficient in two major areas in that it did not provide for adequate testing of subsystem interfaces nor did it require full operational testing of the combat system by either the Navy or the Shipbuilder. Because of the many problems which had arisen within the individual subsystems and in the effort to resolve them, the deficiencies in the overall testing of the Combat System were not recognized by the SHAPM even as late as mid-1973.

2.3.2 Combat System Computer Program Development and Test

The Combat System of the CGN-36 contains computer programs in the ASW, Mk 74-4, Mk 86-3, NTDS/CFU, and in the Operational Command and Control areas. The ITP, as it was to be developed by the TDM, was originally intended to contain the TPs necessary for all the above programs. Because the Operational Program was Government responsible and assigned to FCDSSA, the SHAPM modified the TDM charter and removed this portion of the responsibility.[59] FCDSSA was assigned responsibility for developing the OPFCO, for providing the test plans to the shipyard, and for conducting the test. The split in responsibility for test planning and test conduct contributed to the lack of centralized test program control.

It was attempted to test and run portions of the Combat System software programs at LBTS. The NTDS/CFU - Mk 74 systems were installed and run at Mare Island and the NTDS/CFU - Mk 86 programs at Dahlgren. However, these efforts were conducted on a "not to interfere" basis, and while some problem areas were uncovered and fixed, there were many problems that remained to be solved aboard ship.

Configuration control of software programs was virtually nonexistent. Program changes were made by PARM personnel both at the LBTS and aboard ship and there was no coordinating authority to establish what effect these changes would have on the integrated performance of the total system.

2.3.3 Government Administration of the T&E Program

The administration of the T&E program by the Government was inadequate both in test development and in implementation. The performance of an essentially Government-furnished combat system is inherently the responsibility of the Navy. Although the SHAPM recognized this fact and proceeded to structure and fund a Government-furnished test program, several key tasks were removed from the test development manager's charter and not otherwise adequately performed. Although he was envisioned as both manager and systems engineer, all basic technical responsibilities were pulled back from the TDM. Thus he could not "direct" the addition of new tests, eliminate nonrequired ones, nor properly analyze the integrated test package for adequacy and coverage. When the TDM did attempt to take these actions, his management control of supporting subsystem test directors was ineffective. The SHAPM also limited the TDM's area of interest to predelivery, even pre-INSURV, activities.

The SUPSHIP had two new factors introduced into the ongoing construction contract. One was the Government package of testing (ITP) to be contractually conducted by the builder; the second was Government test specialists who were independent from the local organization. Under the terms of FMR 142, the ITP was provided to the builder, who was then left alone to conduct the tests. Witnessing tests was done only in the random quality control sense and Government representatives were not required for test completion.(59) The SUPSHIP office was overworked/undermanned with varied shipbuilding programs; however, the utilization of TDM-provided representatives was minimal.

2.3.4 Introduction of Developmental Combat Subsystems

Program approval for DLGN-36 was not as dependent upon "approved" systems as required in more recent ship acquisition programs. On DLGN-36 the Mk 74 (TARTAR D) system was a major T&E program factor that consumed combat system test and maintenance time and repair parts at an inordinate rate. It was planned to obtain service approval of this system through introduction on DLGN-36. Other systems caused some disruption but, by comparison, created few problems.

2.3.5 Shipbuilder Implementation of the Shipboard Test Program

The DLGN-36 Shipbuilder had to be pursuaded to use the ITP concept and documentation. In initial negotiations he felt it would be very costly to conduct and initially was not convinced that he needed assistance. Negotiations continued and the builder finally agreed to a "no cost" change provided that the Government would provide the ITP and essentially exert minimum control over test scheduling and conduct. This resulted in the builder using test sequence networks only for guidance.

In view of the above, the SUPSHIP office, although retaining approval authority for specific TPs to be used and broad schedule control, had little specific grounds for holding the builder to test discipline. Without such test discipline, overall system operability cannot be assured.

2.3.6 Ship Delivery Schedule Compression

Various factors impacted the DLGN-36 delivery schedule. Although initial ship delivery slipped from July 1972 to December 1973, the Government and builder still had many problems in conducting the test program on the ship. As documented by PCO and test progress reports, Combat System testing never recovered from the impact of unreliable Government-Furnished systems. Compounding this problem was the inadequacy of the Computer Operational Program which, even after delivery of the ship, had several uncorrected technical problems. In short, the Government needed more "debug" or proofing time for the total combat system than was foreseen.

All of this delayed parts of the test program until a compressed schedule of testing was mandatory; and a layering of subsystem, system operability, Government integration, and pre-INSURV testing resulted. This precluded orderly and sequential testing of the combat system and adequate verification/analysis of test conduct data.

2.4 CGN-36 TEST AND EVALUATION CONCLUSIONS

a. A ship combat system, being a balanced integration of system hardware, computer software and ship's force, must be tested as such. On DLGN-36 there was an adequate program to test hardware while the testing of software was inadequate, and the ship crew "testing" (combined with training) was incomplete during the timeframe allotted. The modification of the DLGN-36 contract was deficient in that it only provided desired sequences for tests rather than invoking mandatory test sequence.

b. Coordination and control of all land-based test activity was fragmented. During planning of DLGN-36 LBTS activity, it was recognized that dedicated LBTS were difficult to justify; however, stronger management control of the ones utilized could have resulted in more complete computer software development and testing.

c. The Government could have better utilized test support resources such as Navy personnel and vendor services in the conduct of the test program. When the contract does not permit active involvement of the trained Navy crew to support testing, a larger and more talented group of Government vendors must be contractually provided to the builder than was in evidence on DLGN-36. Additionally, on-site test development resources must be more actively involved in the progression, witnessing, and analyses of test programs.

d. There was no overall performance statement/specification for the DLGN-36. Consequently, there was no test specification for use by the test development organization to produce integrated test procedures or for use by the SUPSHIP office to accept/reject test conduct results.

e. There was sufficient test data obtained from the ITP and Government integration testing to predict the status of the ship at delivery. Thus it must be concluded that the Navy reached a considered decision at the CNO/staff levels to accept delivery of DLGN-36 knowing she was incomplete.

f. In summary, even though an element of risk in the integration of the CGN-36 Combat System was recognized by the SHAPM, it was not fully appreciated in degree until late in the summer of 1973. The T&E plan, as it was modified by FMR-142, was an attempt to alleviate the risk as it was understood by the Program Manager early in the construction phase. Because of management ineffectiveness, inadequate administrative discipline of the CSTP, and lack of specific overall performance specifications to provide a basis for integration testing, the T&E plan did not fully address the risk as it in fact existed. The situation was compounded by the unresolved problems in specific subsystems which obscured the problems in the overall integration of the Combat System as a whole.

3. CGN-38 CASE HISTORY

3.1 BACKGROUND

It is evident in the evaluation of the acquisition planning for VIRGINIA, that there was a considerably greater understanding of the risks involved in Combat System Integration for this ship than there was in the planning for CALIFORNIA. In March 1970, soon after the specifications for VIRGINIA were issued, the T&E Management Handbook for DLGN-38[62] proposed a radical change in T&E planning which delayed all tests of Combat System Integration until after delivery of the ship. In April 1972, the Integrated Combat System Management Plan (ICSMP),[63] devoted an entire section to Risk Definition and Control and described the software elements of the C&C program to be of "moderate" technical risk.

There was a growing apprehension in DOD concerning the effectiveness of T&E, not only in the Navy, but in all DOD acquisition programs. Prior to DOD Instruction 5000.3 which was issued in January 1973, in a Memo dated 13 October 1972,[64] Secretary Rush directed the Navy to conduct "maximum operational test and evaluation by OPTEVFOR as early as practicable on all combat subsystems and their integration." He requested a plan within 120 days and asked that this plan give particular attention to the Mk 116 Mod 1 UFCS, the Mk 26 GMLS, the Mk 74 Mod 5 MFCS, and OT&E of system integration at the LBTS. He further requested plans for conducting an Operational Appraisal by OPTEVFOR after delivery of the lead ship (CGN-38).

The OT&E Plan[65] that resulted was not fully responsive to the intent of the Rush memo and COMOPTEVFOR, in his review of a draft copy of the plan, discussed its deficiencies in a letter to CNO dated 31 January 1973.[66] In April 1973, DDR&E requested the Navy to make every effort for a 2-4 week OT&E at the SSIS by OPTEVFOR and for an Op-Appraisal of the ship post-delivery.[67]

The problems with CALIFORNIA began to surface in summer 1973 and the growing apprehension over the condition of her combat system gave additional emphasis to the requirements for adequate and effective T&E for VIRGINIA. The result was the assignment by CNO of X/S 30, an OT&E project at Mare Island and of F/S38, an Op-Appraisal of the VIRGINIA to be conducted post-delivery.[68] A chronology of CGN-38 Combat System Events is appended in Tab D.

The assessment of risk was far more complete and had a much greater impact on T&E for VIRGINIA than on T&E for CALIFORNIA. Although the specific improvements in management which derived from the CALIFORNIA experience were implemented to great advantage in the VIRGINIA program, some problems remained.

3.2 SPECIFIC MANAGEMENT IMPROVEMENTS

3.2.1 SHAPM and CSM

It was clearly apparent from the problems of the CALIFORNIA that there was no clear cut positive control, in the office of the SHAPM, over the corporate efforts of the PARMs involved. A single overall Combat System Manager was recommended by the CNM *ad hoc* review board[59] and on 17 May 1974, PMS378 designated and chartered a CSM in his office who had the unique responsibility for all management required for the successful completion of the integration of the Combat System. This provided an authoritative focal point in the SHAPM office and centralized control over all PARM effort. The ICSMP[63] was updated and an increased discipline of Configuration Management was established in the SHAPM Change Control Board.

3.2.2 Shipbuilder

Experience in the Shipbuilder's yard increased as work on the CALIFORNIA progressed. The big improvement, insofar as VIRGINIA was concerned, was in his recognition of need and value of Schedule B Vendor Services. The utilization of this talent by both the Shipbuilder and by SUPSHIPS was far greater than it was for the CALIFORNIA. The acceptance of the CSTP and the ITP was markedly improved. For the VIRGINIA, most ITP Test Procedures and Test Sequence Numbers were validated and confirmed at shore-based test sites so that they were presented to the Shipbuilder as proven tests. The entire ITP was now under control and the CSPR program with its rapid response mechanism reflected the actual test condition aboard ship.

3.2.3 Shipbuilding Contract

The contract was modified by HMR 144[69] to invoke the CSTP; and the "complete ship" definition now permitted the Navy to accept a ship which meets the shipbuilding contract installation requirements, with the higher level integration and OPFCO to be completed after delivery. This allowed the Shipbuilder to have a better idea of the requirements he must meet.

3.2.4 Government-Furnished Equipment

The management of GFE and GFI was recognized as a major problem in the CALIFORNIA and one of the earliest actions by the SHAPM after the CNM ad hoc Review was to establish an ILS or GFE manager in the SHAPM office responding to the CSM. Deliveries of equipment were not made until requested by the Shipbuilder and in many instances were stored and maintained at Cheatham Annex in Navy hands until ready for installation. The Configuration Status Accounting Document (CSAD), published 1 June 1975, was the best possible status of installed equipments. Updates were published monthly, and it became the master source of configuration status.

3.2.5 SUPSHIPS

From the CALIFORNIA experience, it was obvious that more Navy help was needed in the SUPSHIPS organizaiton. A Warrant Officer and 3 CPOs were designated and assigned. Test personnel from NOSSOLANT, NSWSES, Philadelphia NSY plus about 20 vendor engineers and technical service personnel were organized into a competent team to run the ITP. A Local Combat System Manager reporting to both the CSM and to SUPSHIPS was the focal point for the waterfront test program.

3.2.6 Test Discipline

The overall result of the increased emphasis on T&E was significantly greater test discipline in the administration of the CSTP including the ITP. In NAVMATINST 3960.7 of 31 May 1974[70] a policy statement was made that: "The SHAPM shall be responsible for developing, from OPNAV design requirements and from his own risk analyses, definitive traceable test requirements necessary to demonstrate a progressive reduction of risk from initial factory T&E to land-based testing, ship construction T&E, and post-delivery operational T&E. These test requirements must be successfully satisfied and resolved before they jeopardize high level and costly system integration." The execution of the CSTP and the resolution of CSPRs that followed from HMR 144 achieved the desired results in the spirit of the policy statement quoted.

3.2.7 Software Configuration Control

Of all of the problems that beset CALIFORNIA, perhaps the most difficult to understand and the crux of a whole matrix of problems was the management of the software programs. There was no single office in charge and the integration of independent computer programs was not achieved until after delivery. For VIRGINIA, in the summer of 1974, steps were undertaken to bring FCDSSA under the direct responsibility of the SHAPM and to make them the Software Configuration Control Manager. Individual subsystem computer programs were required to undergo a certification process. Once certified, they were delivered to FCDSSA for configuration control. In essence, the software programs were frozen and no further changes took place without positive identification of their impact on the other programs. This relationship between FCDSSA and the SHAPM was formalized by CNO on 12 September 1974. The whole area of software management was resolved through this expedient; and while there were still problems with the C&C computer program, it was not in the SHAPM FCDSSA management of it that problems occurred.

3.3 SPECIFIC RESIDUAL PROBLEMS

3.3.1 Command and Control Programs

The Command and Control Program, to be built by UNIVAC and under NAVSEC as PARM was scheduled to be available at Mare Island in October 1974. One of the earliest indications of trouble was a report from NAVSEC on 8 July 1974 that the C&C program was about a year late. A final design review was scheduled by NAVSEC to take place on 6 December 1974 to determine the configuration and finalize a schedule. This meeting was cancelled the week before it was to be held and the SHAPM decided to take personal control over the C&C program. X/S30 was cancelled, not by decision, but by the inability to have a C&C program to support it. There was no other alternative. A version of the C&C program was delivered to the ship at the end of 1975, however it was not acceptable for maintenance or for acceptance testing because of the excessive number of patches. It was, however, suitable for System Integration Tests at a less formal level and was used post-delivery for these tests.

3.3.2 Mk 26 GMLS

The Mk 26 Launchers had unique problems in that they were not Approved for Service Use items. Norton Sound OT&E gave provisional acceptance but several ORDALTs were necessary to correct problems which had surfaced as a result of these tests (DD 599).[71] Blast effects and reliability criteria were scheduled to be tested in OT-IVB by COMOPTEVFOR.

3.4 T&E IMPACT

3.4.1 Risk Assessment

Test and Evaluation as an integral part of the acquisition planning for VIRGINIA had an increased impact over that on CALIFORNIA simply because there was a far more realistic assessment of risk. Adequate T&E was mandated in the DEPSECDEF Memo of October 1972.[64] Non-ASU subsystem components were recognized in this Memo and particular attention was directed to the integration of subsystems. The ICSMP had previously identified technical problems in Combat System Integration as "moderate" and in August 1974, NSWSES assessed the delivery of operationally acceptable combat system software as "high risk" in accomplishment.[72] In OPTEVFOR initial planning for F/S38 (later to be OT-IV as per OPNAVINST 3960.10), a list of certain critical items was formulated in the TEMP as prerequisites for accomplishment prior to the conduct of OT-IV tests. Each of these risk assessments had an impact on the T&E planning to reduce the risk element which was identified.

The NSWSES Memo of August 1974, mentioned above, was the subject of the SSIS Integration Testing meeting held at Mare Island during the first week of October 1974 and reported on 9 October 1974.[73] Specific test deficiencies were identified, prioritized and scheduled. The Mare Island LBTS was not as effective in the System Integration Test effort as it could have been because of the unavailability of the C&C operational program from UNIVAC and the cancellation of X/S30. However, the identification of problems as was done at this stage of the software development did indeed reduce the risk and highlighted the interface requirements between subsystems.

3.4.2 Subsystem Computer Program Certification

The requirement for each PARM to undertake a certification of his Computer Program forced greater parallelism in computer program development. As expected, the Mk 74 Mod 5 program was the most difficult and the last subsystem to be certified. The relative ease in its integration aboard ship, however, would not have been possible without the certification process and the rigid software configuration control imposed by the SHAPM.

3.4.3 Test Discipline

The administration of the ITP and the Test Sequence Numbers and the requirement for satisfactory test results from tests by the Shipbuilder reoriented the construction schedule to be T&E achievement controlled. Problem reports (CSPRs) continued to be uncovered because of test development errors but were resolved, for the most part, on site and in a minimum amount of time.

3.4.4 Systems Not Approved for Service Use (ASU)

Those equipments and subsystems of the CGN Combat System which were not ASU, were clearly identified as risk items early in the program in the Sec. Rush Memo.(64) Each PARM was required to submit a plan leading to ASU and the required T&E was included in the Test and Evaluation Master Plan. In brief, the non-ASU items were: (1) the UFCS Mk 116 Mod 1 (a digital UYK-7 version of the Mk 114), (2) the GFCS Mk 86 Mod 5 with CWI, (3) the GMLS Mk 26, (4) the new equipments in the MFCS Mk 74 Mod 5 (principally WDS Mk 13) and (5) the overall Combat System Integration. The system which gave the greatest amount of trouble was the Mk 26 Launcher, and the problems were largely in reliability and availability.

3.4.5 Test and Evaluation Master Plan (TEMP)

OPNAVINST 3960.10 was not officially promulgated until October 1975, however its content was well known and the new requirements for TEMP material and organization were the governing elements of the cooperative effort of NAVSEA and OPTEVFOR in the writing of the CGN-38 TEMP. OPTEVFOR formulated a list of critical DT&E events which were provided to the SHAPM, and these items formed a basis for a list of prerequisites to OP-APPRAISAL (OT-IV) and were included in the TEMP.

3.5 T&E CONCLUSIONS

a. Risk assessment for VIRGINIA was more realistic and much better understood than was the case with CALIFORNIA.

b. Weaknesses in the management of T&E of CALIFORNIA were corrected and the result was a much stronger basis for T&E discipline in the case of VIRGINIA.

c. OPTEVFOR influence in the Navy's adherence to DOD T&E planning policies resulted in a TEMP which was responsive to risk assessments.

d. Utilization of an LBTS (Mare Island) was greatly improved over the CALIFORNIA program. The late delivery of the C&C computer program prevented it from filling its full potential.

4. SUMMARY

There would have been problems with CALIFORNIA in any case. There were non-ASU items and the Mk 74/4 TARTAR "D" system was truly a development system. There was a lack of risk understanding which was at least partly due to a general lack of understanding throughout the Navy of real time digital computer technology and of system integration.

However, one of the most significant differences in the management of VIRGINIA T&E was the early inclusion of OPTEVFOR in the T&E planning cycle. OPNAVINST 3960.10 produced a TEMP which controlled the T&E program.

The identification of critical DT&E areas, the list of prerequisites to OT-IV tests and the scope of OT&E all by OPTEVFOR had a great impact on DT&E planning including Post Delivery System Integration Tests and CSSQT.

REFERENCES

1 Assignment of Project D/S531 to OPTEVFOR, 16 February 1960 -- Evaluate 40,000 shp CRP (BLH Design).

2 Hearings on Military Posture and Legislation to Authorize Appropriations During the Fiscal Year 1970 -- (H.A.S.C. No. 91-14) - House of Representatives Committee on Armed Services, March 27, 1969.

3 Same as above except date May 5, 1969.

4 Deputy Secretary of Defense Memorandum to the Secretary of the Navy, 23 June 1970.

5 Committee on Undersea Warfare, National Research Council of the National Academy of Sciences Report dated May 1972 -- A Study of the DD963 Class Destroyer.

6 DD963 Class Destroyer Development Concept Paper #9, 28 July 1970.

7 Selected Acquisition Report (SAR) dated 31 December 1970.

8 Minutes of Meeting -- Defense Systems Acquisition Review Council (DSARC) DD963 Program, dated 13 January 1972.

9 Chief of Naval Operations Memorandum OP-090X A/S #1022-71, Ser 0450 P090, dated 3 January 1977, (Confidential) -- CEB Report on DD963 (U).

10 Final Report DD963 Class Destroyer Propulsion System Prototype Tests at NAVSEC Philadelphia Division (U), dated March 1976.

11 COMOPTEVFOR letter Ser C223 to CNO (OP-03), dated 24 August 1974.

12 "U.S. Navy Controllable Pitch Propeller Programs" by J.J. Angelo, R.M. Petios, and M. Hauschildt. Presented at Joint Meeting of American Society of Naval Engineers and the Society of Naval Architects and Marine Engineers, April 19, 1977.

13 COMOPTEVFOR ltr. ser 879, dated 12 September 1975 -- Operational Appraisal of the DD963 Class Power Plant, COMOPTEVFOR Test Plan for Project F/S18.

14 PMS-302 memo, 27 July 1973 -- Coordination of Sonar Program.

15 Dr. Goldberg report to NAVSEA, 26 Sept 1975 -- Sonar Design Review.

16 CNO OPOO memo, 20 May 1972 -- PF Alternatives.

17 OPNAV memo OP-90B3/mjs, Serial 01505P90, 1 June 1971 -- PF Definition.

REFERENCES (continued)

18 NAVSHIPS Report, July 1971 -- Patrol Escort Concept Exploration Report.

19 COMOPTEVFOR interview, 14 December 1976.

20 MASWP letter to OP-971, 6 August 1973 -- ASWSPO Report PF ASW Suite Analysis Inputs.

21 NAVSEA letter to OP-03D, June 1972 -- PF Sonar Assessment of Candidate Sonars and Recommendations.

22 PMS-399 memo to PMS-302, July 1972 -- Sonar Procurement.

23 OP-03D memo to NAVMAT, 7 July 1972 -- Sonar Procurement.

24 OASN comments, August 1972 -- Selection of A Sonar for the PF Shipbuilding Program.

25 OSN to NAVMAT/NAVSHIPS, 8 November 1972 -- Buy American.

26 NAVHSIPS to NAVMAT, APP 125-72-73.2, 6 December 1972 -- Advanced Procurement Plan.

27 OPTEVFOR report to CNO, 29 December 1972 -- Assessment of SQS-505 Sonar System.

28 OASN memo to NAVMAT/NAVSHIPS, 19 January 1973 -- RAN for PF.

29 PMS-302 Point paper, January 1973 -- PF Sonar Prototype Program.

30 PMS-302 memo to file, 16 April 1973 -- NAVMAT 02 Information Request.

31 TECHEVAL report, 9 June 1975 -- AN/SQS-56 (XN-1) Sonar Set, Prototype, Technical Evaluation Project T/A-99 Final Report.

32 NAVSEA report, 26 February 1975 -- AN/SQS-56 PF Sonar Design Review.

33 OPTEVFOR representative interview, 17 February 1977.

34 MASWP representative interview, 15 April 1977.

35 NAVSHIPS 0967-490-1041, 3 April 1973 -- Prime Item Development Specification for the PF Sonar System.

36 PMS 302 memo to MASWSP, 25 May 1973 -- NUC Laboratory Technical Support.

37 NAVSHIP task to NUC, 1 June 1973 -- Sonar Support Task Assignment.

38 NUC report to NAVSHIPS -- Factory Test Reports.

39 COMOPTEVFOR study plan, October 1976 -- AN/SQS-56 Sonar.

40 NAVSEA letter to OP-37, 25 April 1975 -- AN/SQS-56 (XN-1), Prototype FFG-7 Class Sonar, Status as of TECHEVAL Completion and Recommendations.

41 OPTEVFOR Report O/S 204, 30 October 1975 -- Operational Evaluation of the AN/SQS-56 (XN-1) Sonar.

42 Decision Coordinating Paper, DCP-97, 27 November 1975 -- Guided Missile Frigate (FFG-7).

43 OSD memo, 11 December 1975 -- DCP Approval.

44 Sonar Test Problem Reports, May 1974 through October 1975.

45 NAVSEA (661) representatives interviews, February 1977 through May 1977.

46 NAVSEA, report, 11 November 1976 -- Review of the AN/SQS-56 Sonar Program.

47 C/S58 NSMSES Technical Report No. 229, 1 Jan. 1972 - (final report) of C/S58 Technical Evaluation Mk 86 GFCS.

48 C/S79 NWSES Technical Report No. 269, 31 Jan. 1973 -- Concurrent Evaluation Mk 86 GFCS.

49 COMOPTEVFOR Msg 131600Z Dec. 72.

50 CNO Memo for Record Op 351G1 No. 0222-72, 12/20/72-Mk 86 GFCS.

51 CNO Ltr Op 411 D/1 FN 4205.1 Ser 011P41, 1/2/73 - Approval for Service Use Mk 86 GFCS.

52 Technical Memo 841-1471 FAC Corona, 16 Sept. 76.

53 Tabulation of Operational Data NAVSEA 653 Chart CGN 36/37 4/1/75 to 4/30/76 and 5/1/76 to 12/30/76.

54 COTF Evaluation Report (3960-12) DD963 Class, 3/21/77.

REFERENCES (continued)

55 PRESINSURV ltr 22/mbs DLGN36 Ser 514 of 14 Jan. 1974 - Official Findings of the Board at AT CALIFORNIA.

56 SUPSHIPS Code 154 Memo of 27 Aug 1973 reflecting CNO decision regarding CALIFORNIA Acceptance.

57 Combat System Test Plan invoked by FMR 142 to the Shipbuilding Contract, on 12 June 1970.

58 PM-18 Trip Report File #5214-1 Ser 299 of 7 May 1973 provided comments on combat system test progress and concern over shipbuilders optimism.

59 CNM ltr 00C/WRJ of 8 Mar 1974 - USS CALIFORNIA (DLGN-36) Combat System, Condition of at Acceptance Trials.

60 USS CALIFORNIA TDM Final Report of 23 Sep 1974 forwarded by PM-18 ltr ser 459 of 9 Oct 1974.

61 PCO Reports commencing Sep 1971.

62 DLGN-38 Test and Evaluation Management Handbook published by NAVSHIPS dated 13 March 1970.

63 Integrated Combat System Management Plan (ICSMP) DLGN-38 Class Rev. 3 of April 1972.

64 DEPSECDEF Rush Memo to SECNAV of 13 Oct 1972 - DLGN-38 Class Management Review

65 OT&E Plan DLGN-38 Class drafted by PMS-378 in Nov 1972.

66 COMOPTEVFOR ltr Ser 88 of 31 Jan 1973 - DLGN-38 Class Combat Subsystem OT&E Plan

67 DDR&E Memo for Under SECNAV of 23 April 1973 - OT&E Plan of the DLGN-38 Combat System.

68 CNO 042139Z of Apr 1975 - DLGN-38 Combat System FOTE Project F/S38.

69 Combat System Test Plan invoked by HMR-144 forwarded by PMS-378 ltr Ser 1195 of 4 Nov 1974.

70 NAVMATINST 3960.7 of 31 May 1974.

71 D/S 599 - Development Assist Tests of GMLS Mk 26.

REFERENCES (continued)

72 NSWSES Memo Code 4230 of 20 Aug 1974 - Review of DLGN-38 Integration Tests.

73 NAVSEC Memo 172 of 9 October 1974 - DLGN-38 SSIS Integration Testing.

74 Approved Characteristics DLGN-36 -- Change 1 issued by CNO on 25 Aug 1965.

75 NAVSHIPS ltr Ser 62 of 23 Feb 1970 - DLGN-36 Class, Test Development Manager (TDM) Charter, forwarding of.

76 NAVSHIPS 282137Z of Feb. 1975 -- DLGN-38 Combat Class OT&E Planning.

77 CNM Memo to Ass't SECNAV (I&L) of 4 Feb. 1974 -- Integration of New Shipboard Systems.

TAB A

DD963 PROPULSION SYSTEM CHRONOLOGY

DATE	DD963 PROGRAM EVENTS	DATE	ALLIED EVENTS
Fall/65	Started DX Program		
		1966	Funds for 2 DDGs not provided by Congress.
12/66	Started Concept Formulation of DX	1st Qtr./ 1967	2 DDGs eliminated from FY 1968 budget by OSD for second year in a row.
		3/67	Commissioning of the Coast Guard Cutter HAMILTON with FT-4A gas turbine as boost propulsion.
4/2/67	Proposals requested for DX		
		6/67	Studies initiated to power the Ocean Escort with gas turbines.
		8/67	Authorization given to proceed with design of a gas turbine powered Ocean Escort, leading to acquisition of one ship.
9/67	CNO approved characteristics DX		
		12/67	Sea Trials of Military Sea Command (MSC) GTS ADM CALLAGHAN - Gas turbine powered FT-4A turbines.
2/68	DX authorized to proceed with Contract Definition (CD). Phase A of CD started. Released RFP which started the competitive CD effort.	2/68	RFP issued for new propulsion systems for Ocean Escort, (two-step procurement).
		2/28/68	Dr. Frosch, Assistant Secretary of Defense for R&D testimony re R&D funds in FY 1969 requested for development of gas turbines to provide fully developed components for the DX/DXG Program, and for a new generation of DEs.
		5/68	Pratt and Whitney, Propulsion Systems, Inc., and Todd Shipyards Corp. responded to Ocean Escort RFP.
4/68	SEC McNamara's statement before Hearings on Military Posture - Committee on Armed Services, House of Representatives - Ninetieth Congress re consideration of gas turbine propulsion in DX and DXG.		

DD963 PROPULSION SYSTEM CHRONOLOGY

DATE	DD963 PROGRAM EVENTS	DATE	ALLIED EVENTS
7/68	Signed contract for Phase B of CD DX Program started.		
		9/68	Step 2 of solicitation for new propulsion system for Ocean Escort.
		11/68	Propulsion Systems, Inc. (PSI) awarded contract for design and supplying of a new propulsion system including 35,000 hp Controllable Pitch Propeller (CPP).
1/69	SECDEF approved 30 ship program for DX.		
		2/69	Contract awarded to General Electric for two LM-2500 marine gas turbines for Navy tests.
		3/27/69	DEFSEC Laird's testimony at Hearings on Military Posture before House Armed Services Committee - Proposed elimination of experimental DE (FF) from FY69 Budget.
4/69	Contractors submitted proposals.	4/69	GTS ADM CALLAGHAN completed 16,720 hours of FT-4A operations.
Mid 69	Navy told Litton to price out ship on basis of Pratt and Whitney gas turbines.		
9/69	DX Competition narrowed to Bath and Litton.		
12/69	Congress funded first increment DX Program.	12/69	One LM-2500 engine substituted for one of the two installed FT-4A engines in the ADM CALLAGHAN.
		2/16/70	Assignment of Project D/S 531 to OPTEVFOR - Evaluate 40,000 shp CRP (BLH Design)
5/28/70	DSARC - Second review prior to commencement of detail design and construction. (Equivalent to DSARC III).		
		6/70	Baldwin-Lima-Hamilton 35,000 hp CPP under procurement - scheduled for delivery 3rd Qtr. 1970 with T&E in a DE during calendar 1971. PSI CPP scheduled for delivery late 1971; T&E in a FF to complete in Mid 1973.
6/70	Multiyear contract awarded to Litton for 30 DD963 (FT-4A propulsion system specified).		
6/23/70	DEPSECDEF authorized award of 30 destroyer program (3 in FY70, 6 in FY71, and 7 in each program year FY72 thru 74.		

DD963 PROPULSION SYSTEM CHRONOLOGY

DATE	DD963 PROGRAM EVENTS
7/28/70	DD963 Class Destroyer Development Concept Paper #9.
12/70	ECP approved to permit use of either LM-2500 or FT-4A engines in DD963 Class. Navy consented to a subcontract submitted by Litton for LM-2500 G/T. Site selected for land-based testing of prototype propulsion plant.
12/30/70	Litton ordered DD963 LM-2500 gas turbines.
2/71	DSARC - DD963 Management Review
3/20/71	The first technical milestone in the DD963 Contract met, i.e., "complete system design of the baseline propeller design."
5/71	Secretary of the Navy, John Chafee, requested a special study of the DD963.
7/2/71	Litton ordered CPP from Bird-Johnson.
9/21/71	Agreement MC 9181 consummated between Litton Systems and NAVSEC Philadelphia Division to test one-half shipset.
12/17/71	CNO/Sea Control Panel of CEB reviewed DD963 Program.
1/72	Subcontract awarded for construction phase of land-based test site.
1/3/72	OP-090X/cb A/S #1022-71 Ser 0450 P090 Memorandum (CONF) reported on 17 Dec 1971 meeting of the CEB that reviewed the DD963 Program, directed CHNAVMAT to review R&D gas turbine technology and large controllable pitch propellers (CPP) in the DD963, and recommend urgent augmentation if needed. Due Date 1/14/72.

DATE	ALLIED EVENTS
7/70	Started LM-2500 tests (engine only). (Down in August and September).
10/70	Stopped LM-2500 tests at NAVSEC Philadelphia. Terminated further development of the LM-2500
12/70	LM2500 engine in CALLAGHAN completed about 6,000 hrs of operation.
3/71	CAPT Robert H. Smith's article: Naval Institute "The United States Navy for the Future."

DD963 PROPULSION SYSTEM CHRONOLOGY

DATE	DD963 PROGRAM EVENTS	DATE	ALLIED EVENTS
1/13/72	DSARC DD963 review prior to committing funds for the FY 1972 increment of 7 ships.		
2/72	Factory test completed first LM-2500 Propulsion G/T Module for DD963.		
2/23/72	The fourth technical milestone in the DD963 D&P Contract met, i.e., "complete system and test facility design for the propulsion one-half shipset."		
3/72	Shock tests of the LM-2500 module completed. The fifth technical milestone in the DD963 D&P Contract met.		
4/72	Completed 100-hour test and inspection above module.		
4/72	T&E Plan for land-based test site testing completed.		
		5/72	LM-2500 returned to lab for qualification and endurance tests.
6/16/72	Committee on Undersea Warfare, National Research Council of the National Academy of Sciences submitted its report, "A Study of the DD963 Class Destroyer," - May 1972.		
		8/11/72	Baldwin-Lima-Hamilton (BLH) CPP installed in USS PATTERSON (DE 1061). Commenced CPP trials.
9/72	LM-2500 engine that was shock tested and returned to G.E. Evondale plant for fuel qualification testing completed 1,000 hours of operation - no degradation of components noted.		
		10/72	PATTERSON in two month RAV for correction of defects in BLH CPP. Trials interrupted.
12/72	LM-2500 modules landed at NAVSEC Philadelphia.		
12/72	Start construction of DD963.		
		12/15/72	PATTERSON comoleted 4-hour full power run; modifications to CPP checked out. CPP trials continued.

DD963 PROPULSION SYSTEM CHRONOLOGY

DATE	DD963 PROGRAM EVENTS	DATE	ALLIED EVENTS
2/1/73	The sixth technical milestone in the DD963 D&P Contract was met, i.e., "complete propulsion engine fuel qualification test."		
3/14/73	The seventh technical milestone in the DD963 D&P Contract was met, i.e., "completion of CPP propeller shock test."		
3/73	DT&E of propulsion control system started by contractor – Scheduled for completion in June 1974.		
3/73	Qualification tests completed on reduction gear.		
4/9/73	The eight technical milestone in the DD963 Contract was met, i.e., "completion of propulsion clutch qualification test."		
		4/13/73	PATTERSON in RAV to replace propeller blade wear plates and convert to distillate fuel. CPP trials completed 1,500 hrs of CPP operation.
		4/25/73	CNM Ltr to CNO SHIP04T:REG:kds "Fleet Introduction of the LM-2500 Marine Gas Turbine Engine" - Proposed a 3-year Fleet Introduction Program.
		6/73	Installed second LM-2500 G/T in GTS ADM CALLAGHAN.
7/73	Complete equipment installation at LBTS.	7/73	PATTERSON completed RAV. Undergoing one year of operational evolution of CPP.
8/13/73	The ninth technical milestone in the DD963 D&P Contract was met, i.e., "complete CRP propeller spin test."		
9/73	OPNAV detailed OT&E Phase I Program DD963 - Specified that DD963 T&E Planning Group should supervise preparation of the TEMP.		
9/73	Prototype Plant at NAVSEC Philadelphia lit off.		
9/30/73	Selected Acquisition Report (SAR) noted that a production model engine had a failure while being tested by G.E. Determined to be the result of a turbine blade production deficiency. Deficiency being corrected by field modification on all engines delivered for DD963 Class.		

DD963 PROPULSION SYSTEM CHRONOLOGY

DATE	DD963 PROGRAM EVENTS	DATE	ALLIED EVENTS
10/73	The eleventh technical milestone in the DD963 D&P Contract was met, i.e., "commence system test operation of propulsion one-half ship set."		
11/73	DD963 launched.		
		11/73	Replaced remaining FT-4A with LM-2500 G/T in GTS ADM CALLAGHAN.
		11/20/73	PSI CPP installed in USS BARBEY (DE 1088) - Completed 4-hour full power trial.
		12/3/73	BARBEY commenced CPP trials.
		2/74	NAVSHIPS R&D Planning Summary for 35,000 - 70,000 shp CPP Supporting Technology revised.
		2/4/74	CNO Ltr Ser 971/705 - "Assignment of Project X/S39, Conduct an Operational Assist for PF Propulsion System Land-Based Test Site."
		2/27/74	BARBEY completed CPP trials, undergoing one year of operational evaluation.
		4/74	On diver's inspection PSI CPP on BARBEY the upper part of one bolt was readily removed, completely cracked through at first threat below bolt head. Other leaky bolt suspect. Bolt of ARMCO 17-4 PH material. Seven hundred hours of steaming when discovered.
4/31/74	The DD963 Propulsion Plant at NAVSEC Philadelphia completed 500 hours of operations, control problems experienced.		
		5/74	Further examination - 3 cracked bolts - fatigue cracks. Eventually found 7 bolts cracked.
		5/16/74	BARBEY resumed employment as test bed for missile development - not sent forward in the Pacific as originally planned because of doubts of her spare parts situation for CPP. 17 4-bolts installed (modified) - Inconel 718 material preferred but not available.
		6/74	PATTERSON CPP Casualty - Could not move blades but could move valve rod - later identified as failure of a small steel key (1/4" x 1/8" x 1-1/4"), fitted in each of the mechanical couplings to join the sections bayonet joint to rotate and disengage. NOTE: Oct 72 Naval Engineers Journal article cited this pipe as a critical component carrying HP hydraulic fluid but also functioning as a rod to actuate mechanically, the 4-way control valve in the propeller hub.

DD963 PROPULSION SYSTEM CHRONOLOGY

DATE	DD963 PROGRAM EVENTS	DATE	ALLIED EVENTS
6/30/74	DT&E of propulsion control system scheduled to complete.		
6/30/74	LM-2500 propulsion gas accumulated 27,200 hours of operation in MSC-GTS ADM CALLAGHAN. In view of this experience and the 1,000 hours of test of the DD963 propulsion set at NAVSEC Philadelphia, routine reporting of ADM CALLAGHAN's experience in SARs suspended and item considered low risk.		
7/74	One-half set of DD963 propulsion system completed 2,000 hours of integration, reliability testing at Philadelphia. Extensive high powered operation not conducted. Continued training of crew.		
		8/21/74	COMOPTEVFOR Completion Reports, CPP - Project D/S531 and D/S662.
8/23/74	Completed 2,000 hours of testing one-half ship set at NAVSEC Philadelphia.		
8/24/74	COMOPTEVFOR Ltr Ser C223 to CNO (OP-03) pointing out the concerns of COMOPTEVFOR for the DD963 propulsion plans control system as demonstrated by LBTS testing.		
		8/31/74	BARBEY MSG 310508Z - Catastrophic failure reported in PSI propeller.
9/18/74	COMOPTEVFOR requested assignment of F/S (Fleet Operational Appraisal) project for DD963 Class propulsion system (during Phase II OT&E).		
9/74	Acceptance Trials DD963 - (Schedule in DCP of May 15, 1974).	9/74	Completed DT&E BLH CPP in PATTERSON. 6,500 hours of operation with BLH CPP.
10/7/74	CNO 071548 Z Assigned Project F/S 18, Op Appraisal for DD963 to COMOPTEVFOR.		
10/74	Delivery of DD963 - Scheduled in DCP of May 15, 1974 original delivery.		
10/29/74	NADEC on DD963 Fleet introduction.		

DD963 PROPULSION SYSTEM CHRONOLOGY

DATE	DD963 PROGRAM EVENTS	DATE	ALLIED EVENTS
12/74	Completed testing at LBTS - Total 2,119 hours. Completed training of DD963 Class crews at LBTS.		
		1/75	Removed CPP from PATTERSON; installed conventional propeller.
2/28/75	FOT&E in DD963 to be accomplished under F/S 18 (Tasks I-VIII) approved by CNO Ltr Ser 03/104935 of 28 Feb 75.		
		3/75	Completed 3,000 hour qualification and endurance test at Philadelphia on LM-2500 G/T.
		3/11/75	Reinstated Project D/S 662, Evaluate 35,000 shp PSI CPP - CNO Ltr - Ser 982F/68211.
3/24/75	FOT&E under F/S 18 (Tasks I and VIII) promulgated as Appendix A to DD963 TEMP (COMNAVSEA PMS389.63/JAP DD963 Ser C433.		
		4/75	Further tests run on PSI CPP.
		4/75	Started FFG-7 tests at LBTS.
4/30/75	Scheduled to complete 5,000 hours test of one-half propulsion system at NAVSEC Philadelphia.		
6/10/75	Project Details Task One of DD963 OP Ap| raisal.		
7/9/75	DD963 completed acceptance trials.		
8/12/75	DD963 delivered.		
9/12/75	COMOPTEVFOR Test Plan for Project F/S 18 "Operational Appraisal of the DD963 Class Power Plant, promulgation of - OPTEVFOR Ltr Ser 879.		
9/19/75	CNO MSG 191804 Z directing limitation on propulsion plant		
		9/75	By this time, over 40,000 hours total accumulated operations of LM-2500 turbines.

DD963 PROPULSION SYSTEM CHRONOLOGY

DATE	DD963 PROGRAM EVENTS	DATE	ALLIED EVENTS
8/2 - 6/76	Instrumented CPP trials held on DD963 to determine stresses in bolts, blades, and crank pins; vibration data; and blade face pressures.		
11/5/76	Approved action on CPP fix for the DD963 approved by CNO Ltr. Ser 371E/703051.		
2/28/77	14,285 hours of LM-2500 operations in first five DD963 Class.		

TAB B

MAJOR COMBAT SYSTEM PROBLEMS UNCOVERED

BY PCO REPORTS

	REPORTED TO CNO
Tech Manuals not available	Dec 71
PMS not available	Aug 72
Combat System Test behind schedule	Sep 72
Mk 74 Spares inadequate	Sep 72
Contractor Preventive Maintenance	Oct 72
Delays in NTDS tests	Nov 72
NTDS Op Program not available	Nov 72
NTDS Cabling errors	Jul 73
Spare parts delays	Aug 73
TARTAR problems	Sep 73
NTDS Interfaces	Sep 73
CFU Program not ready	Sep 73
TARTAR not checked out - not ready	Oct 73
CFU Program unsatisfactory	Oct 73
COT	Dec 73
Combat System not fit for Service	Jan 74

TAB C

CGN 36 COMBAT SYSTEM CHRONOLOGY OF EVENTS

16 Nov 64	CNO issued approved characteristics - Combat System consisted of: - TARTAR System similar to that on DDG-15 Class - Mk 68 GFCS W/Mk 42 armament - Latest Antisubmarine Weapons - CIC featuring functionally integrated NTDS
25 Aug 65	Change 1 to characteristics specified: - Mk 86 GFCS (Lightweight digital system) - TARTAR "D" FCS featuring high power dual channel radar AN/SPG-51D and a digital computer complex
28 Jun 66	DLGN 36 Class specifications approved and issued.
1 Mar 68	Mod 7 to specs issued, invoking characteristics changes (5/54" Gun Mk 45 Mod 0 and GFCS Mk 86 Mod 1).
19 Jul 68	Contract awarded to NNS&DDCO.
7 Aug 69	Start Construction.
5 Sep 69	Phila NSY assigned as TDM and NWSO, Phila assigned as ORDANCE TDD.
27 Oct 69	HMR 9 issued to reflect design changes in Weapons and Electronics System (added TARTAR and NTDS Digital Interface).
19 Dec 69	TDM Management Plan approved by NAVSHIPS.
23 Jan 70	CGN-36 keel laid.
27 Jan 70	ORD TDD Charter issued to NWSO by NAVORD.
12 Feb 70	CIC small scale mock-up at NAVSEC reviewed by SAIC Working Group.
23 Feb 70	TDM Charter issued to Phila NSY by NAVSHIPS.
15 Apr 70	First TDM Progress Review Conference.

12 Jun 70	FMR 142 issued by SUPSHIP NN invoking Combat System Test Plan (SOS INST 4730.21) (DLGN 36 only).
26 Oct 70	Test Policy for DLGN 36 and DLGN 38 Class issued by NAVSHIPS (PMS-378).
9 Nov 70	ASW TDD established by NAVSHIPS as requested by MASWSP.
22 Feb 71	TDM/ASW TDD/ORD TDD Working Relationships established.
22 Feb 71	ORD TDD function transferred to NOSSOLANT, NORVA (NWSO disestablished).
9 Mar 71	Full scale mock-up of Pilot House and CIC at Newport News reviewed by SAIC Working Group.
5 Apr 71	Test Sequence Networks Delivered.
28 Apr 71	HMR 92 issued to incorporate Pilot House and CIC full scale mock-up arrangement.
10 May 71	SUPSHIPS INST 4730.22 issued - Combat System Test Development and Implementation Program; Administration of
29 Jun 71	First portion of ITP delivered (Mk 45 LWG).
8 Jul 71	Change 8 to characteristics included: - NIXIE in lieu of FANFARE - Substitue one earch DRT and NC-2 vice two NC-2 Plotters - Update Mk 86 GFCS from Mod 1 to Mod 3
20 Sep 71	CGN-36 Launched
3 Nov 71	SUPSHIPS INST 4730.23 issued - Procedures for Implementing DLGN 36 Class Combat System Test Plan.
21 Dec 71	Contract awarded for Combat System Training Course.
6 Mar 72	Start DLGN 36 Combat System Testing at NN - Stage 3 of Mk 13 Launcher.
9 May 72	Billet established at SUPSHIP NN for OINC of Test and Trials Team (never utilized).

20 Jun 72	LTDM representative at SUPSHIP established.
17 Aug 72	NSWSES assigned to develop and implement Combat System Ship Qualification Trials (CSSQT).
24 Aug 72	FMR 142.2 invoked (added CFU tests).
13 Mar 73	Final portion of ITP delivered (NTDS).
18 Jun 73	HMR 254 invoked combat system test plan for DLGN 37.
25 Jun 73 to 24 Aug 73	NAVSHIPS REP assigned TAD to SUPSHIPS Combat System Test Division.
20 Jul 73	Newport News ltr requested Raytheon support to repair Mk 74 equipment.
27 Aug	Extremis memo - SUPSHIPS code 15A
10 Sep 73	OPFCO commenced.
11 Sep 73	Obtained FAD III material support priority for DLGN 36.
24 Sep 73	Raytheon completed Mk 74 repair and test.
6 Oct 73	Newport News flooded all four AN/SPG-51D waveguide systems.
26 Oct 73	Navy establishes plan to take over TARTAR system. Compromise to provide Raytheon support for the Mk 74 system.
5 Nov	COT was held.
18-19 Dec 73	Builders Trials and mock INSURV.
22 Dec 73	SHAPM request to present CGN-36 to INSURV with waivers for Combat System deficiencies.
27 Dec 73	CNO waived deficiencies and approved INSURV presentation.
2-3 Jan 74	Acceptance Trials.
9 Jan 74	Combat System Coordination Group (CSCG) Charter signed for post delivery continuation of combat system testing.
7 Feb 74	Ship delivered to the Navy.

TAB D

CGN 38 COMBAT SYSTEM CHRONOLOGY OF EVENTS

Feb 68	CF/CD started for DLGN-38
11 Oct 68	Ship Acquisition Plan - General SOR
21 Nov 69	DLGN-38 Specs approved and issued
13 Mar 70	T&E Management Handbook DLGN-38
17 Apr 70	PM for DLGN-38
25 Jun 70	CPFF Contract
20 Jul 70	TDM Assigned and Chartered
26 Oct 70	Test Policy for DLGN-36 and 38 issued
9 Apr 71	CNO ltr OP-03D Ser 0027P03D DLGN-38 Integrated Combat System Characteristics
21 Dec 71	Contract Awarded to NNSDDCO - 3 ships FPI
Dec 71	Start Construction
26 Jan 72	NAVSEC CSIM billet established
Apr 72	ICSMP Rev. 3 - Risk Definition in Section 12
11 Jul 72	PM-2 for DLGN-38
Jul 72	Keel Laid
13 Oct 72	Sec. Rush memo to SECNAV
19 Jan 73	DOD Directive 5000.3 issued by PMS 378
31 Jan 73	OPTEVFOR ltr to CNO (lack of spirit of Rush Memo)
9 Feb 73	OT&E Plan
9 Mar 73	Under Sec Nav ltr funding OT&E Plan describes limited M.I. Test Site effort.
23 Apr 73	DDR&E memo to Under Sec Nav. Directed every effort be made for 2-4 week OT&E at SSIS by OPTEVFOR and OP-Appraisal post delivery.
Dec 73	Launch CGN-38

7 May 74	CNM ltr Ser 154 requesting FCDSSA responsibility for computer program control and accountability to SHAPM
17 May 74	CSM designated and charter signed by SHAPM code 603 established
31 May 74	OPNAVINST 3960.7 T&E of Ship Acquisition
Jul 74	Computer Program Certification (Progress Review)
20 Aug 74	NSWSES Review of DLGN-38 Integration Tests.
12 Sep 74	CNO directed FCDSSA to assume computer program responsibility.
Oct 74	Final OP Program scheduled availability
9 Oct 74	Report of DLGN SSIS Integration Testing meeting at M.I.
4 Nov 74	HMR 144
18 Feb 75	OPTEVFOR 182304Z requested CNO OP-Appraisal CGN-38
20 Feb 75	NAVSEA Ltr PMS 378 Ser 809 - X/S 30 not possible.
28 Feb 75	NAVSEA 282137Z responds to OPTEVFOR request - not funded.
5 Mar 75	OPTEVFOR 050531Z responds and again requests F/S project assignment.
4 Apr 75	CNO 042139Z assigns project F/S 38
30 Apr 75	Est. Computer Program H&S baseline verification of Test Procedures
1 Jun 75	Publish CSAD
30 Jan 76	Complete ITP
28-30 Jul 76	BT
7-8 Aug 76	AT
Post Delivery System Integration Tests DT-IV	
4 Apr 77	OT-IV commences.