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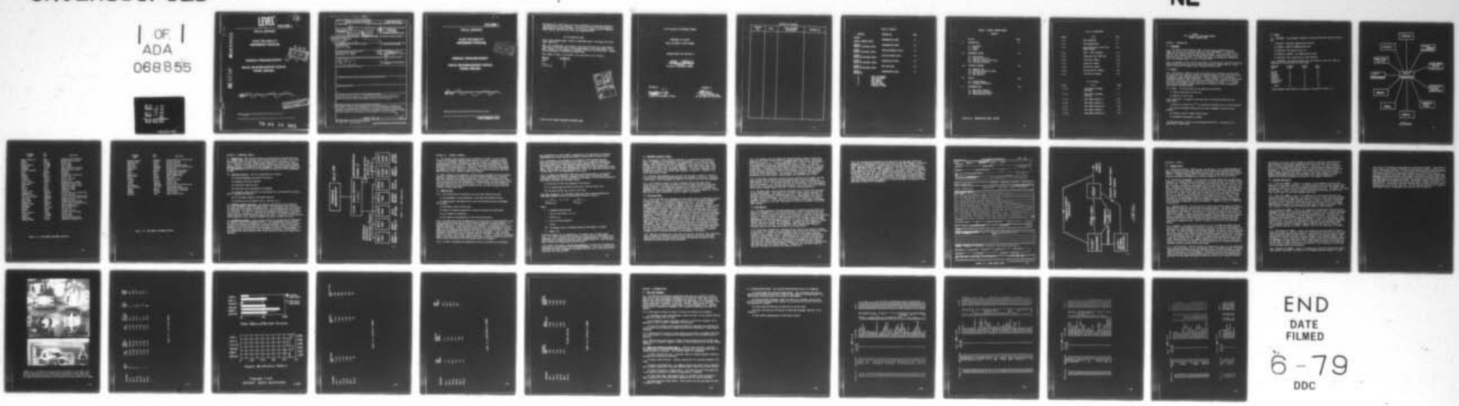

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VOLUME 1

FINAL REPORT

FLEET RELIABILITY ASSESSMENT PROGRAM

GENERAL PROGRAM REPORT

NAVAL WEAPONS SUPPORT CENTER
CRANE, INDIANA

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The report discusses the development of a failure reporting, analysis and corrective action program designed for early identification of maintenance problems encountered with new electronic equipment installations aboard ships, and the results of the program at the conclusion of the pilot phase.

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i to v	0
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FLEET RELIABILITY ASSESSMENT PROGRAM

DEPARTMENT OF THE NAVY

NAVAL ELECTRONIC SYSTEMS COMMAND

PREPARED UNDER THE DIRECTION OF

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RECORD OF CHANGES

CHANGE NO.	DATE	TITLE OR BRIEF DESCRIPTION	ENTERED BY

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SECTION I. INTRODUCTION

1-1 BACKGROUND

1-1.1 The Chief of Naval Material (CMN) indicated through NAVMAT-06 that the number one priority in the reliability area is the development of a reliability reporting and tracking system for operational equipment. This system must be suitable for rapid response to reliability problems so that corrective actions can be initiated as early as possible. The CNM requirements are documented in NAVMATINST 3000.1 and CNM memo (ADM I.C. Kidd) of 10 April 1974.

1-1.2 In response to this priority requirement, with CNM approval and CNO concurrence, NAVELEXSYSCOM initiated the Fleet Reliability Assessment Program (FRAP) as a pilot study of electronics equipment newly introduced into the fleet.

1-2 PURPOSE

1-2.1 The purpose of FRAP was to test the feasibility of reducing life cycle costs and improving fleet readiness through an organized program of controlled observations of samples of newly deployed operational systems followed by early reliability improvements based on these observations. A rapid response is assured by FRAP through a closely coordinated effort involving the operational fleet, naval and contractor facilities, and equipment support activities illustrated in Figure 1-1.1. Problem areas and failure mechanisms are identified, and corrective actions recommended to the cognizant equipment manager.

1-2.2 GOALS. The primary goals of the FRAP are the following:

(1) Improve Operational Availability

(2) Reduce Life Cycle Cost

1-2.3 OBJECTIVES. In support of the FRAP goals the following objectives were established.

(1) Measure the Reliability [1] of electronics equipment early in fleet operation.

(2) Identify equipment deficiencies and take (recommend) corrective action promptly.

(3) Improve logistics support effectiveness.

(4) Recommend improvements to 3M MDS.

(1) Both Operational Reliability and Equipment Reliability. See glossary for definitions of these terms.

1-3 SCOPE.

1-3.1 EQUIPMENT. The equipment included in the pilot FRAP effort were the following:

(1) AN/SSR-1 Satellite Communications Receiver

(2) AN/WSC-3 Satellite Communications Set

(3) AN/URC-85 UHF Communications Set

(4) AN/URC-62 (VERDIN) VLF Communications System

(5) AN/UYK-20 Data Processing Set (Mini-computer)

1-3.2 PLATFORMS. The sample platforms that participated in the pilot FRAP are summarized by platform type and fleet below:

PLATFORM TYPE	ATLANTIC FLEET	PACIFIC FLEET	FLEET TOTAL
Carrier	3	3	6
Cruiser	3	1	4
Destroyer	6	4	10
Frigate	5	1	6
Auxiliary	4	3	7
Landing Ship	5	2	7
Submarine	9	6	15
TOTAL	35	20	55

A more complete identification of platforms is presented in Table 1-1.1

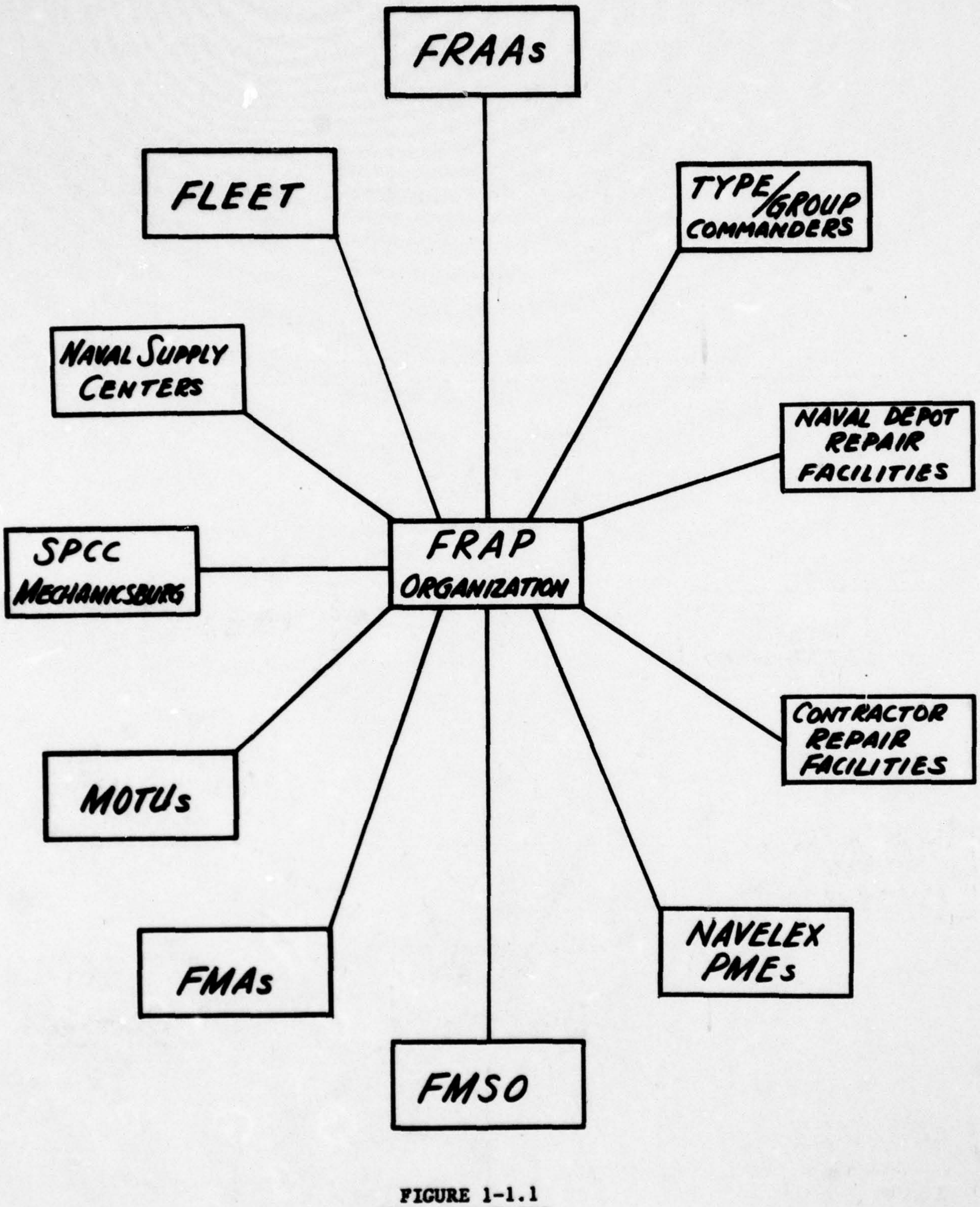


FIGURE 1-1.1
FRAP INTERFACES

PLATFORM NAME	HULL NO.	SHIP TYPE
Adams, Charles E.	DDG-2	Guided Missile Destroyer
Albany	CG-10	Guided Missile Cruiser
Batfish	SSN-681	Nuclear Sub
Brown, Jesse L.	FF-1089	Fast Frigate
Capadanno	FF-1093	Fast Frigate
Coronado	LPD-11	Amphibious Dock Transport
Daniels, Josephus	CG-27	Guided Missile Cruiser
Davis	DD-937	Destroyer
Dupont	DD-941	Destroyer
Farragut	DDG-37	Guided Missile Destoryer
Finback	SSN-670	Nuclear Sub
Forrestal	CV-59	Aircraft Carrier
Flying Fish	SSN-673	Nuclear Sub
Furer, Julius A.	FFG-6	Guided Missile Frigate
Guadalcanal	LPH-7	Amphibious Assault Ship
Guam	LPH-9	Amphibious Assault Ship
Holland	AS-32	Submarine Tender
Hunley	AS-31	Submarine Tender
Ingram, Jonas	DD-938	Destroyer
Kamehameha	SSBN-642	Nuclear Ballistic Missile Sub
Kennedy, John F.	CV-67	Aircraft Carrier
Key, Francis Scott	SSBN-657	Nuclear Ballistic Missile Sub
Lafayette	SSBN-616	Nuclear Ballistic Missile Sub
Lake, Simon	AS-33	Submarine Tender
MacDonough	DDG-39	Guided Missile Destroyer
Madison, James	SSBN-627	Nuclear Ballistic Missile Sub
Milwaukee	AOR-2	Replenishment Oiler
Manitowoc	LST-1180	Tank Landing Ship
Narwhal	SSN-671	Nuclear Sub
Nimitz	CV-68	Aircraft Carrier
Page, Richard L.	FFG-5	Guided Missile Frigate
Sea Devil	SSN-664	Nuclear Sub
Valdez	FF-1096	Fast Frigate
Wainwright	CG-28	Guided Missile Cruiser
Whitney, Mount	LCC-20	Amphibious Command Ship

TABLE 1-1.1A FRAP SAMPLE PLATFORMS (ATLANTIC)

PLATFORM NAME	HULL NO.	SHIP TYPE
Abraham Lincoln	SSBN-602	Nuclear Ballistic Missile Sub
Constellation	CVA-64	Aircraft Carrier
Coral Sea	CVA-43	Aircraft Carrier
Enterprise	CVN-65	Nuclear Aircraft Carrier
Ethan Allen	SSBN-608	Nuclear Ballistic Missile Sub
Hawkbill	SSN-666	Nuclear Sub
Hoel	DDG-13	Guided Missile Destroyer
Jouett	CG-29	Guided Missile Cruiser
Kansas City	AOR-3	Replenishment Oiler
Monticello	LSD-35	Dock Landing Ship
Morton	DD-948	Destroyer
Proteus	AS-19	Submarine Tender
Plunger	SSN-595	Nuclear Sub
Puffer	SSN-652	Nuclear Sub
Sam Houston	SSBN-609	Nuclear Ballistic Missile Sub
San Bernardino	LST-1189	Tank Loading Ship
Somers	DDG-34	Guided Missile Destroyer
Waddell	DDG-24	Guided Missile Destroyer
Whipple	FF-1062	Fast Frigate
Wichita	AOR-1	Replenishment Oiler

TABLE 1-1.B FRAP SAMPLE PLATFORMS (PACIFIC)

SECTION II. MANAGEMENT CONCEPT

2-1 ORGANIZATION. FRAP functions through an organizational structure consisting of a sponsor, Lead Field Activity (LFA), Technical Support Activities (TSA), equipment manufacturers, and participating fleet personnel as illustrated in Figure 1-2.1. The Naval Electronics System Command (NAVELEX 470) sponsers FRAP, provides general direction and guidelines to the LFA, and interfaces with cognizant NAVELEX equipment managers and higher-level Navy management. The Naval Weapons Support Center (NAVWPNSUPPCEN) Crane is the LFA responsible to NAVELEX 470 for the management of FRAP.

2-2 LEAD FIELD ACTIVITY. The LFA's responsibilities include:

(1) Program management and technical direction.

(2) Equipment functional modeling.

(3) Statistical sampling plans.

(4) Functional data requirements for equipment.

(5) Engineering R/M/A (Reliability, Maintainability, and Availability) assessment of equipment performances.

(6) Failure modes diagnosis and effects analysis.

(7) Corrective action proposals (ECP's, training, etc.).

2-3 TECHNICAL SUPPORT ACTIVITIES. The TSAs are responsible for the collection of failed "throwaway" items from organizational-level maintenance activities and for obtaining fleet prepared maintenance forms. The maintenance forms are monitored for completeness and adequacy; deficiencies are noted and appropriate action taken for correction. The TSAs also interface with equipment manufacturers, field maintenance activities, and depots in acquiring failure analysis and reliability data on failed repairable items forwarded to them by the fleet. In addition, the TSA performs failure analysis on the returned throwaways and reports findings to the LFA.

2-4 PLANNING AND CONTROL. Formal program planning was accomplished and implemented by means of LFA and TSA Implementation Plans. The Implementation Plans provided for detailed planning and scheduling of the several phases of the program that were necessary to coordinate the efforts of the field activities involved. The Implementation Plans also established the requirements for other planning documents, such as Sampling Plan, Data Collection Plan, and Report Publication. Program control was accomplished through monthly status letter reports and quarterly program review meetings.

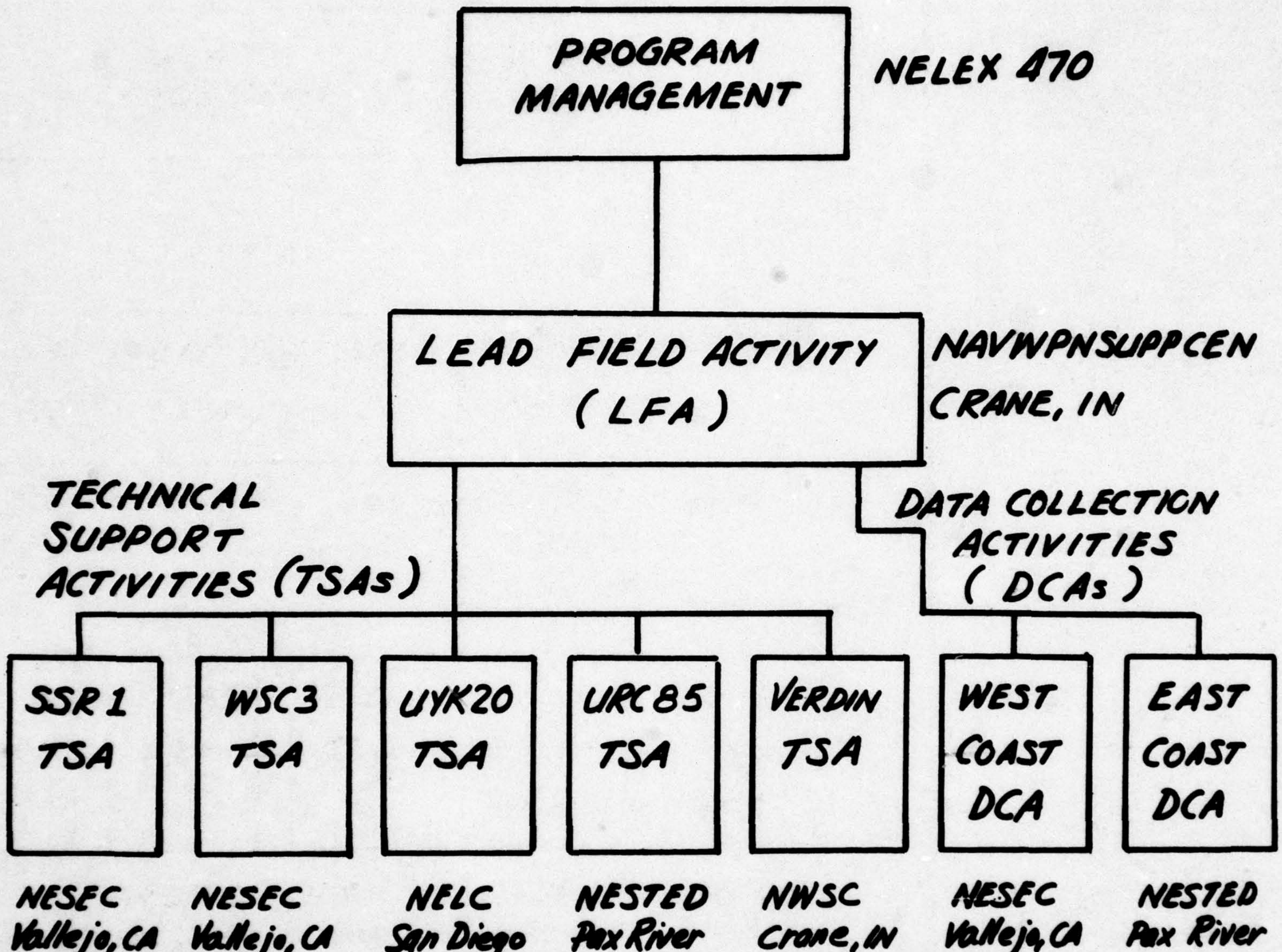


FIGURE 1-2.1 FRAP ORGANIZATION

SECTION III. TECHNICAL APPROACH

3-1 The approach toward accomplishing the objectives of FRAP is an early identification of maintenance problems encountered with electronic equipment operating in the fleet environment followed by an intensive reliability improvement program. Selected samples of each pilot FRAP equipment were closely monitored over a nine-months period of fleet operation. Fifty-five representative platforms were chosen as sources of organizational-level information. This data along with intermediate and depot-level repair records is used to determine achieved operational and equipment reliability and to identify significant problems.

3-2 Major elements of this approach include developing equipment reliability models, choosing a representative sample from the total equipment population, collecting data from organizational and depot maintenance levels, performing fault isolation and failure analysis, analyzing the data in order to assess its significance, identifying corrective action, and recommending for implementation that action proven to be most cost effective from a life cycle point of view. In order to cost effectively accomplish these tasks, FRAP makes extensive use of facilities and data collection resources already established.

3-3 SAMPLING PLAN.

3-3.1 The prerequisites for developing the pilot FRAP sampling plan were:

(1) The parameter of prime importance is the Mean-Time-Between-Failures.

(2) FRAP parameter evaluations be no more discriminating than the procurement test programs.

(3) Confidence level of 90% be used.

(4) Desire to determine appropriate reliability probability distribution.

(5) Environments are important.

(6) The sample be representative of the existing population.

3-3.2 The sampling plan was developed using the above factors as described below. The total population sub-divided by platform types was obtained for each equipment. The platform types were then ranked for each of the equipments in decending order of equipment population. Since environments were important, it was desired to utilize at least the two highest ranking types of platforms for each FRAP equipment and to have samples of each platform type from both the Atlantic and the Pacific Fleet. This also gave sample representation of platforms with the most equipments. Then, to obtain a measure of replication within an expected similar environment, at least two platforms of each type from the same fleet were desired. Further, to determine if different types of platforms and/or Fleets produce significantly different results at least four failure events were desired from the expected similar environments.

3-3.3 In order to determine the appropriate reliability probability distribution and to determine if a failure mode is predominant it was desirable to accumulate approximately 20 failures during the planned six-months data collection period.

3-3.4 Procurement risks (producer's and consumer's) were obtained from the MIL-STD-781 Test Plans when the plans were specified in contract documentation. Since the probability of accepting the minimum acceptable MTBF (θ_1) is different for different Test Plans, the respective operating characteristic curves were used to choose a MTBF for each equipment which would have a 90% probability of acceptance. Thus to obtain similar discrimination in FRAP, the lower 90% confidence limit for FRAP should be in the neighborhood of this value.

3-3.5 To compare the operational MTBF and the procurement MTBF at the expected similar operational environment, confidence limits were constructed for these environments beginning with two platforms per environment. The following assumptions were used to calculate the confidence limits:

(1) Reliability follows the exponential distribution.

(2) A six-months data collection period with a one-third duty cycle.

(3) The specified MTBF (θ_0) exists in the Fleet.

With these assumptions, the following formula was used to obtain expected one-sided 90% confidence limits and expected 80% confidence intervals,

$$\frac{2T}{\chi^2_{0.90,\ 2r+2}} \leqslant \theta \leqslant \frac{2T}{\chi^2_{0.10,2r}}$$

where

T = equipment operating time

= (6 mo x 720 hrs/mo x 1/3 x N)

= 1440 hr x N

r = No. of failures expected

= (T/θ_0)

χ^2 = Chi-square value at indicated percentile and degrees of freedom

N = Sample size

The desired sample size was determined as the lowest value of N which would give: (1) a lower limit at least as great as the MTBF having a 90% probability of acceptance; and, (2) meeting the other criteria enumerated above. Platforms were then selected at random from those not having planned overhaul or restricted availability during the planned data collection period.

3-3.6 Sample sizes and/or platforms were modified as required due to platform unavailability as determined by type and group Commanders. Also, the six-months data collection period was increased to nine-months primarily due to early duty cycles being much less than one-third.

3-4 EQUIPMENT RELIABILITY MODEL.

3-4.1 Maintenance of Naval shipboard equipment is accomplished by replacement or repair of components at Organizational (O), Intermediate (I), or Depot (D) repair levels. Ships Maintenance and Material Management (3-M) routinely collects organizational level repair data but not intermediate or depot level repair data. Using 3-M field data requires that the lowest components of the model be the lowest level reported by 3-M, the O-level replaceable component. This O-level component can be a piece part, printed circuit board, major assembly, or whatever is planned in the O-level maintenance concept.

3-4.2 Although FRAP equipments may have more than one mode of operation, typically all modules are completely energized whenever the equipment is turned on. Therefore, a serial model is both convenient and realistic for most of the pilot FRAP equipments.

3-4.3 The reliability models are used to determine the achieved operational reliability and also to assess the effect of ECPs and other corrective action upon system reliability. Maintenance Action Reports are compared against the model to determine whether or not a reported component failure results in a system failure, a degradation of system performance, or has no effect on the system capability. The models are also used in determining logistics support requirements.

3-5 DATA COLLECTION.

3-5.1 Each of the FRAP pilot equipments has two planned levels of maintenance--organizational and depot. At the organizational level either chassis-mounted components or electronic modules are replaced to complete the repair. The chassis-mounted components are typically considered throwaway items; but, repairable electronic modules are returned to the depot for component repair or replacement. Repair records of organizational and depot-level maintenance constitute the basis for reliability and maintainability analysis. Organization-level repair and maintenance data for the selected sample of equipment were received from the fleet by direct mail using FRAP provided mailing envelopes. Depot repair records were obtained on the total equipment population. Besides determining equipment reliability, FRAP has secondary objectives which include: (1) evaluating equipment maintenance--especially the reliability of software diagnostics and built-in-test; (2) verifying some of the basic assumptions used in the reliability model--especially the failure rate distribution and component MTBF predictions; (3) developing a maintenance model; and, (4) describing the field environment. These secondary objectives require information not generally collected by 3-M. Therefore, a rapid means to provide additional data beyond normal maintenance data had to be identified. Necessary additional data included time meter readings at time of problem discovery and completed maintenance, descriptions of diagnostic procedure used to isolate malfunctions, and environmental information.

3-5.2 FRAP was coordinated very early with both Atlantic and Pacific Fleet operational units and NAVMAT to determine a suitable way of obtaining the desired data that would be both timely and consistent with present 3-M operating procedure without creating an excessive burden on naval personnel.

3-5.3 The procedure that was adopted and approved by CNM is simply to report the additional data items in Block 35 of the standard OPNAV 4790/2K Ships' Maintenance Action Form, Figure 1-3.1. A copy of completed forms is sent by the organizational-level maintenance activity to a designated FRAP point of contact. In addition, a completed copy of maintenance form should be attached to each repairable item sent to the depot. A reference Job Control Number on the forms allows the part and maintenance actions at the O-and D-level to be correlated. Visits by FRAP team members to the individual platforms for initial data collection briefings facilitated the collection of the required data. For the one air cog equipment, the AN/ART-50, Maintenance Action Forms (MAF's), OPNAV 4790/60, were obtained during visits.

3-5.4 At the start of the data collection period, equipment serial numbers and time meter readings were recorded to initialize data records. These recordings were taken during a visit to the selected platforms for the purpose of providing briefings and training material. At the end of the data collection period, visits were made to record final serial numbers and time meter readings. Also, during the data collection period monthly feedback reports were sent to the participating platforms.

3-5.5 The depot repair facility receives repairable units from the total population of each FRAP equipment. Each month, the LFA receives repair action summaries from the depot covering the entire equipment population. These summaries are used to determine which maintenance actions initiated by the organizational level resulted in repair actions at the depot. Such failure tracking is necessary to calculate equipment reliability. Failure analysis on parts removed at the depot is performed either by the depot, LFA, or TSA. See Figure 1-3.2 for an illustration of the Fleet FRAP interface.

3-6 DATA ANALYSES.

3-6.1 The major purposes of the data analyses are to determine the operational reliability or dependability of the selected equipment; assist in proposing and implementing cost-effective corrective action within contractors' warranty periods; and, assist in presenting methods of improving the operational reliability of new electronics equipment. The basic source of FRAP operational reliability data is the additional data requested for FRAP and entered into Block 35 of the 3-M OPNAV 4790/2K or OPNAV 4790/60 forms for the sample FRAP equipments. The additional data requested included specific time meter readings and environmental assessment both upon observation and correction of a failure. Other additional items requested were diagnostic procedure used and more complete corrective action description.

3-6.2 Maintenance information is obtained directly from the data normally recorded on 3-M forms. For example, Active Maintenance Times (Block 32 of 2K form) is the Time to Repair (TTR) in hours; and, Date Completed (Block 31) minus Date Discovered (Block 17) gives downtime in days. Maintenance actions are uniquely identified by Job Control Numbers (JCN), thus, allowing traceability of failures from reporting units to repair depots whenever a copy of the 2K form accompanies the failed part. 3-M forms also contain data further identifying the equipment on which failures were observed. The Depot Monthly Repair Summaries list the failed parts received from the fleet and results of failure analyses. Therefore, when the JCN is given for each part returned, the failures are uniquely identified.

3-6.3 The statistical distribution of the time to failure and other reliability parameters are determined from the data collected for each FRAP equipment. Statistical methods such as non-parametric distributions, distribution plots, goodness-of-fit tests, confidence intervals, computer simulation, and other suitable techniques are used. These methods are described in Appendix D. The reliability model is updated as dictated by such analyses. The updated reliability model is exercised using fleet operational data; and, the results compared with specification values. The model is also used to assess the significance of other variables such as proposed engineering changes and logistics support. Discrepancies noted between specified reliabilities and measured or predicted reliability values are analyzed to identify problem areas and evaluate whether the complexity of reliability models are adequate or need modifying to account for discrepancies.

OPNAV 4790/2K (Rev. 6-73) **SHIP'S MAINTENANCE ACTION FORM (2-KILO)** COMP DEFL

SECTION I. IDENTIFICATION

JOB CONTROL NUMBER: 1. SHIP'S UIC | 2. WORK CENTER | 3. JOB SEQ. NO. | 4. APL/AEL

A. SHIP'S NAME | B. EQUIPMENT NOUN NAME | 5. W N D | 7. S T A | 8. C A S | 9. D F R | 10. | 11. | 12.

C. HULL NUMBER | 13. IDENT/EQUIPMENT SERIAL NUMBER | 14. EIC

15. SAFETY HAZARD | 16. LOCATION *(Compartment/Deck/Frame/Side)* | 17. WHEN DISCOVERED DATE YR. DAY

CONFIGURATION CHANGE: 18. ALTERATIONS *(SHIPALT, ORDALT, Fld Chg, etc.)*

FOR INSURV USE: 19. ∅ / ∅∅ | 20. INSURV NUMBER | 21. SUFFIX | 22. U | 23. S | 24. P.F

SECTION II. DEFERRAL ACTION

25. S/F MHRS. EXP. | 26. DEFER. DATE YR. DAY | 27. S/F MHRS. REM. | 28. DEADLINE DATE YR. DAY

SECTION III. COMPLETED ACTION

FOR SELECTED EQUIPMENTS ONLY

29. ACT. TKN. | 30. S/F MHRS | 31. COMPLETION DATE YR. DAY | 32. ACT. MAINT. TIME | 33. TI | 34. METER READING

SECTION IV. REMARKS/DESCRIPTION

35. REMARKS/DESCRIPTION

1 AT TIME OF DISCOVERY:
a ETM READING (ETM IDENTIFICA-
TION & LOCATION)
b EQUIPMENT ENVIRONMENT
c OTHER CLARIFYING REMARKS
2 AT TIMES OF COMPLETION & DFER:
a ETM READING (ETM IDENTIFICA-
TION & LOCATION) b CORRECT-
TIVE ACTION & DIAG PROC
c EQUIP ENV d OTHER REMARKS

36. CONT. SHEET

37. COMP SUMMARY

38. FIRST CONTACT/MAINT. MAN *(Print)* | 39. RATE | 40. SECOND CONTACT/SUPERVISOR *(Print)* | 41. PRI | 42. T/A | 43. INTEGRATED PRIORITY | SCREENING

C. DIV. INIT. | D. DEPT. INIT. | E. COMMANDING OFFICER'S SIGNATURE | F. TYCOM AUTHORIZATION | 44. UC | 45. TYCOM

46. SPECIAL PURPOSE | A. | B. | C. | D. | E. | F. | G. | H. | I. | J. | K. | L.

SECTION V. SUPPLEMENTARY INFORMATION

47. BLUEPRINTS, TECH. MANUALS, ETC. | AVAILABLE ON BOARD YES NO | 48. PREARRIVAL/ARRIVAL CONFERENCE ACTION/REMARKS

SECTION VI. REPAIR ACTIVITY PLANNING/ACTION

49. REPAIR W/C | 50. EST. MHRS. | 51. ASST. REPAIR W/C | 52. ASST. EST. MHRS. | 53. SCHED. START DATE YR DAY | 54. SCHED. COMP. DATE YR DAY

55. REPAIR ACTIVITY UIC | 56. WORK REQ. ROUTING | 57. EST. MANDAYS | 58. EST. MANDAY COST $ | 59. EST. MATERIAL COSTS $

60. EST. TOTAL COST $ | 61. JOB ORDER NUMBER | 62. LEAD P&E CODE | 63. DATE OF EST. YR. DAY

64. FINAL ACT. | 65. MHRS. EXPENDED | 66. DATE COMPLETED YR DAY | G. COMPLETED BY *(Signature - Rate)* | H. ACCEPTED BY *(Signature - Rate/Rank)*

FIGURE 1-3.1 OPNAV 4790/2K FORM

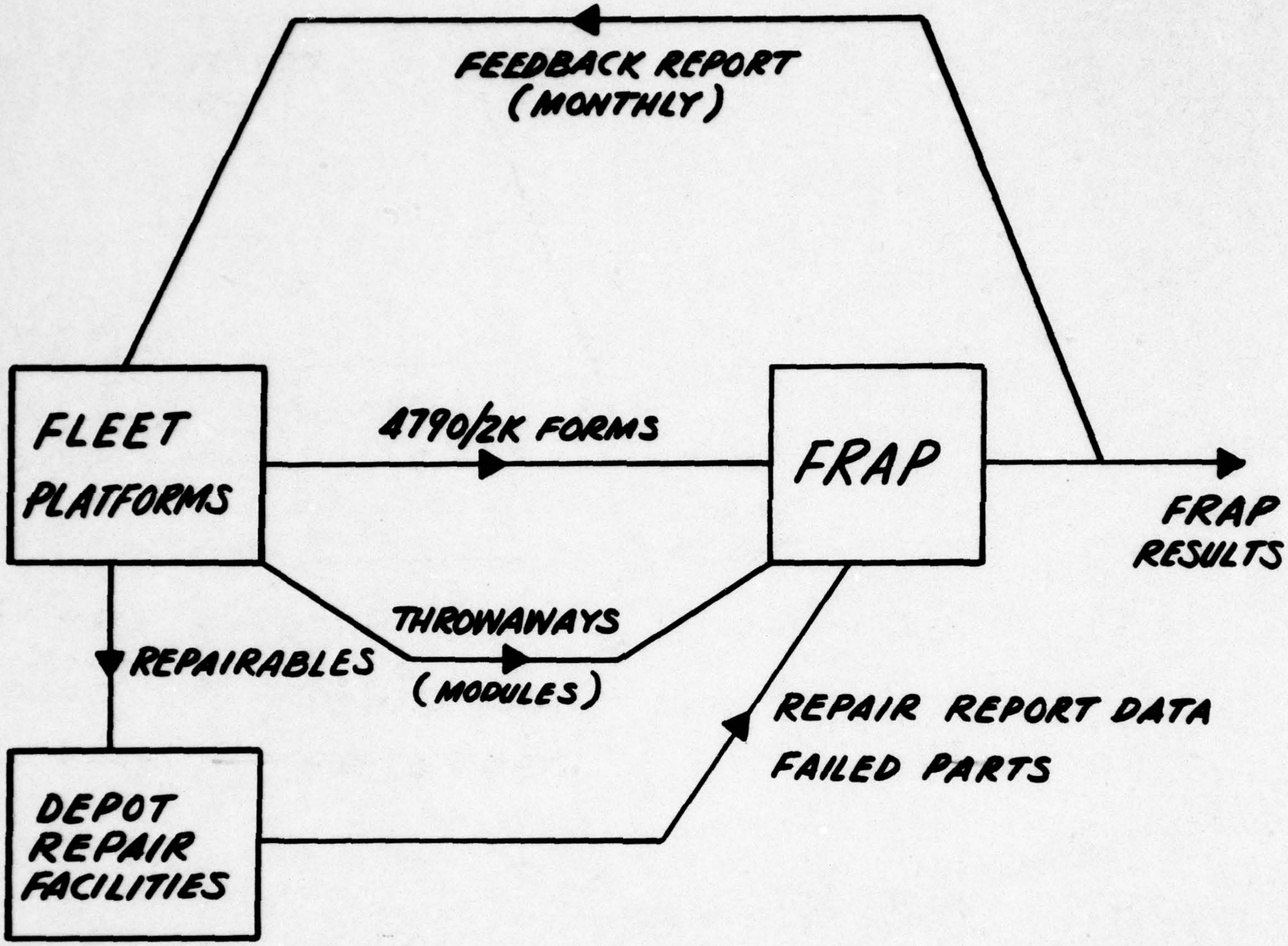


FIGURE 1-3.2
FLEET-FRAP INTERFACE

SECTION IV - RESULTS

4-1 PROGRAM RESULTS

4-1.1 OBJECTIVES ACHIEVED. FRAP achieved its objectives. The planned management concept was successfully implemented, and the LFA/TSA organization provided the required support to NAVELEX despite a SYSCOM-wide funding crunch in the second and third quarters of FY 77. In NAVELEX headquarters a liaison billet was established that greatly facilitated coordination and communication between headquarters and field activities.

4-1.2 RELIABILITY MEASUREMENT. The fleet data collection program was successfuly implemented. A computer program was developed to facilitate analysis of the data received from the fleet. A number of visits were made to platforms at Guam, Pearl Harbor, Subic Bay, San Diego, San Francisco, New London, Norfolk, Charleston, Mayport, Holy Loch, and Rota. Information obtained from 4790/2K failure reports, ships' logs, and direct contact were analyzed by computer to obtain probability distributions for operational reliability, repair time, and down time, as well as mean value and median value estimators for reliability, repair time, down time, inherent availability, and operational availability. In addition to the above analysis conducted at the system level, analysis and printouts were obtained for WRA and O-level component levels of assembly. Refer to Section IX of the Equipment Reports for examples of these analyses. Analysis of data obtained from Depot Repair Facilities enabled operational reliability parameters to be converted to equipment reliability parameters. Numerical results are summarized in Section 4-2.

4-1.3 PROBLEM DETECTION. Both the analysis of depot data and the analysis of fleet data enable the detection and isolation of hardware problems. The FRAP developed structured analysis technique indicates the relative importance of module-level problems with respect to one another. The analysis of fleet data indicates the severity of the problem with respect to specification values or operational criteria, such as availablity. In addition to these two formalized methods of problem detection and isolation, the open communication between FRAP and the fleet and between FRAP and Depot Repair Facilities has resulted in the detection and identification of problems other than catastrophic hardware failures. Specific instances are discussed in the Equipment Reports.

4-1.4 LOGISTICS. The collection and analysis of real time RMA performance data has led to a better understanding of the mutual influence of reliability, maintainability, and logistics in the attainment of necessary operational availability and readiness in the fleet. The FRAP developed logistics model (Appendix E) permits a better understanding of the current Fleet Logistics Support Improvement Program (FLSIP) and the effect of Best Replacement Factor (BRF) calculations upon operational availability. Specifically, it has been shown that FLSIP leads to a minimum-element allowance parts list (APL) rather than a minimum-cost APL. Results obtained from the FRAP logistics model using actual reliability data for the AN/WSC-3 Communications Set has led to a significant increase in the APL for the AN/WSC-3 and has provided the solid information needed for realistic logistics planning and decision making.

4-1.5 FLEET RECEPTION. FRAP has received the enthusiastic support of, and cooperation from, shipboard personnel on all the platforms visited. Shipboard personnel are vitally concerned with the reliable operation, the maintainability, and the logistics support (spares availability) of their equipment. The person-to-person contact between the fleet and the FRAP team has been highly beneficial because of the willingness and the ability of the men aboard the ships to discuss and analyze their equipment problems.

One example of the extra effort extended by the fleet is the fault location/failure analysis packet received from the submarine tender USS SIMON LAKE, AS-33, dealing with a failure of the AN/WRR-7 VERDIN receiver. Figure 1-4.1 is a partial reproduction of six photographs indicating the results of an overheating voltage regulator microcircuit. The original photographs are of excellent quality and clearly show the blackened case, and the melted solder on the reverse side of the printed circuit board. Another example of the fleet's concern is the 4-page commentary on AN/UYK-20 overheating problems submitted by the USS GUAM, LPH-9, and the 4-page follow-up report on the solution achieved by relocation of the computer installation.

4-2 EQUIPMENT RMA RESULTS

4-2.1 FLEET DATA SUMMARY. Figure 1-4.2 presents a brief summary of the basic data obtained from fleet data collection. The total operating hours and total calendar hours are used to compute duty cycle, which varies from a high of 0.733 for the AN/SSR-1 SATCOM receiver to a low of 0.219 for the AN/ART-50 VERDIN transmitter. The number of failures and the number of repairs during the data collection period are shown as well as the total active repair and the total equipment down time.

4-2.2 DEPOT DATA SUMMARY. Figure 1-4.3 summarizes the verification factors as obtained from analysis of depot data. The usual practice is to count only those failures that are verified at the depot as being relevant. In effect, this practice attributes all errors to the fleet while considering the repair depot to be perfect. Having encountered specific instances of less than perfect test and analysis at repair depots, FRAP prefers to consider the fleet and the depot equally likely to make errors; therefore, one-half of the non-verified failures are counted as being relevant.

4-2.3 RELIABILITY SUMMARY. Figure 1-4.4 summarizes the operational reliability and equipment reliability for each of the equipments in the FRAP study. Comparing the equipment MTBF with the specification MTBF gives the unexpected result that, with the exception of the VERDIN equipment, all systems meet the specification. The MTBF values stated are the equivalent MTBF values for exponential reliability distribution. Since the exponential reliability distribution assumption is implicit in the equipment specification as well as in the test requirements of MIL-STD-781, the exponential equivalent MTBF is the only reasonable value that can be compared with the specification MTBF. For the AN/WSC-3 and for the AN/WRR-7, however, the data indicates the reliability is distributed according to a Weibull function, which in turn indicates an increasing MTBF.

4-2.4 MAINTAINABILITY SUMMARY. Figure 1-4.5 summarizes the maintainability results. Comparison of mean-time-to-repair (MTTR) with the specified value gives the result that only the AN/URC-85 meets the specification. Reasons for the large discrepancy between reported MTTR and specified repair time are discussed in the Equipment Reports. This discrepancy is rather insignificant, however, except in the case of the AN/UYK-20 where an improvement in repair time would have a slightly beneficial affect on availability. The mean down time (MDT) shown is to a very large extent indicative of the effectiveness of logistics support provided to the fleet and is only influenced in a minor way by the equipment design and performance.

4-2.5 AVAILABILITY SUMMARY. Figure 1-4.6 summarizes operational availability results. FRAP considers operational availability to be extremely important because it is the final result of reliability, maintainability, and logistics support. The proper balance of these three elements to achieve the operational availability needed in the fleet, at a minimum cost level, is a prime goal of Systems Effectiveness Engineering. The classical calculation of operational availability is difficult in that it must be calculated by simulation, which requires recourse to a digital computer and knowledge of both the reliability and the down time probability distributions. FRAP performed 2000 calculations for each equipment to obtain the estimates shown for the population mean and the population median. Considerably simpler to calculate and more meaningful to the typical user is the value shown as "sample observation". This availability is calculated as the total operating hours divided by the sum of total operating hours and the total down time. For all practical purposes, this number is the probability that the equipment will work when the user needs it.

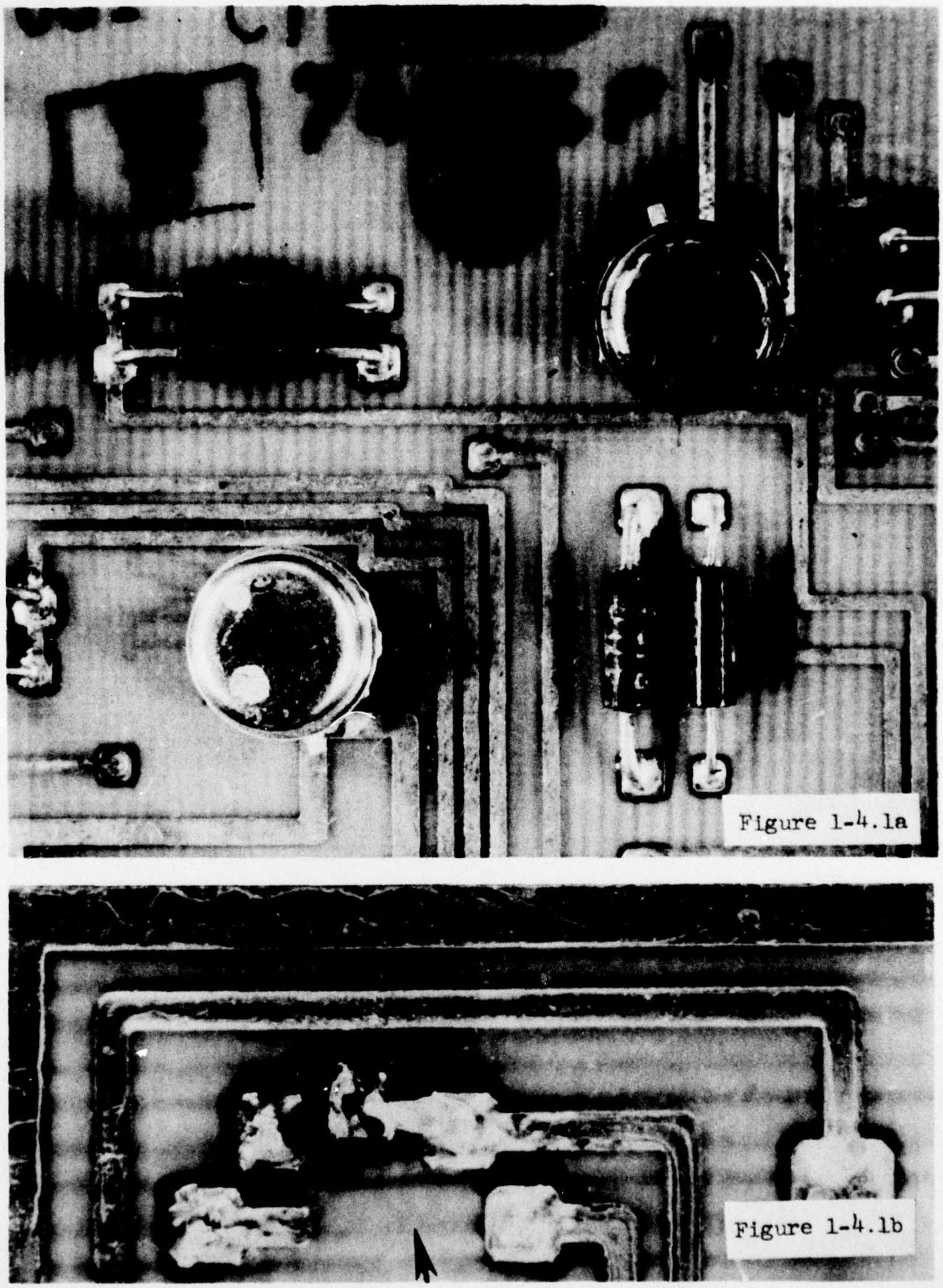
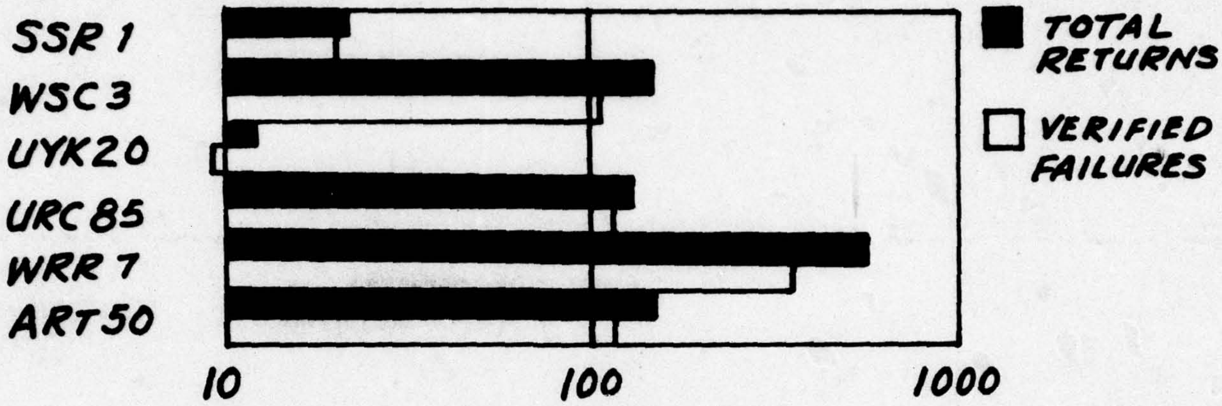


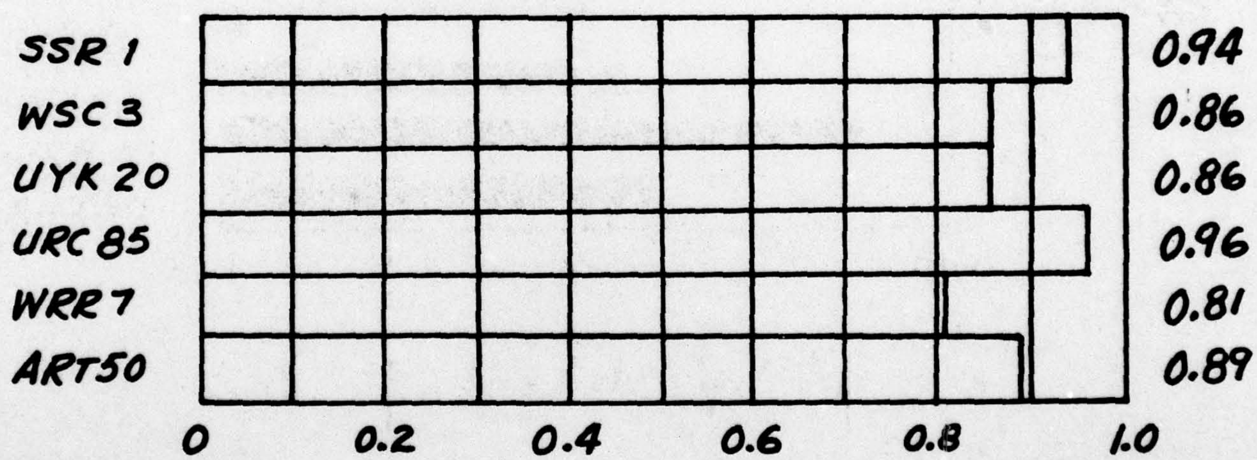
FIGURE 1-4.1 An example of the extra effort volunteered by the fleet is this partial reproduction of the six photographs submitted by the USS SIMON LAKE. (a) shows the heat-blackened case of the voltage-regulator integrated circuit, (b) shows the melting of solder on the reverse side of the printed circuit board.

EQUIPMENT	SAMPLE SIZE	TOTAL OP-HRS	TOTAL CALENDAR HOURS	DUTY CYCLE	NO. OF FAILURES/ REPAIRS	TOTAL REPAIR TIME	TOTAL DOWN TIME
SSR-1	36	153,454	204,024	0.752	9/6	8	295
WSC-3	31	131,965	203,064	0.650	35/29	117	3020
UYK-20	15	34,427	91,824	0.375	20/16	364	1015
URC-85	7	10,423	21,504	0.485	7/6	24	434
WRR-7	11	28,373	64,008	0.443	15/17	39	1750
ART-50	...	5,542	25,344	0.219	37/46	204	...

FIGURE 1-4.2 FLEET DATA SUMMARY



Total Returns & Verified Failures



Failure Verification Factors

FIGURE 1-4.3
DEPOT DATA SUMMARY

EQUIPMENT	OPERATIONAL MTBF	EQUIPMENT MTBF	SPECIFICATION MTBF
SSR-1	17,051	18,139	1000
WSC-3	3,770	4,384	3000
UYK-20	1,721	1,967	2000
URC-85	1,489	1,568	500
WRR-7	2,432	3,078	1000
ART-50	150	169	750

FIGURE 1-4.4 RELIABILITY SUMMARY

EQUIPMENT	FRAP MTTR (HOURS)	SPECIFIED VALUE (HOURS)	FRAP MDT (HOURS)
SSR-1	1.3	0.2	49.2
WSC-3	4.0	0.17	104.1
UYK-20	49.3	0.25	248.5
URC-85	4.0	2.0	104.1
WRR-7	2.3	0.62	336
ART-50	4.0	0.74	...

FIGURE 1-4.5 MAINTAINABILITY SUMMARY

EQUIPMENT	ESTIMATED POPULATION MEAN	SAMPLE OBSERVATION	ESTIMATED POPULATION MEDIAN
SSR-1	.993	0.998	0.989
WSC-3	0.91	0.978	0.984
UYK-20	0.89	0.971	0.983
URC-85	0.90	0.960	0.982
WRR-7	0.81	0.942	0.982
ART-50	*NO DOWN TIME DATA*		

FIGURE 1-4.6 AVAILABILITY SUMMARY

SECTION V - RECOMMENDATIONS

5-1 MAKE FRAP PERMANENT.

5-1.1 The FRAP pilot program has successfully shown that it is possible to obtain data from the fleet which enables determination of actual RMA values that can be compared to the stated requirements of equipment specifications. Thus, FRAP closes the control loop and allows the NAVY to determine the effectiveness of its management tools used to obtain RMA of equipment in the fleet. Therefore, FRAP provides the prerequisite knowledge to improve the effectiveness of these management tools - equipment specifications, standards and handbooks, test, prediction techniques, and other procedures.

5-1.2 FRAP enables the Navy to reduce Life Cycle cost through cost avoidance:

(1) Knowledge of actual RMA performance enables the Navy to avoid putting additional money into systems that are "good".

(2) The potential payback from money invested in a particular equipment can be determined so that low-return investments can be avoided.

(3) Trade-offs between reliability/maintainability improvement and increased logistics support can be evaluated to enable cost effective allocation of limited monies available.

5-1.3 FRAP motivates contractors to make effective corrections to equipment deficiencies since the Navy is in the position of knowing whether or not the specification is being met.

5-1.4 FRAP motivates contractors to conduct failure analyses and to solve their component quality, screening, assembly, or quality control problems before the Navy becomes involved.

5-2 MODIFY MDS INSTRUCTION (OPNAV 4790.4). FRAP has shown that only a relatively few modifications to the present 3M MDS system along with an effective depot data collection program are necessary. The following changes are recommended:

(1) Report Failure-Free Time. A periodic report of elapsed-time-meter reading is necessary for reliability calculations.

(2) Report Time-of-Failure. Currently reported for SEL (Selected Equipment List) items.

(3) Modify the 4790/2K Form. For example, report active repair time in tenths of hours instead of whole hours since most specified repair times are less than one hour.

(4) Select Platforms on a Sampling Basis. Data from the entire fleet population is not required; typically 10 to 20% of the population is adequate.

(5) Limit Time Frame. FRAP requires only 3 to 9 months of data collection to make a determination of RMA performance, depending upon the specific equipment.

(6) Authorize Direct Fleet Contact. Direct contact with the men aboard the ship is essential to FRAP.

5-3 NAVELEXSYSCOM ACTIONS. The following NAVELEXSYSCOM actions are recommended.

(1) Develop Depot Data Collection Requirements. Short term depot data requirements can be satisfied by ensuring an effective CDRL (Contract Data Requirements List) and DID (Data Item Description) are included in procurements.

(2) Ensure Elapsed Time Meters (ETMs) are required in equipment specifications and that the ETMs are appropriately located so as to monitor the correct time and to be accessible for reading.

(3) Ensure that ETM locations are specified for 3M SEL items.

(4) Ensure the effecitve utilization of established equipment expertise in TSA selection.

(5) Work toward standardization of RMA analysis method.

SSR-1 TABLE 1-1.1C

SERIAL NO.	OPERATING HOURS	NO. OF FAILURES	PLATFORM		FLEET
A247	6147.8	0	MONTICELLO	LSD 35	PACIFIC
A031	4930.0	0	CORAL SEA	CVA 43	PACIFIC
A002	4875.1	0	CONSTELLATION	CVA 64	PACIFIC
A267	0.0	0	ENTERPRISE	CVN 65	PACIFIC
A479	6381.0	2	NIMITZ	CV 68	ATLANTIC
A214	1627.3	0	PROTEUS	AS 19	PACIFIC
A381	0.0	0	SOMERS	DDG 34	PACIFIC
A771	0.0	0	SOMERS	DDG 34	PACIFIC
A374	4201.5	0	SOMERS	DDG 34	PACIFIC
A378	5095.8	0	MORTON	DD 948	PACIFIC
A436	3466.2	0	ADAMS,CHARLES F.	DDG 2	ATLANTIC
A469	4923.1	0	HOEL	DDG 13	PACIFIC
A315	6940.6	0	HUNLEY	AS 31	ATLANTIC
A474	4088.3	0	WADDELL	DDG 24	PACIFIC
A138	0.0	0	LAKE,SIMON	AS 33	ATLANTIC
A457	7460.5	0	PAGE,RICHARD L.	FFG 5	ATLANTIC
A348	5247.5	0	FURER,JULIUS A.	FFG 6	ATLANTIC
A162	3541.8	0	WICHITA	AOR 1	PACIFIC
A358	5974.0	0	MILWAUKEE	AOR 2	ATLANTIC
A463	6651.5	0	GUAM	LPH 9	ATLANTIC
A327	5348.0	0	CORONADO	LPD 11	ATLANTIC
A356	0.0	0	GUADALCANAL	LPH 7	ATLANTIC
A363	7004.8	0	WHITNEY,MOUNT	LCC 20	ATLANTIC
A361	3436.4	0	MANITOWOC	LST1180	ATLANTIC
A101	4662.3	0	SAN BERNARDINO	LST1189	PACIFIC
A189	6279.5	1	BROWN,JESSE L.	FF 1089	ATLANTIC
A086	1632.1	1	CAPODONNO	FF 1093	ATLANTIC
A091	6596.2	1	VALDEZ	FF 1096	ATLANTIC
A180	5071.9	0	KANSAS CITY	AOR 3	PACIFIC
A491	4709.3	0	DAVIS	DD 937	ATLANTIC
A011	4652.1	0	DUPONT	DD 941	ATLANTIC
A313	3510.6	0	FARRAGUT	DDG 37	ATLANTIC
A209	0.0	0	MACDONOUGH	DDG 39	ATLANTIC
A087	6274.6	0	DANIELS,JOSEPHUS	CG 27	ATLANTIC
A100	4456.0	2	WAINWRIGHT	CG 28	ATLANTIC
A422	3391.4	2	JOUETT	CG 29	PACIFIC
A422	119.0	0	JOUETT	CG 29	PACIFIC
A418	4557.9	0	WHIPPLE	FF 1062	PACIFIC

WSC-3 TABLE 1-1.1D

SERIAL NO.	OPERATING HOURS	NO. OF FAILURES	PLATFORM		FLEET
B049	4493.7	1	MONTICELLO	LSD 35	PACIFIC
B079	6383.4	0	NIMITZ	CV 68	ATLANTIC
B086	6380.8	0	NIMITZ	CV 68	ATLANTIC
B129	6382.1	0	NIMITZ	CV 68	ATLANTIC
B148	5056.1	2	NIMITZ	CV 68	ATLANTIC
B124	5213.7	3	SOMERS	DDG 34	PACIFIC
B063	6771.5	1	MORTON	DD 948	PACIFIC
B093	6133.3	1	ADAMS,CHARLES F.	DDG 2	ATLANTIC
B125	6210.0	4	HOEL	DDG 13	PACIFIC
B033	6138.2	2	WADDELL	DDG 24	PACIFIC
B084	7586.3	1	PAGE,RICHARD L.	FFG 5	ATLANTIC
B038	6003.0	1	FURER,JULIUS A.	FFG 6	ATLANTIC
B106	205.0	1	PLUNGER	SSN 595	PACIFIC
B136	477.5	0	ABRAHAM LINCOLN	SSBN602	PACIFIC
B132	1658.0	0	ETHAN ALLEN	SSBN608	PACIFIC
B101	185.5	0	SAM HOUSTON	SSBN609	PACIFIC
B137	2265.6	0	SEA DEVIL	SSN 664	ATLANTIC
B118	0.0	0	NARWHAL	SSN 671	ATLANTIC
B144	2051.5	4	HAWKBILL	SSN 666	PACIFIC
B140	3887.4	0	FINBACK	SSN 670	ATLANTIC
B108	0.0	0	FLYING FISH	SSN 673	ATLANTIC
B121	817.0	2	WICHITA	AOR 1	PACIFIC
B226	2878.3	0	WICHITA	AOR 1	PACIFIC
B023	4028.8	1	MILWAUKEE	AOR 2	ATLANTIC
B095	4941.3	0	CORONADO	LPD 11	ATLANTIC
B031	0.0	0	GUADALCANAL	LPH 7	ATLANTIC
B035	2876.2	1	MANITOWOC	LST1180	ATLANTIC
B051	5866.0	2	SAN BERNARDINO	LST1189	PACIFIC
B030	1952.7	1	BATFISH	SSN 681	ATLANTIC
B061	6.0	1	KANSAS CITY	AOR 3	PACIFIC
B215	4540.5	1	KANSAS CITY	AOR 3	PACIFIC
B014	5671.3	1	DAVIS	DD 937	ATLANTIC
B090	2272.0	0	INGRAM,JONAS	DD 938	ATLANTIC
B098	5760.2	0	DUPONT	DD 941	ATLANTIC
B041	2578.5	2	JOUETT	CG 29	PACIFIC
B041	121.5	0	JOUETT	CG 29	PACIFIC
B268	121.5	0	JOUETT	CG 29	PACIFIC
B282	121.6	0	JOUETT	CG 29	PACIFIC
B293	121.4	0	JOUETT	CG 29	PACIFIC
B026	3808.1	2	WHIPPLE	FF 1062	PACIFIC

UYK-20 **TABLE 1-1.1E**

SERIAL NO.	OPERATING HOURS	NO. OF FAILURES	PLATFORM		FLEET
A003	1772.0	1	CONSTELLATION	CVA 64	PACIFIC
A068	1235.0	2	CONSTELLATION	CVA 64	PACIFIC
A050	2185.0	0	ENTERPRISE	CVN 65	PACIFIC
A149	4317.0	1	ENTERPRISE	CVN 65	PACIFIC
A257	2346.0	6	ENTERPRISE	CVN 65	PACIFIC
A083	2613.0	4	ADAMS,CHARLES F.	DDG 2	ATLANTIC
A400	399.8	0	PLUNGER	SSN 595	PACIFIC
A369	29.0	0	ABRAHAM LINCOLN	SSBN602	PACIFIC
A417	541.0	0	ETHAN ALLEN	SSBN608	PACIFIC
A423	0.0	0	SAM HOUSTON	SSBN609	PACIFIC
A437	200.0	1	PUFFER	SSN 652	PACIFIC
A376	0.0	0	SEA DEVIL	SSN 664	ATLANTIC
A375	3129.0	0	HAWKBILL	SSN 666	PACIFIC
A395	0.0	0	FINBACK	SSN 670	ATLANTIC
A443	0.0	0	FLYING FISH	SSN 673	ATLANTIC
A294	0.0	0	GUAM	LPH 9	ATLANTIC
A410	800.0	1	GUAM	LPH 9	ATLANTIC
A052	173.0	0	WHITNEY,MOUNT	LCC 20	ATLANTIC
A268	6902.9	3	WHITNEY,MOUNT	LCC 20	ATLANTIC
A430	176.2	1	BATFISH	SSN 681	ATLANTIC
A245	174.0	1	KANSAS CITY	AOR 3	PACIFIC
A122	4011.0	2	KANSAS CITY	AOR 3	PACIFIC
A124	3689.0	1	DANIELS,JOSEPHUS	CG 27	ATLANTIC
A254	0.0	0	DANIELS,JOSEPHUS	CG 27	ATLANTIC
A065	2080.0	2	DANIELS,JOSEPHUS	CG 27	ATLANTIC

WRR-7 **TABLE 1-1.1F**

SERIAL NO.	OPERATING HOURS	NO. OF FAILURES	PLATFORM			FLEET
C024	0.0	0	PROTEUS	AS	19	PACIFIC
A024	0.0	0	PROTEUS	AS	19	PACIFIC
A026	0.0	0	PROTEUS	AS	19	PACIFIC
A015	218.5	3	HUNLEY	AS	31	ATLANTIC
A034	1829.0	2	HUNLEY	AS	31	ATLANTIC
A040	1197.8	2	LAKE,SIMON	AS	33	ATLANTIC
C003	2189.0	0	ABRAHAM LINCOLN	SSBN602		PACIFIC
A043	0.0	0	ABRAHAM LINCOLN	SSBN602		PACIFIC
B106	0.0	0	ETHAN ALLEN	SSBN608		PACIFIC
A035	77.8	3	SAM HOUSTON	SSBN609		PACIFIC
C041	717.0	0	SAM HOUSTON	SSBN609		PACIFIC
A021	3234.1	0	LAFAYETTE	SSBN616		ATLANTIC
B021	2846.8	3	LAFAYETTE	SSBN616		ATLANTIC
A027	3418.6	1	MADISON,JAMES	SSBN627		ATLANTIC
B043	5.0	0	MADISON,JAMES	SSBN627		ATLANTIC
B030	0.0	0	MADISON,JAMES	SSBN627		ATLANTIC
A004	3868.5	0	KAMEHAMEHA	SSBN642		ATLANTIC
C082	4667.3	0	KAMEHAMEHA	SSBN642		ATLANTIC
A044	954.2	1	KEY,FRANCIS SCOT	SSBN657		ATLANTIC
B083	3153.5	0	KEY,FRANCIS SCOT	SSBN657		ATLANTIC

URC-85 **TABLE 1-1.1G**

SERIAL NO.	OPERATING HOURS	NO. OF FAILURES	PLATFORM			FLEET
A007	1102.2	0	CORAL SEA	CVA	43	PACIFIC
A015	0.0	0	FORRESTAL	CV	59	ATLANTIC
A017	2003.6	3	CONSTELLATION	CVA	64	PACIFIC
A008	3182.5	2	ENTERPRISE	CVN	65	PACIFIC
A016	4134.9	2	KENNEDY,JOHN F.	CV	67	ATLANTIC
A011	3750.9	5	NIMITZ	CV	68	ATLANTIC
A001	0.0	0	MACDONOUGH	DDG	39	ATLANTIC