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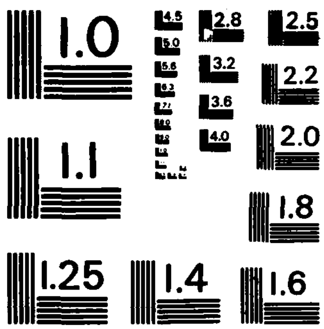

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AN/APN-128 LIGHTWEIGHT DOPPLER NAVIGATION SYSTEM (LDNS) CASE STUDY REPORT

(IDA/OSD R&M Study)

Paul F. Goree
IDA R&M Case Study Director

DTIC FILE COPY

August 1983

Prepared for
Office of the Under Secretary of Defense for Research and Engineering
and
Office of the Assistant Secretary of Defense
(Manpower, Reserve Affairs and Logistics)

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

This document records the activities and presents the findings of the AN/APN-128 Lightweight Doppler Navigation System (LDNS) Case Study Working Group, part of the IDA/OSD Reliability and Maintainability Study conducted during the period from July 1982 through August 1983.

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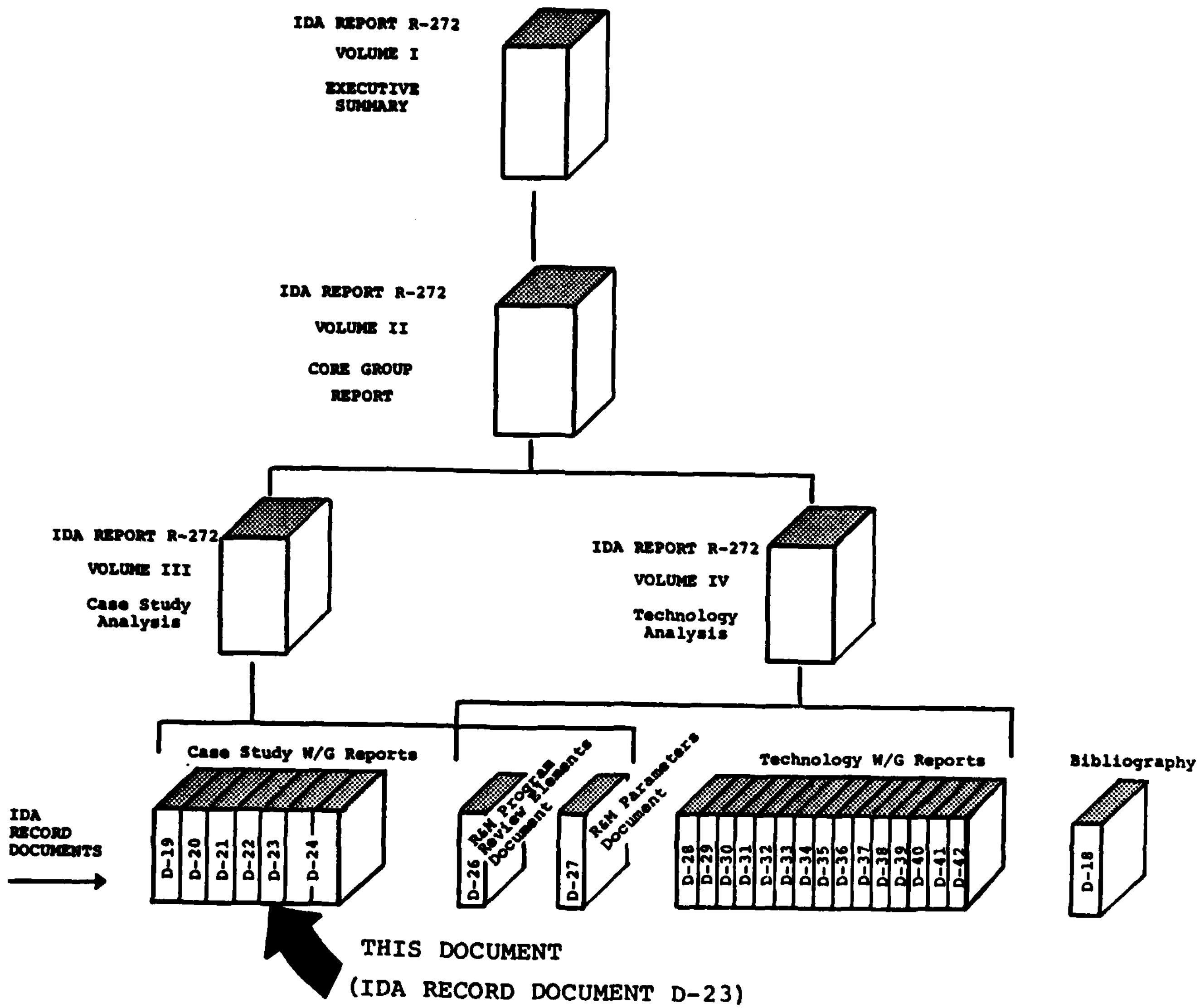
1801 N. Beauregard Street, Alexandria, Virginia 22311
Contract MDA 903 79 C 0018
Task T-2-126

RELIABILITY AND MAINTAINABILITY STUDY

— REPORT STRUCTURE —



PREFACE

As a result of the 1981 Defense Science Board Summer Study on Operational Readiness, Task Order T-2-126 was generated to look at potential steps toward improving the Material Readiness Posture of DoD (Short Title: R&M Study). This task order was structured to address the improvement of R&M and readiness through innovative program structuring and applications of new and advancing technology. Volume I summarizes the total study activity. Volume II integrates analysis relative to Volume III, program structuring aspects, and Volume IV, new and advancing technology aspects.

The objective of this study as defined by the task order is:

> "Identify and provide support for high payoff actions which the DoD can take to improve the military system design, development and support process so as to provide quantum improvement in R&M and readiness through innovative uses of advancing technology and program structure."

The scope of this study as defined by the task order is:

> To (1) identify high-payoff areas where the DoD could improve current system design, development program structure and system support policies, with the objective of enhancing peacetime availability of major weapons systems and the potential to make a rapid transition to high wartime activity rates, to sustain such rates and to do so with the most economical use of scarce resources possible, (2) assess the impact of advancing technology on the recommended approaches and guidelines, and (3) evaluate the potential and recommend strategies that might result in quantum increases in R&M or readiness through innovative uses of advancing technology.

The approach taken for the study was focused on producing meaningful implementable recommendations substantiated by quantitative data with implementation plans and vehicles to be provided where practical. To accomplish this, emphasis was placed upon the elucidation and integration of the expert knowledge and experience of engineers, developers, managers, testers and users involved with the complete acquisition cycle of weapons systems programs as well as upon supporting analysis. A search was conducted through major industrial companies, a director was selected and the following general plan was adopted.

General Study Plan

Vol. III • Select, analyze and review existing successful program

Vol. IV • Analyze and review related new and advanced technology

Vol. II (• Analyze and integrate review results
(• Develop, coordinate and refine new concepts

Vol. I • Present new concepts to DoD with implementation plan and recommendations for application.

The approach to implementing the plan was based on an executive council core group for organization, analysis, integration and continuity; making extensive use of working groups, heavy military and industry involvement and participation, and coordination and refinement through joint industry/service analysis and review. Overall study organization is shown in Fig. P-1.

The basic case study approach was to build a foundation for analysis and to analyze the front-end process of program structuring for ways to attain R&M, mature it, and improve it. Concurrency and resource implications were considered. Tools to be used to accomplish this were existing case study reports, new case studies

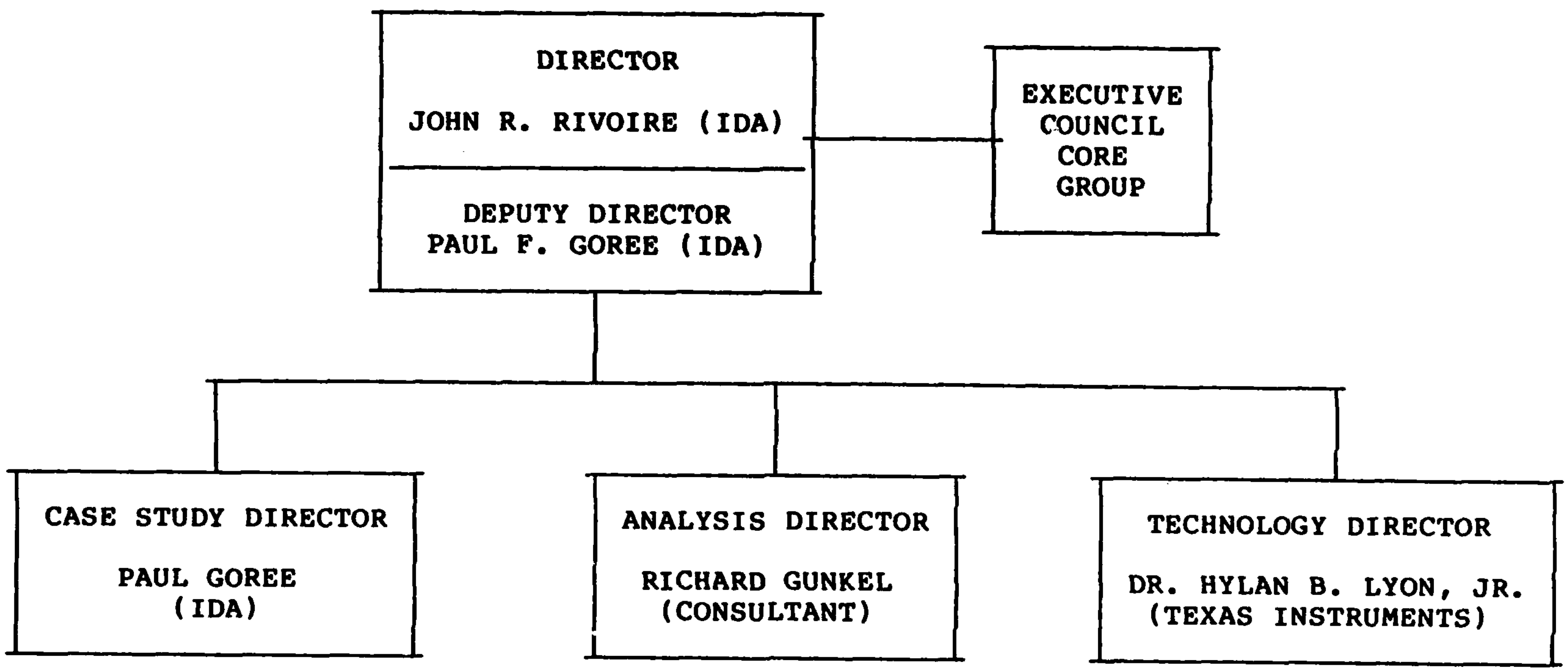


FIGURE P-1. Study Organization

conducted specifically to document quantitative data for cross-program analysis, and documents, presentations, and other available literature. In addition, focused studies for specific technology implications were conducted by individual technology working groups and documented in their respective reports. To accomplish the new case studies, the organization shown in Fig. P-2 was established.

In some areas where program documentation and records did not exist, the actual experience and judgement of those involved in the programs were captured in the case studies. Likewise, in the analysis process, the broad base of experience and judgement of the military/industry executive council members and other participants was vital to understanding and analyzing areas where specific detailed data were lacking.

This document records the program activities, details and findings of the Case Study Working Group for the specific program as indicated in Fig. P-2.

Without the detailed efforts, energies, patience and candidness of those intimately involved in the programs studied, this case study effort would not have been possible within the time and resources available.

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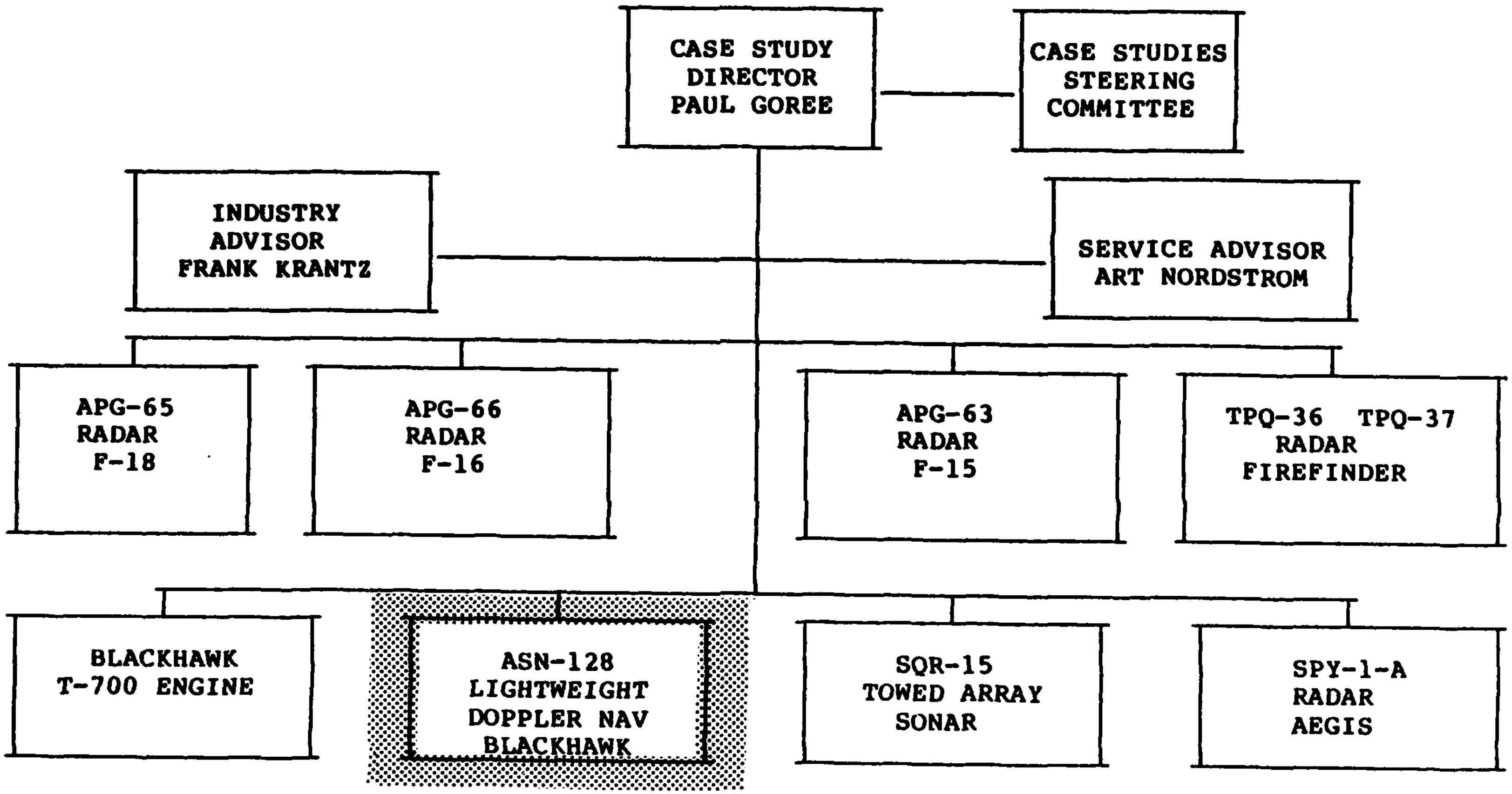

FIGURE P-2. Case Study Organization

AN/APN 128 LIGHTWEIGHT DOPPLER NAVIGATION SYSTEM

RELIABILITY AND MAINTAINABILITY CASE STUDY

ABBREVIATIONS

ATE	Automated Test Equipment
BITE	Built-In Test Equipment
CEP	Circular Error Probability
CDU	Control/Display Unit
CPFFIF	Cost Plus Fixed Fee Incentive Fee
CMOS	Complementary Metal Oxide Semiconductor
DTUPC	Design-To-Unit Production Cost
DRVS	Doppler Radar Velocity Sensor
EMI	Electromagnetic Interference
ECP	Engineering Change Proposal
ED	Engineering Development
IAD	Initial Anniversary Date
LCC	Life-Cycle Cost
LDNS	Lightweight Doppler Navigation System
LRU	Line Replaceable Unit
LRIP	Low-Rate Initial Production
MTBF	Mean Time Between Failure
MTTR	Mean Time To Repair
ORLA	Optimum Repair Level Analyses
PEP	Producibility Engineering Planning
QALI	Quality Assurance Letter Of Instruction
RTA	Receiver-Transmitter Antenna
RIW	Reliability Improvement Warranty
R&M	Reliability and Maintainability
SDC	Signal Data Converter
STE	Special Test Equipment
SRU	Shop Replaceable Unit
UTM	Universal Transverse Mercator

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AN/APN-128 LIGHTWEIGHT DOPPLER NAVIGATION SYSTEM

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AN/APN-128

LIGHTWEIGHT DOPPLER NAVIGATION SYSTEM

EXECUTIVE SUMMARY

I. INTRODUCTION

1. Program features included design-to-unit-production cost, producibility engineering planning, a reliability improvement warranty, and a 1000 hour MTBF requirement.

2. The Army periodically graded the contractor's performance. This appraisal received high level management attention.

3. Turn-around time, based on a special RIW pipeline, is about 14.9 days.

CASE STUDY CONTENTS

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R&M PROGRAM REVIEW ELEMENTS

CONTRACT

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3. Life Profile Establishment
4. R&M Failure Definition
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23. Reliability Growth Testing
24. Demonstration Testing
25. Operational Test and Evaluation
26. Inservice Assessment

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LIGHTWEIGHT DOPPLER NAVIGATION SYSTEM

MATERIEL NEED

The AN/APN-128 Lightweight Doppler Navigation System is the standard airborne doppler navigator for the Army. The system operates over territory which does not have external radiating sources. The pilot, by reading the digital output, determines the present position in Universal Transverse Mercator (UTM) coordinates. By using an accessory Bearing Distance Heading Indicator or Steering Hover Indicator Unit, the pilot may obtain course and distance to fly to a predetermined destination. Navigational accuracy will be 2% circular error probability (CEP) of the distance traveled when a heading reference with an accuracy of 1° (1 sigma) is provided. The system shall consist of a maximum of three line replaceable units (LRU).

The Doppler Radar Velocity Sensor may consist of one or two LRU (antenna and receiver/transmitter). The volume will not exceed 700.0 cubic inches. The radar antenna position will not exceed 14.8 inches in length, 14.4 inches in width, and 4.6 inches in height. The control/display unit will not exceed 8 inches in height. The total system, exclusive of interconnecting and power cables, will not exceed 30 lb or 900 cubic inches.

The operation of the LDNS shall not be limited by the replacement of the following items by equivalent items:

(1) Gyromagnetic Compass Set, AN/ASN-43

(2) Vertical Gyro (MD-1) or Lear 9000C series or equivalent

(3) Navigation Set AN/ARN-114

(4) Steering Hover Indicator Units

(5) Bearing Distance Heading Indicator.

MATERIEL NEED

- NO EXTERNAL RADIATING SOURCE
- OUTPUT
  - PRESENT POSITION
  - COURSE
  - RANGE
- ACCURACY OF 2 PERCENT CEP
- MAXIMUM 3 LRU
  - DOPPLER RADAR VELOCITY SENSOR (1 OR 2 LRU)
  - CONTROL/DISPLAY UNIT
- LDNS OPERATION NOT AFFECTED BY REPLACEMENT OF:
  - GYROMAGNETIC COMPASS
  - VERTICAL GYRO
  - NAVIGATION SET
  - STEERING HOVER INDICATOR UNITS
  - BEARING DISTANCE HEADING INDICATOR

SYSTEM DESCRIPTION

The LDNS consists of three line replaceable units; the Receiver-Transmitter Antenna and the Signal Data Converter, which make up the Doppler Radar Velocity Sensor, and the Computer Display Unit.

The sensor determines aircraft velocity along the three axes by measuring the Doppler frequency shift in radar energy transmitted toward, and received back from, the ground. When prime power is applied to the sensor, it transmits microwave energy toward the ground in four non-coplanar beams and measures the Doppler frequency shift in the backscattered energy. The four frequency shifts are fed into the computer for computing navigation and steering data.

The LDNS is a self-contained system and requires no ground based aids.

SYSTEM DESCRIPTION

- THREE LINE REPLACEABLE UNITS
  - RECEIVER-TRANSMITTER ANTENNA)
  - SIGNAL DATA CONVERTER) DOPPLER RADAR VELOCITY SENSOR
  - COMPUTER DISPLAY UNIT)
- SELF-CONTAINED; NO GROUND-BASED AIDS
- PHYSICAL CHARACTERISTICS

PHYSICAL CHARACTERISTICS	ACHIEVED	MV
• WEIGHT	28 LB	30 LB
• VOLUME	1191 CU IN	900 CU IN
• MTBF	2121 HOURS	--

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PROGRAM SUMMARY

The lightweight Doppler program contained the features shown above. The Design-to-Unit Production Cost (DTUPC) of $25,100 was based on a production run of 1000 units calculated in FY-74 constant dollars. Two contractors competed for the production contract. The specification requirements were considered desirable, with the exception of essential requirements shown on the next vugraph.

PROGRAM SUMMARY

- DESIGN-TO-UNIT PRODUCTION COST (DTUPC)
- TWO CONTRACTORS
- FLOATING SPECIFICATION
- PRODUCIBILITY ENGINEERING PLANNING (PEP)
- RELIABILITY IMPROVEMENT WARRANTY (RIW)
- CONTRACT INCENTIVES

REQUIREMENTS

The contractor needed to comply with the essential technical requirements as well as the DTUPC in order to be considered for the follow-on production contract. Another feature of this program included the joint (contractor and government) development of the terms and conditions for the Reliability Improvement Warranty (RIW) during the development phase. Also the contract incentive fee clause required periodic grading of the contractor's performance by the government. The attention given to this performance appraisal by higher management (both contractor and government) contributed to the success of this program.

ESSENTIAL REQUIREMENTS COMPLIANCE

REQUIREMENT: LDNS MAXIMUM WEIGHT - 50 LB. ESSENTIAL (E)
35 LB. DESIRED (D)

LDNS MAXIMUM VOLUME - 3,500 CU. IN. (E)
2,000 CU. IN. (D)

CDU MAXIMUM SIZE: (60 IN. X 570 IN. X 8.0 IN.) (E)

PRESENT POSITION DISPLAY: WORLDWIDE UTM (E)
LAT./LONG. (D)

CEP: 2.0% (E)
1.0% (D)

ALTITUDE: 2 TO 10,000 FT. (E)
2 TO 15,000 FT. (D)

DESTINATIONS: 6 (E)
10 (D)

DRVS INTERFACE (E)

RELIABILITY (MTBF,θ)
1,000 HRS. (E)

MEASURES OF SUCCESS

The reliability of the Doppler navigator was demonstrated to be 1000 hours per the test requirements of MIL-STD-781B test plan XXI. The field reliability as calculated per the terms and conditions of the RIW is 1162.1 hours. The turnaround time is based on a specially designed pipeline for RIW. The turnaround times achieved have been 14.9 days.

The Doppler navigator contains extensive BITE. The system was designed to isolated failures and provide a visual go-no-go indication. The performance of the system has met all Army requirements.

MEASURES OF SUCCESS

- RELIABILITY
- TURNAROUND TIME
- BITE
- PERFORMANCE

PROGRAM ELEMENTS

CONTRACT

R&M REQUIREMENTS

The MTBF of 1000 hours was demonstrated in accordance with MIL-STD-781B test plan XXI. The field MTBF figures and turnaround times are derived from calculations made with data collected under the RIW program. The MTTR specification requirements were demonstrated by laboratory tests during the engineering development phase.

CONTRACT

R&M REQUIREMENTS

	SPECIFICATION	TEST	RIW FIELD
• MTBF	1000 HR. θ_1	1,000 HR.	1162.1 HR.
• MTTR			
ORGANIC	15 MIN.	8.96 MIN.	--
INTERMEDIATE	30 MIN.	13.2 MIN.	--
DEPOT	60 MIN.	NOT TESTED	--
• TURNAROUND TIME (RIW)	--	14.9 CALENDAR DAYS	

MISSION PROFILE ESTABLISHMENT

The specification described the service conditions under which the Doppler navigator would be required to operate. The performance parameters, areas of operation, and type of aircraft the Doppler would be used in, were identified at the beginning of the full-scale development phase. The environment and performance envelopes were validated through qualification and flight tests.

CONTRACT

MISSION PROFILE ESTABLISHMENT

- FIXED WING AND ROTARY WING
- AVIONICS 100% USAGE
- PERFORMANCE ENVELOPE
- WORLDWIDE OPERATION

LIFE PROFILE ESTABLISHMENT

A life-cycle cost analysis was conducted. The life-cycle cost was defined as R&D cost, plus acquisition costs, plus ten years of operating and maintenance costs. Design and maintenance tradeoffs (RIW versus Organic) were considered in determining the minimum cost of this equipment over its 10-year life span. Usage of the equipment in all phases of the life profile were considered. Cost-quantity relationships and risk-uncertainty criteria were developed as part of the LCC analyses.

CONTRACT

LIFE PROFILE ESTABLISHMENT

- 10-YEAR LIFE SPAN
- DESIGN AND MAINTENANCE TRADEOFFS
- AVIONICS USAGE 100% DURING MISSION

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R&M FAILURE DEFINITION

The failure definition for qualification tests was defined in the engineering development system specification. These criteria required the Doppler navigator to meet established performance criteria, maintenance repair times, and reliability requirements.

The failure criteria during the operational test were derived from the PANS MN. These requirements were set against the successful completion of missions. These missions were performed under various profiles and flight conditions, e.g., low level, high dynamics, night, rain, etc.

CONTRACT

R&M FAILURE DEFINITION

- QUALIFICATION TEST
- OPERATIONAL TEST

INCENTIVES

The engineering development contract was a cost plus fixed fee incentive fee (CPFFIF) type contract with a special provision for an award fee. The award fee was the real incentive to the contractor to meet or exceed the program requirements. It was administered through an award fee board of government personnel. There were three rating periods. At the end of each period, the award fee board met and determined the dollar amount of the award fee based on performance criteria set forth in the contract. The award fee represented a small amount of money when compared to the dollars involved in winning the production contract. Since two contractors were competing for this production carrot, they were very interested in how well their performance was viewed by the government. These reviews always received top management attention both in the government and by the contractors.

CONTRACT

INCENTIVES

- COST PLUS FIXED FEE INCENTIVE FEE
- AWARD FEE
- RELIABILITY

At the beginning of the Engineering Development phase, the Project Office considered the Reliability Improvement Warranty (RIW) as an alternative to in-service support for low rate initial production. Contractor response to the concept influenced the ED contract award fee plan. The Project Office communicated the objectives of the RIW concept to the contractor, and together tailored RIW provisions to be included in the LRIP solicitation package.

The Project Office integrated RIW activities with other program management as early as 1974, starting with post-award conferences. Within two months of each ED contract award, post-award conferences took place at the contractor facility. The importance of the RIW was stressed by the Project Office, and contractor input was welcomed.

The ED contracts required the contractors to hold quarterly progress reviews. RIW was addressed when desired by the Project Office or the contractor.

At intervals throughout the ED phase, particularly during the last eight months of development, the RIW provisions were revised as needed. The contractor reviewed and commented on the changes. A free exchange of ideas on these issues was encouraged.

During Engineering Development, a central point for RIW was created within the Project Office. The contractors were requested to establish RIW contact points and focal points of effort. This was done to improve, and speed up, dissemination of information on and status of RIW activity.

RELIABILITY IMPROVEMENT WARRANTY

- RIW ALTERNATIVE TO IN-SERVICE SUPPORT FOR LOW-RATE INITIAL PRODUCTION (LRIP) SOLICITATION
- PROJECT OFFICE WORKED WITH ED CONTRACTOR IN TAILORING RIW PROVISIONS OF SOLICITATION PACKAGE
- RIW ACTIVITIES:
  - POST-AWARD CONFERENCES
  - QUARTERLY MEETINGS
  - RIW TERMS AND CONDITIONS REVISED PERIODICALLY
  - PROJECT OFFICE-CONTRACTOR COORDINATION

WARRANTY

The Contractor warranted that the Lightweight Doppler Navigation System units furnished were free of defects in material, workmanship and design, and would operate in the intended environment for the specified warranty period. The contract provided for renewal of the warranty.

Any unit failing to meet the warranty and returned to the Contractor was to be repaired or replaced at the Contractor's sole option and expense. The Contractor was not obligated to perform cosmetic repairs. Repaired or replaced items were tested against a specified Acceptance Test Procedure. The Government witnessed test activity and reviewed the documented results.

For purposes of the warranty, the Initial Anniversary Date (IAD) was the date of successful completion of DT III PVT-G (Production Validation Testing-Government) Testing. This date was used to establish reporting and adjustment periods for the warranty.

For all Low Rate Initial Production Units, the initial warranty period started when the government accepted a unit and extended 48 months after the IAD. The Contractor and Contracting Officer would negotiate the price for any renewal of the warranty period.

The Contractor does not pay for repair/replacement of units for nonconformance, loss or damage due to:

(1) Non-LDNS induced fire or explosion
(2) Submersion
(3) Aircraft crash
(4) Enemy action
(5) Natural disaster, or
(6) Accidental or willful mistreatment.

RELIABILITY IMPROVEMENT WARRANTY

- REPAIR/REPLACEMENT OF DEFECTIVE ITEMS AT CONTRACTOR'S EXPENSE
- INITIAL WARRANTY PERIOD EXTENDS 48 MONTHS PAST IAD--RENEWABLE
- EXCLUSIONS:
  - NON-LDNS INDUCED FIRE OR EXPLOSION
  - SUBMERSION
  - AIRCRAFT CRASH
  - ENEMY ACTION
  - NATURAL DISASTER
  - ACCIDENTAL OR WILLFUL MISTREATMENT
- CONTRACTOR NOT LIABLE FOR SPECIAL OR CONSEQUENTIAL DAMAGE

The exclusions did not apply at Contractor-controlled locations, or if the LDNS caused one or more of the above events. Clear and convincing evidence was required to accompany the Contractor's claim from relief from Warranty Obligation for any of the above listed exclusions.

The Contractor was to repair or replace any defective unit in accordance with the terms of the warranty. The Contractor was not liable for special or consequential damages.

SOUR E SELECTION CRITERIA

In order for the contractors to receive consideration for contract award, they were required to receive an acceptable rating in the "Must Meet" Criteria. Reliability was an essential requirement. Both contractors successfully met this requirement.

CONTRACT

SOURCE SELECTION CRITERIA

- "MUST MEET" CRITERIA
  - DESIGN TO UNIT PRODUCTION COST
  - ESSENTIAL TECHNICAL REQUIREMENTS
- OTHERS
  - COST
    - A. PRODUCTION CONTRACT PRICE
    - B. COST OF OWNERSHIP
  - TECHNICAL PERFORMANCE

LIFE-CYCLE COST CONSIDERATION

The MTBF was derived from a calculation using piece parts in the Doppler design. The MTBF and maintenance requirements as set forth in the development specification did impact the Life Cycle Cost (LCC) analysis. The generalized electronic maintenance model was exercised to come up with the most cost-effective maintenance concept; and this was used in the LCC analysis. MTBF and space were considered significant cost driving parameters. Stockage levels were analyzed in the optimum repair level analyses (ORLA). MTBF was sensitized from 500 hours to 1600 hours and the ORLA was analyzed at each maintenance level. As a note, after six years of field operation under RIW, the government is considering using two-level maintenance in lieu of the recommended three-level because of the high cost of spares stockage required at the intermediate level. The government plans to be under contractor maintenance support from FY 85 to FY 87, and organic support starting in FY 87.

CONTRACT

LIFE CYCLE COST

- 10-YEAR LIFE SPAN
- DESIGN AND MAINTENANCE ALTERNATIVES
- RISK AND UNCERTAINTY
- QUANTITY-PRICE RELATIONSHIP

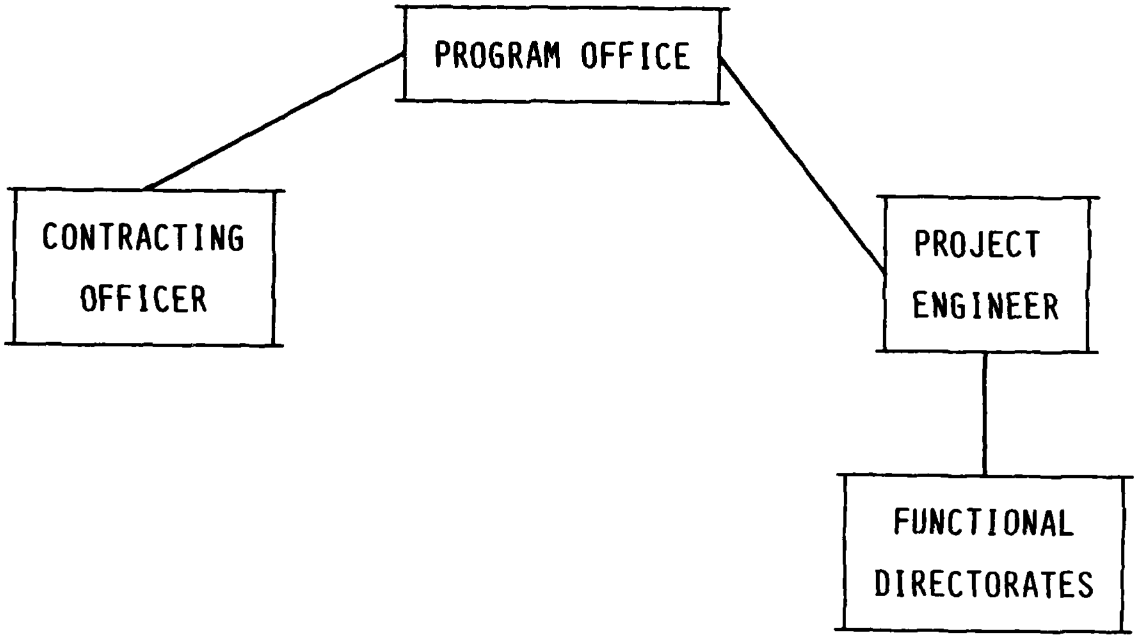
MANAGEMENT

PLANNING, CONTROL AND EMPHASIS

The project manager had overall program responsibility. The project engineer had technical responsibility. The internal team was established early in the program, with a commitment from the functional directorates to provide a dedicated individual to the Doppler program. Frequent team meetings kept the team on top of all problems and ensured good communications.

MANAGEMENT

PLANNING, CONTROL, AND EMPHASIS



GOVERNMENT ORGANIZATION

CONTRACTOR PROCEDURES

The contractors had frequent design reviews which considered the elements listed below. Unique in this design activity was the role of the production engineer. He was given sign-off authority very early in the program. Configuration control was maintained by the contractor. The government was given access to status or data when required. The design baseline was frozen after the completion of all testing. This alleviated the need for cumbersome Engineering Change Proposal (ECP) processing during the time-frame when frequent changes were anticipated.

CONTRACTOR PROCEDURES

- DESIGN TRADEOFFS
- PRODUCTION SIGN-OFF
- COST BOGEY
- RELIABILITY BUDGET
- CONFIGURATION CONTROL

MONITOR/CONTROL OF SUBCONTRACTOR AND SUPPLIES

The contractor imposed company requirements on vendors. He was allowed parts specification sheet deviation whenever it could show reliability or cost advantage.

MANAGEMENT

MONITOR/CONTROL OF SUBCONTRACTOR AND SUPPLIES

- USED STANDARD QUALITY ASSURANCE LETTER OF INSTRUCTION (QALI)
- USE OF STANDARD PARTS
- FLEXIBLE ON SPECIFICATION SHEETS AND PARTS SCREENING

DESIGN

DEVELOPMENT OF DESIGN REQUIREMENTS

The design requirements were developed from the user need. This information was transmitted to the contractor in the development specification. The contractor took a top down approach, where an MTBF number was allocated for each subassembly. The maintenance design used BITE to isolate failures to the module level, thus eliminating the requirement for special test equipment.

DESIGN

DEVELOPMENT OF DESIGN REQUIREMENTS

- 1000 HR. MTBF REQUIREMENT
- 15 MIN. MTTR ORGANIZATION
  30 MIN. MTTR INTERMEDIATE
- TOP DOWN R&M DESIGN APPROACH

DESIGN ALTERNATIVE STUDIES

The BITE capability for isolating failures to the module level eliminated the requirement for special test equipment at organizational or direct support levels of maintenance. Failure modes as well as recommended mode of operation are provided visually to operator. A printed grid planar array was selected because of simplicity, reliability, low cost, and freedom from terrain bars. The two-LRU DRVS configuration was selected because of:

(1) Simplified installation

(2) Improved maintainability--High reliability of receiver/transmitter antenna (over 12,000 hours) means virtually no removals

(3) Minimized thermal problems

(4) Reduced vibration problems

(5) Lower logistic support costs (fewer DRVSs required per base, since reliability is high)

(6) Easy repackaging for growth to different antenna dimensions and techniques.

DESIGN

DESIGN ALTERNATIVE STUDIES

- BUILT-IN TEST EQUIPMENT (BITE)
- PRINTED GRID PLANAR ARRAY ANTENNA
- ONE VERSUS TWO LRU DOPPLER RADAR VELOCITY SENSOR (DRVS)

DESIGN EVALUATION ANALYSES

The contractor's design evaluation was an integral part of the design process. Examples of how this process impacted the design were given under design alternative studies. Unique in this process was the role the production engineer played, e.g., sign-off on final design.

DESIGN EVALUATION ANALYSES

- THERMAL ANALYSIS
- VIBRATION ANALYSIS
- WORST COST ANALYSIS
- ENGINEERING DESIGN ANALYSIS REVIEW

DESIGN TO UNIT PRODUCTION COST (DTUPC)

Production Proposal Evaluation Criteria included "must meet" criteria, cost, and technical performance. The DTUPC concept played a part in the LDNS program. LDNS Trade-off analyses made use of the following factors, in order of priority:

1) Hardware status (Technical Risk)
2) Development and Production Cost
3) Overall size, weight and power
4) R&M (LCC Factors)
5) Computational Capability (Speed, Memory, etc.)

Studies were conducted on three types of machines; off-the shelf LSI CPU, custom LSI CPU, and discrete IC Technology. The off-the shelf LSI CPU was selected as optimum.

Examples of Producibility Trade-offs are shown on the following page.

PRODUCIBILITY TRADE-OFFS

- CASTING VERSUS DIPPED BRAZED ASSEMBLY FOR CDU MAIN FRAME

  COST ESTIMATES IN QUANTITY OF 1,000

CASTING	45
MACHINING	68
TOTAL	$113

  DIPPED BRAZED HOUSING $220

  SELECTED CASTING FOR LOWER PRODUCTION COST

- CDU INTERCONNECTION TRADE-OFFS

MULTI-LAYER MOTHER BOARD	$ 55
SOLDER INTERCONNECT WIRE	70
TOTAL	$125
WIRE WRAP PROCESS	$ 36

- SELECTED WIREWRAP APPROACH FOR LOWER COST

108/32-1

DATA STORAGE DURING POWER OFF

- PROBLEM
  - CMOS LSI RAM CHIPS LOSE CONTENTS AFTER POWER TURNED OFF
  - OPERATOR MUST RE-INITIALIZE PRESENT POSITION AND DESTINATIONS UPON POWER TURN-ON

- ALTERNATIVES:
  - SERIAL CORE MEMORY-PRODUCTION COST >$2,000
  - MNOS RAM (NITRIDE)
    - LOW DENSITY/HIGH COST
    - SLOW WRITE TIME
    - STILL UNDER DEVELOPMENT
  - SELF-CONTAINED BATTERY POWERS RAM WHEN PRIME POWER TURNED OFF
    - SMALL COST INCREASE <$20
    - LOW POWER DRAIN <0.2 MILLIAMPS
    - PERIODIC MAINTENANCE REQUIRED
  - RE-INITIALIZE ALL DATA EVERY POWER OFF
- APPROACH SELECTED

108/32-2

TRADE-OFF MANUAL vs AUTOMATIC SPHEROID BOUNDARY DETECTION

- MANUAL DETECTION
  - OPERATOR DETERMINES WHEN AIRCRAFT TRANSITIONS BOUNDARY AND CHANGES PRESENT POSITION SPHEROID DESIGNATOR

- AUTOMATIC DETECTION
  - COMPUTER DETERMINES TRANSITION AND AUTOMATICALLY CHANGES SPHEROID DESIGNATOR
  - COMPUTATIONAL COMPLEXITY GREATER, REQUIRES ADDITIONAL MEMORY TO STORE BOUNDARY DATA WITH RESULTANT COST INCREASE OF >$150

- APPROACH SELECTED - MANUAL DETECTION
  - LOWER PRODUCTION COST
  - BOUNDARY CROSSINGS OCCUR VERY RARELY IN ARMY TACTICAL ENVIRONMENT
  - "OVERLAP" OF SPHEROIDS PROVIDED ON ALL UTM MAPS NEAR BOUNDARIES

108/32-3

PARTS AND MATERIAL SELECTION AND CONTROL

The MIL-P-11268 specification was a contract requirement. The parts control and selection was managed through a government/contractor parts control board. The use of standard parts was stressed. Deviation from part selection and material selection control was granted by government (project engineer or project manager). The contractor was required to show cost advantage or reliability improvement. Project personnel control of the board expedited the selection process. Configuration control was not enforced until the completion of testing to alleviate cumbersome procedures. After configuration control was enforced, ECP approval was administered through the project office.

DESIGN

PARTS AND MATERIALS SELECTION CONTROL

- MIL-P-11268 PARTS, MATERIALS AND PROCESSES USED IN ELECTRONIC COMMUNICATION EQUIPMENT
- PARTS CONTROL BOARD
- CONTRACTOR VENDOR SCREENING

THERMAL PACKAGING CRITERIA

The development specification imposed conductive cooling and low power as requirements for the Doppler navigator. The thermal-packaging criteria was an element considered by the contractor during the engineering design analysis reviews. Thermal analyses were conducted and thermal surveys were performed prior to the Reliability Demonstration test.

DESIGN

THERMAL-PACKAGING CRITERIA

- REQUIREMENT FOR CONDUCTIVE COOLING
- LOW POWER
- USE OF CMOS
- DERATING OF COMPONENTS

66/1-19

DESIGN

COMPUTER-AIDED DESIGN

- USED TO PERFORM WORST CASE ANALYSIS
- TIME SAVING
- COMPREHENSIVE

66/1-20

TESTABILITY ANALYSIS

The specification required that the system have a self test capability with automatic fault isolation to the LRU. Also a visual cue of failure was desired. The system was designed with the requirement to be compatible with Army maintenance systems such as USM 410, at a future date.

DESIGN

TESTABILITY ANALYSIS

- PRODUCTION ENGINEER REVIEWED DESIGN FOR PRODUCIBILITY AND TESTABILITY
- DIGITAL CARDS COMPATIBLE WITH ATE
- ANALOG LAYOUT FOR SIMPLE TROUBLE SHOOTING

The specification required fault isolation to the LRU. However, automatic fault isolation to the module level without the use of Special Test Equipment (STE) was accomplished.

Only minor changes were required to extend the LRU-level BITE to the module-level capability, thus saving not only the cost of the Special Test Equipment, but also the STE development and verification costs, handbooks, logistics, and standard test equipment. The LDNS does not require any adjustments at the system, LRU, or module level, and thus STE is not needed for this function. For these reasons, BITE to the module level is provided.

Display of the results of the BITE is another tradeoff item. The LRU and module failure indicators could be located on the LRUs and modules, or failure data could be shown on the CDU's display. Kearfott elected to display all BITE results on the CDU alphanumeric display to reduce cost (eliminates all failure indicators) and enhance maintainability [the Signal Data Converter (SDC) and Receiver-Transmitter Antenna (RTA) are usually not as accessible in the aircraft as the CDU]. The recommended mode of operation, in the event of a failure, is also displayed on the CDU. In summary, at the end of the TEST mode, the CDU displays the recommended mode of operation, the failed LRU and the failed module. If no failure has occurred, the "GO" is displayed.

The BITE design is a combination of continuous test and test on command. The SDC Power Supply and the CDU are tested on a continuous basis, but the Doppler data outputs are checked only when the system is put in the TEST mode. Continuous BITE of the Doppler was considered, but this would have required a reduced duty cycle for the Doppler data and was therefore rejected.

DESIGN

BIT AND ATE PERFORMANCE

- SELF-TEST CAPABILITY
- AUTOMATIC ISOLATION TO LRU
- VISUAL CUE OF FAILURE

DESIGN

FEATURES TO FACILITATE MAINTENANCE

- MODULAR DESIGN
- TEST POINTS
- BITE
- QUICK DISCONNECT OF SRU
- HIGH RELIABLE PARTS
- NO SPECIAL TEST EQUIPMENT
- NO SPECIAL TOOLS
- 2-LRU DRVS

66/1-23

MANUFACTURING

FAILURE REPORTING, ANALYSIS AND CORRECTIVE ACTION SYSTEMS

Upon the indication of a failure, the cause is determined. The failure is localized to a single component part(s). These parts are analyzed by the Reliability Engineering Failure Analysis Laboratory for further processing and analysis. Corrective action is taken and the repair is verified by retest.

MANUFACTURING

FAILURE REPORTING, ANALYSIS, AND CORRECTIVE ACTION SYSTEM

- FAILURE INDICATION
- INVESTIGATIVE TESTING
- FAILURE CONFIRMATION
- CORRECTIVE ACTION
- VERIFICATION OF REPAIR
- RETEST

66/1-24

TEST AND EVALUATION

DESIGN LIMIT QUALIFICATION TEST

The listed tests were performed in accordance with the test procedures of MIL-STD-810, 461, and 704. The purpose of the tests was to determine how the equipment would operate under the environmental conditions imposed. Failure analyses were performed on failed components and verification of repairs accomplished. No data were collected to calculate R&M limits. The sequence of tests was arranged such that all nondamaging tests were performed prior to damaging test. It is interesting to note that all qualifications tests were completed prior to Reliability Demonstration Test.

TEST AND EVALUATION

DESIGN LIMIT QUALIFICATION TEST

- DEVELOPMENT SPECIFICATION REQUIREMENTS
  - TEMPERATURE/ALTITUDE
  - RAIN
  - HUMIDITY
  - VIBRATION/SHOCK TEST
  - POWER VARIATION TEST MIL-STD-704
  - SALT/FOG
  - EXPLOSIVE ATMOSPHERE
  - ACCELERATION
  - FUNGUS
  - SAND/DUST
  - ELECTROMAGNETIC INTERFERENCE (EMI)

66/1-25

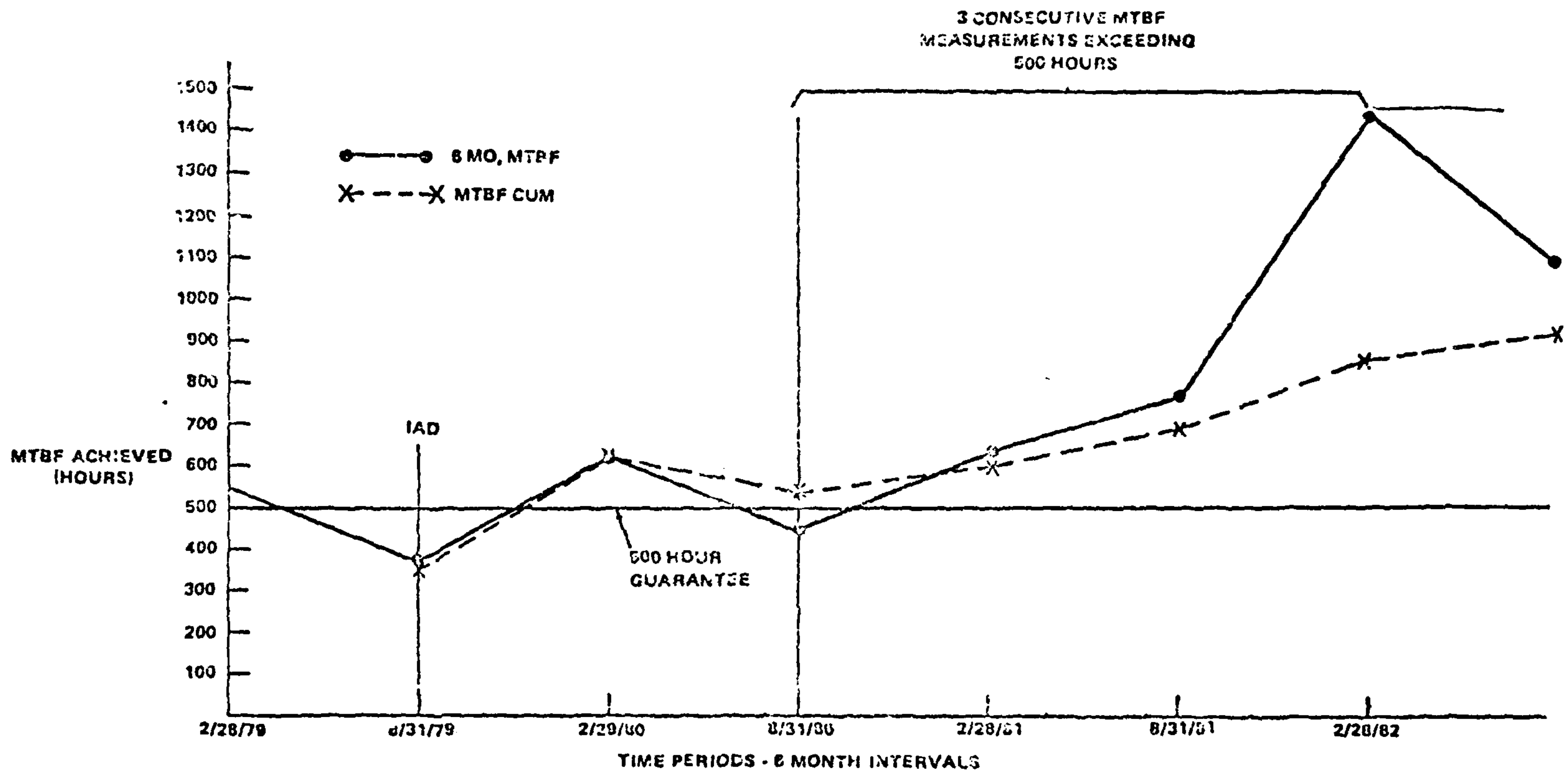
TEST AND EVALUATION

RELIABILITY GROWTH TESTING

- RELIABILITY GROWTH TESTING WAS NOT A PART OF THE ENGINEERING TEST PROGRAM
- RELIABILITY GROWTH WAS ACCOMPLISHED AS PART OF THE RIW

66/1-26

LIGHTWEIGHT DOPPLER NAVIGATION SYSTEM MTBF



DEMONSTRATION TESTING

A Reliability Demonstration Test was performed on the Doppler navigator during the development program to determine that the equipment design complied with the reliability requirement in terms of the specified MTBF of 1000 hours. The test was performed in accordance with Plan XXI of MIL-STD-781B. The total test time (equipment on) was 1840 hours with three failures occurring. This test was the only measure of acceptance for the reliability requirement.

A maintainability demonstration was performed in accordance with MIL-STD-471A procedure 1B. The objective of this test was to show compliance of the equipment with the maintainability requirements of the engineering development specification. Fifty-four maintenance tasks, consisting of failed LRUs, and 54 maintenance tasks, consisting of replacement of failed modules, were demonstrated. This was the only measure of the MTTR requirements. Field measurements were not taken because of the decision to use RIW initially in production.

TEST AND EVALUATION

DEMONSTRATION TESTING

- RELIABILITY DEMONSTRATION
- MAINTAINABILITY DEMONSTRATION

66/1-27

OPERATIONAL TEST AND EVALUATION

The Doppler navigator was evaluated against the requirements of the PANS MN. The test activity defined the critical issues of the user command. Prior to the start of test, training classes were conducted for pilots and maintenance personnel. Manuals were validated as part of the maintainability demonstration. Spare parts (LRUs) were in place for the test. Comments received from test pilots and maintenance personnel with regard to the imput of data, display of data, human factors, technical suitability, accuracy and maintainability did influence the system design prior to production.

TEST AND EVALUATION

OPERATIONAL TEST AND EVALUATION

- USER TEST
- DEVELOPMENT TEST

<u>TEST AND EVALUATION</u>

<u>IN-SERVICE ASSESSMENT</u>

- RIW

LESSONS LEARNED

- AWARD FEE
  - GOOD FEEDBACK
  - UPPER MANAGEMENT ATTENTION
- STRONG, COHESIVE INTEGRATED MANAGEMENT TEAM
- WELL DEFINED REQUIREMENTS
  - ESSENTIAL
  - DESIRED
  - DESIGN-TO-UNIT PRODUCTION COST
- CONFIGURATION CHANGE CONTROL
- TRAINING PROBLEMS
  - USER
  - MAINTENANCE

66/1-30

APPENDIX

SINGER-KEARFOTT

Attachment 11

WARRANTY TERMS AND CONDITIONS

PART I

Statement of Warranty

1. Notwithstanding Government inspection and acceptance of supplies and services furnished under this contract or any provisions of this contract concerning the conclusiveness thereof, the Contractor warrants that each Lightweight Doppler Navigation System AN/ASN-128(XE-2), consisting of:

Receiver-Transmitter-Antenna, Radar RT-1193(XE-2)/ASN-128,
Computer Display Unit CP-1252(XE-2)/ASN-128, and
Converter, Signal Data, Radar CV-3338(XE-2)/ASN-128,

(hereinafter referred to as Units) furnished under this contract will be free from defects in material, workmanship, and design and will operate in its intended environment in accordance with contractual specifications of this contract for the warranty period set forth herein and as it may be renewed under the provisions hereof. This warranty is in addition to and does not affect or limit the Government's rights under any other provision of this contract.

2. Any Unit furnished under this contract that fails to meet the aforesaid warranty and is returned to the Contractor by the Governement shall be either repaired or replaced at the Contractor's sole option and expense, so as to operate in accordance with said contractual specifications. Satisfactory operation of a Unit shall be demonstrated by successful completion of the Acceptance Test Procedure (ATP) contained in CDRL Item No. 0013AF. The contractor is not required to perform cosmetic repairs on Units returned under this warranty. Unless agreed to otherwise by the Government, all warranty repair and test activity shall be performed by the Contractor. The Government shall have the right to witness test activity and review the documented results.

3. For the purposes of this warranty, the Initial Anniversary Date (IAD) shall be defined to be the date of successful completion of DT III PVT-G

(Production Validation Testing - Government) testing. The Contractor will be notified of the IAD date by the ACO prior to release of the PVT-G Test Report. In any event, such notification will occur no later than 90 days after the successful conclusion of PVT-G testing. This IAD will be used to establish reporting and adjustment periods for this warranty.

4. For all Low Rate Initial Production (LRIP) Units purchased under this contract, the initial warranty period shall start upon government acceptance of a Unit (signing of the DD 250) and shall extend until 48 months after the IAD defined in Part I, paragraph 3. The warranty period specified herein may be renewed for additional periods at the option of the Government. The Contracting Officer and the Contractor agree to negotiate in good faith the price for any renewal of the warranty period.

5. The Contractor shall not be obligated to pay for the repair or replacement of any Units under this warranty for nonconformance, loss, or damage by reason of (1) Non-LDNS induced fire, (2) non-LDNS induced explosion, (3) submersion, (4) aircraft crash, (5) enemy action, (6) natural disaster, su as flood, hurricane, tornado, earthquake, or lightning, or (7) accidental or willful mistreatment. These exclusions apply only to loss or damage occurring at locations other than those owned or controlled by the Contractor or where a defect in the Unit is not a cause of one or more of the above listed events. Clear and convincing evidence must accompany the Contractor's claim for relief from warranty obligation for any of the above listed exclusions.

6. Nothwithstanding the provisions of the "Inspection" (1958 May) Clause (ASPR 7-103.5(a)) regarding the conclusiveness of acceptance and the waiver of defects which are susceptible to discovery prior to acceptance, the Contractor shall be obligated to repair or replace any defective Unit in accordance with the terms and conditions of this warranty. The rights and obligations of the parties under this warranty are in addition to and independ ent of the rights and obligations of the parties under the other provisions of this contract. Except as provided by the general provision of this contract entitled "Inspection", the Contractor's obligations and the Government's remedies for repair and replacement are solely and exclusively as stated herei In no event shall the Contractor be liable for special or consequential damages.

Part II

Contractor Obligations

1. Contractor-initiated ECPs to improve Unit reliability or maintainability at no change in contract price are encouraged under this warranty. All Government approved no change in price ECPs shall be incorporated into all new production units and into applicable prior production Units returned by the Government to the Contractor for repair. As a part of each no change in price ECP, the Contractor agrees to submit a schedule of prices to the Government for supplying the necessary parts (modification kits, instructions or other necessary material and supplies) for Units in the Government inventory for which the warranty has expired or will expire and which are known not to be of the latest configuration. The Government option to buy these necessary parts (modification kits, etc.) at the ECP price schedule shall extend until the earliest warranty expiration date for the LDNS, as a minimum.

This provision does not limit the Contractor's rights or privileges to develop and submit cost ECPs for other purposes.

2. The Contractor shall cause a suitable and prominent display of warranty information in form and content suitable to the Contracting Officer to be placed conspicuously on the surfaces of each Unit under warranty. A typical example is shown in Figure 1.

3. The Contractor shall cause a suitable label for permanently recording Unit installation and removal data in form and content suitable to the Contracting Officer to be placed conspicuously on the surface(s) of each Unit under warranty. A typical example is shown in Figure 2.

WARRANTY NOTICE

1. This unit is under warranty until (Date to be inserted).

2. Do not break or tamper with warranty seals.

3. Verify failures using approved procedures and test equipment of TM (To be inserted).

4. Record failure circumstance data and line tester findings on (Appropriate form reference to be inserted).

5. Package in accordance with Section II of TM (To be inserted) and promptly return with failure circumstance data and line tester data to (Insert contractor's address).

FIG 1 (TYPICAL)

	INSTALLATION DATA Date and Time Totalizing Meter				FOR CONTRACTOR USE ONLY
	Installed	Time	Removed	Time	Code
1					
2					
3					
4					
5					
6					

FIGURE 2 (TYPICAL)

Note that, there is a "Code" column next to the removal data in which the Contractor will record, on returned Units only, a code representing the result of Contractor/ACO action. The coding scheme is as follows:

0 - Unit removed for other than warranty repair

1 - Failure not covered under warranty
(ACO concurrence)

2 - Failure verified, corrective action taken
under warranty

3 - Failure not verified (ACO concurrence)

4. The Contractor shall provide and install appropriate seals for all Units which shall minimize inadvertent seal breaking. Furthermore, the design of the seals should be such that a breaking of a seal through tampering is detectable.

5. The Contractor shall submit for Government approval the proposed content, wording, placement, material, and method of application of the items required in Part II, paragraphs 2, 3, and 4.

6. The Contractor shall insert a notice in all technical manuals that cover the Units, to the effect that they are under warranty. The Contractor shall place those warranty provisions applicable to using activities in all pertinent Technical Manuals developed under this contract.

7. The Contractor shall maintain throughout the warranty period a fully operational warranty-repair facility located in the Continental United States. The Contractor shall maintain at this repair facility a secure area for storage of Government-owned spare units and repaired units.

8. In the event of a failure of a Unit, the Government shall promptly notify the Contractor in writing or by electronic message (e.g., TWX) of said failure.

Upon receipt of such notification, the Contractor shall package and pack in accordance with BASIC COMMERCIAL PACKAGING ~~[illegible]~~ for the levels cited, and ship a replacement Government-owned Unit from the secure storage area to a location designated by the Government. To the extent possible, Units will be selected for shipping from the secure storage area on a first- A-2 day from the time of receipt of notification, but in no event shall such shipment be made later than 96 hours after receipt of notification. For shipment, the Contractor shall use a Government Bill of Lading (GBL) accompanied by a DD Form 1149 for transfer of Government property accountability. In the event there are insufficient Units in the secure storage area to meet demands, the Contractor shall follow a shipping-priority system as directed by the ACO.

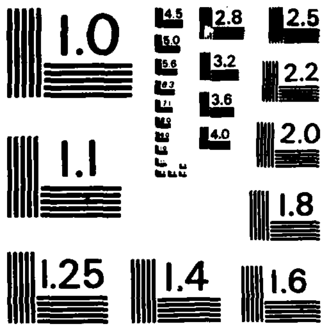
9. Units returned to the Contractor for repair or replacement under this warranty for which the Contractor cannot verify any nonconformance shall be subjected to and pass this contract's approved test procedure, packaged, and delivered to the secure storage area by the Contractor. This shall be done at no change in contract price unless the number of such returns exceeds (a) an averac of two such returns per month or (b) 25% of the total number of all returned Units in the reporting period, whichever figure is greater. For purposes of this adjustment, the reporting periods are defined to be twelve month periods beginning with the IAD. The Contracting Officer will annually adjust the contract price and make payment to the Contractor at the rate of $200 per Unit for the number of such returns that exceed the foregoing amount in each reporting period. For the purposes of computation, the returns of all Units will be combined. The Contractor shall promptly present evidence to the ACO or his designated representative that nonconformance of a returned Unit cannot be verified. The ACO shall review and cooroborate this determination.

10. The Contractor shall repair, replace and/or install approved ECP modifications, perform and pass the Contract's approved test procedure, package, and store a returned Unit for which this warranty is in force in the secure storage area in an average time less than or equal to "Tspec" calendar days as defined herein. Each Unit's turnaround time starts on the day it is received at the Contractor's repair facility and √ Joint inspection is made by the Contractor and Government representative ends on the day it is placed in the secure storage area or shipped to a Government location.

+6

Calculation of the Contractor's average turnaround time shall be made over six-month periods. The first such period shall start with the initial anniversary date, and subsequent six-month periods shall follow consecutively until warranty termination. If the average turnaround time in a six-month period exceeds the specified value, as computed from warranty data records, the Contractor will be assessed a liquidated ...

AD-A142 072 AN/APN-128 LIGHTWEIGHT DOPPLER NAVIGATION SYSTEM (LDNS) 2/2
CASE STUDY REPORT..(U) INSTITUTE FOR DEFENSE ANALYSES
ALEXANDRIA VA SCIENCE AND TECH.. P F GOREE AUG 83
UNCLASSIFIED IDA-D-23 IDA/HQ-83-25935 MDA903-79-C-0018 F/G 17/7 NL



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

This formula is based on a liquidated damage of $25 per day for each Unit which, on the average, exceeds the specified turnaround time. Such a fixed amount is established and agreed to by the Contractor in recognition of the fact that actual liquidated damages are difficult, if not impossible, to determine.

In this formula:

R = number of returned Units that have been received by the Contractor during the six-month period and which are not subject to the exclusions of Part I, paragraph 5.

$\bar{T}$ = average turnaround time of the R returned Units during the six-month period calculated to three decimal places from the equation $\bar{T} = D/R$. D is defined as the total number of calendar days for Contractor processing of the R items returned for warranty service.

Tspec = Specified turnaround time = Tc + Tm

The following table defines Tc for each measurement interval:

Interval	Tc (calendar days
IAD to IAD + 6 mos	30
IAD + 6 mos to IAD + 12 mos	25
IAD + 12 mos to IAD + 18 mos	20
Intervals after IAD + 18 mos	15

Tm is a turnaround time adjustment which depends on achieved MTBF and is defined in Part V, paragraph 5.

Liquidated damages will not be due for a measurement period if, during the period (see Part II, paragraph 8),

(a) The Government contractor had sufficient assets in the bonded storeroom to meet each asset demand during the period, and

(b) each such demand was met within the 96 hour time limit.

add'l 10. The Contractor shall not be charged with liquidated damages when the delay arises out of causes beyond the control and without the fault or negligence of the Contractor and its

11. The Contractor shall have a continuing responsibility to accept for correction and ECP installation and to complete the correction or ECP installation of, or furnish a replacement for, any Unit shipped to the Contractor's repair facility with a shipping date on or before the last day of the warranty period as extended notwithstanding any other provisions of this warranty. Any replacement units furnished under this warranty must be of the latest configuration and must pass the applicable ATP.

12. The Contractor shall maintain records by serial number for each Unit under warranty as required in Part VI hereunder. These records shall be made available to the Government at the Contractor's plant upon request during the warranty period and for two years following the expiration of warranty on any ~~LRIP~~ Unit.

PART III

A-6

Government Obligations

1. The Government shall, to the extent possible, verify failures VUT Government Contractor Approved Technical Orders prior to the return of Units to the Contractor, provide failure date and failure circumstance data to the Contractor, and use appropriate packing and packaging when returning Units under warranty. However, in the event that any or all of these conditions are not met, the warranty shall remain in effect for such Units.

2. In recognition of the high contractor motivation for total cost control effectiveness through the incentive feature of this warranty, the Government agrees that all no change in contract price ECPs which are complete and submitted in accordance with MIL-STD-481 to improve reliability or maintainability of the Units will receive expeditious processing through the approval cycle. Notwithstanding this special processing, any such ECP shall be automatically incorporated in the contract by the Government thirty-five (35) calendar days after receipt of such ECP by the PCO unless the PCO has issued a written notification of its non-approval prior to that date. ECPs developed and submitted for other purposes will be subject to the normal ECP review cycle.

4. "Analyses which identify contract price adjustments or needs for engineering analysis or corrective engineering actions in Parts IV and V shall be reviewed by the Contracting Officer and approved by him prior to implementation of these actions. The Contracting Officer's decision shall be final.

Added

A 8

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3. "The Government shall establish within its organization a single point of contact to communicate with the Contractor its requirements under RIW including, but not limited to, shipping instructions and establishment of priorities on shipment."

Add

A-6

8A

SK
6-24-76

PART IV

Miscellaneous

1. Upon receipt of a returned Unit at the Contractor's plant or repair facility, a joint inspection shall be made by the Contractor and the resident Government quality assurance representative for the purpose of categorizing the warranty status of each Unit. The re[illegible]esentative shall report his findings to the contracting officer. There is a presumption that a returned Unit is covered under this warranty and only the provisions of Part I, paragraph 5 thereof shall void the Contractor's responsibility to repair or replace at no cost to the Government under this warranty. In the event of a controversy, the Government reserves the right to make a final determination as to whether any Unit is covered by this warranty. The Contractor may exercise his prerogative under the Disputes Article of the contract.

2. The Contractor agrees to enter into a separate contract with the Government to cover the correction, repair, replacement, or disposition of Units that have sustained damage attributable by the Government to the causes/events set forth in Part I, paragraph 5.

Each such Unit returned for repair which upon examination at the Contractor's facility is not considered by the Government to be economically repairable shall be disposed of by the Contractor as directed by the contracting officer. The Contractor shall have the right to assess charges for any reasonable services performed as directed by the contracting officer in connection with the disposition of any such nonrepairable Unit. Any material required to be furnished by the Contractor in connection with shipment of such Units shall be subject to equitable adjustment. The Contractor may retain any such Units with the approval of the Contracting Officer if reimbursement is made to the Government for its reasonable value.

3. Any Unit returned to the Government after replacement hereunder shall have applied hereto the balance of the warranty period of the Unit it replaces.

When more than 10 percent of the Units provided under this contract have sustained damage attributable by the ACO to the causes/events set forth in Part I, paragraph 5, and ...

the provisions of Part IV, paragraph 2, or have otherwise been certified by the Contracting Officer as lost or damaged beyond repair, an adjustment in contract price shall be made for the unused portion of the warranty for the Units exceeding the 10 percent threshold.

For each Unit for which such adjustment is applicable, the Contractor shall rebate the Government at the rate of 0.0160 percent per day per Unit of the system RIW price in CLIN 0016AA. The rebate will apply to the unused portion of warranty time starting with the day the Unit was declared lost or damaged beyond repair.

5. The Government shall not be obligated to provide facilities, tooling, or equipment of any type for Contractor performance under this warranty except where Government Furnished Property is identified in the contract.

6. A average operate time of twenty (20) hours per month for each Unit delivered to the Government is expected for the LDNS equipment. Starting twenty-four (24) months after the Initial Anniversary Date (as defined in Part 1, Paragraph 3) and annually thereafter, the contract price shall be adjusted upward or downward to account for significant deviations (greater than plus or minus 10%) from this 20-hour standard during the previous twelve (12) month period. No adjustment shall be made for an operating differential in the period between contract award and twelve (12) months after the initial anniversary date.

Such adjustments shall be made by analyzing the elapsed-time-indicator (ETI) readings of all returned Units during the preceding twelve (12) months to estimate total operating time and comparing this estimate with the expected total operating time based on a 20 hour per month average.

Expected total operate hours (EXTOH) over an M month period is calculated as follows:

$$\mathrm{EXTOH} = \overline{N} \times \overline{OT} \times M$$

where

$$\overline{N} = \frac{1}{3 \cdot M} \sum_{j=1}^{M} Nj$$

and

Nj is the total number of LDNS Units accepted by the Government through the end of month j of the M month interval.

$\overline{OT}$ = 20 hours per month, the expected average operate time per month per Unit

M = number of months in the period

Estimated Total Operate Hours (ESTOH) over an M month period is calculated as follows:

$$ESTOH = D \times \overline{AOT} \times \overline{n}$$

where:

D = number of calendar days in the M month period

$\overline{AOT}$ = estimated average operate time per day

$$= \frac{\sum_j \Delta Time_j}{\sum_j \Delta Days_j}$$

$$\overline{n} = \frac{1}{3 \cdot M} \sum_{j=1}^{M} n_j$$

and n_j is the total number of LDNS Units accepted by the Government which are under warranty, and not at the Contractor's repair facility or in his secure storage area at the end of month j of the M month interval.

All Units received at the Contractor's repair facility during the measurement period will be used to compute $\overline{AOT}$.

Δ $Time_j$ for a Unit returned during the measurement period is defined to be the ETI reading of the Unit when received by the Contractor minus the ETI reading of the Unit when last shipped by the Contractor. Δ $Days_j$ for a Unit returned during the measurement period is defined to be the total number of calendar days the Unit was out of the Contractor's repair facility or secure storage area starting with the date the Unit was last shipped to a Government installation up to the date the Unit was again received by the Contractor. It is noted that the values in the numerator and denominator of the above equation must be based on the same Units. ~~[illegible] for a returned Unit, then that Unit's data shall be excluded~~ If the Units' ETI is inoperative or its data not available, then that Units data shall be excluded from the calculation of AOT.

2b

The usage ratio (UR) for the measurement period is given by:

$$UR = \frac{ESTOH}{EXTOH}$$

The correction factor (CF) for warranty payment for the period is given by

$$CF = \begin{cases} \dfrac{5(UR) + 4.5}{9} & 0 \leq UR < .9 \\ 1.0 & .9 \leq UR \leq 1.1 \\ \dfrac{5(UR) + 3.5}{9} & 1.1 < UR \end{cases}$$

The warranty price adjustment (AWP) due to equipment usage over the interval is calculated in two parts. For systems supplied under CLIN 0001AA:

$$AWP1 = \frac{CF - 1.0}{4} \; CLINP$$

where CLINP is the price of CLIN 0016AA

For systems supplied under the option quantity provisions of this contract:

$$AWPO = (CF - 1.0) \; \frac{QS}{QO} \left[\frac{PRICE}{3} \right]$$

where QO is the total option quantity exercised,

QS is the number of option quantity systems accepted by the Government by the last day of the usage measurement period, and

PRICE is the option quantity RIW price for QO systems.

Then

$$AWP = AWP1 + AWPO$$

A positive AWP indicates that the price is adjusted upward. A negative AWP indicates that the price is adjusted downward.

PART V - MTBF GUARANTEE

1. The Contractor shall guarantee that the achieved MTBF of the LDNS will be equal to or greater than that shown below:

Period	LDNS Achieved MTBF
1 through 48 months after IAD	500 hours

2. For this guarantee, the method for measuring achieved MTBF of the LDNS is given in Part V, paragraph 6.

3. The Contractor shall make semi-annual measurements of achieved MTBF of the LDNS over the previous six (6) month period. The first such measurement shall be made eighteen (18) months after the IAD. Paragraph 6 of this section provides the method for measuring achieved MTBF. The Contractor's obligation with respect to this MTBF guarantee shall terminate when three (3) consecutive measurements yield MTBF values that equal or exceed the guaranteed MTBF value shown in Part V, paragraph 1. In no event shall the Contractor's obligation be continued beyond forty-eight (48) months after the IAD unless mutually agreed to otherwise. Notwithstanding the termination of this MTBF Guarantee, the RIW shall continue in accordance with the applicable provisions of that clause.

4. In the event that the achieved MTBF for any measurement period is less than 500 hours, the Contractor shall furnish to the Government, at no additional cost to the Government, the following:

(a) Engineering analysis to determine the reasons for the failure to achieve the guaranteed figure

(b) Corrective engineering design changes

(c) Modification of the Units, as required.

5. In Part II, paragraph 10, the turnaround time adjustment factor (Tm) for a given period will depend on the achieved MTBF of the previous measurement period as follows:

Achieved MTBF (hours)	Tm (calendar days)
Less than 400 hours	-4
400 hours to 600 hours	0
more than 600 hours	4

6. This paragraph provides the method for measuring achieved MTBF over a six-month measurement period.

Achieved MTBF is defined as follows:

$$MTBFA = \frac{ESTOH}{F}$$

where

MTBFA = achieved MTBF

ESTOH = the estimated total operate hours of the LDWS over the six month period (See Part IV, paragraph 6, with M = 6)

F = number of Units received at the Contractor's repair facility during the measurement period which are coded '2' in accordance with Part II, paragraph 3.

PART VI

Data Requirements

The contractor shall establish and maintain a data accumulation, processing, analysis and reporting system capable of providing the information required by the following data items:

CDRL	Data Collection and Analysis Plan
CDRL	Warranty Data Report
CDRL	Warranty Effectiveness Study

THE LIGHTWEIGHT DOPPLER NAVIGATION SYSTEM & THE DTUPC PROCUREMENT CONCEPT

Lt. Col. Roy White
Army Project Office (NAVCON)
Ft. Monmouth

PRESENTATION KEY POINTS:

1. The DTUPC procurement concept is alive and well in the office of the Project Manager, Navigation/Control Systems (NAVCON). The latest program in which it is being used is the Army's Lightweight Doppler Navigation System (LDNS).

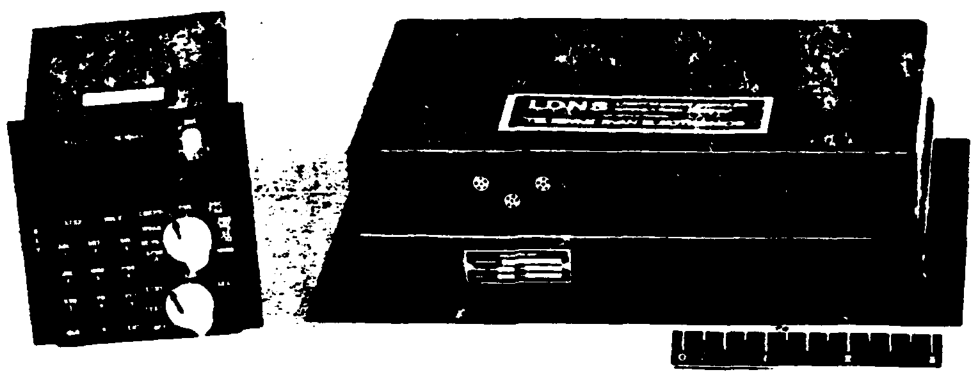
2. The Project Manager, NAVCON, is no stranger to the concept; the LDNS being the second DTUPC program start in one year. Lessons were learned from the first one, and the benefits of those lessons are being incorporated in the LDNS program. This presentation offers some detail on the comparisons of these programs.

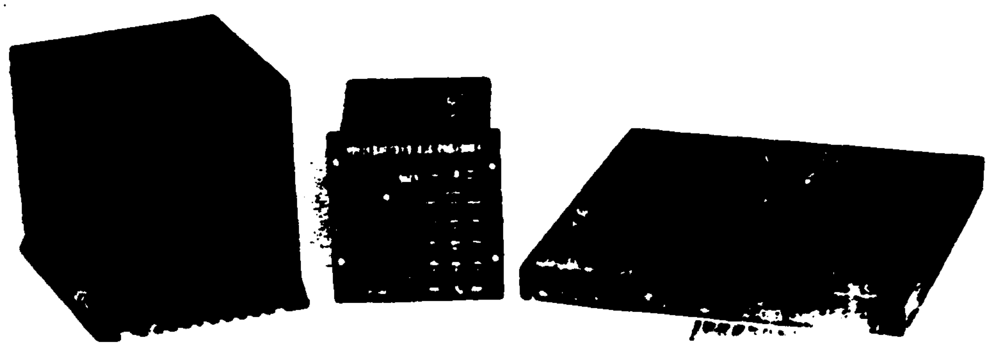
3. The Project Manager, NAVCON, also has another program similar to the LDNS, except that it is not a DTUPC program. Interesting comparisons are made between these two programs and how use of the DTUPC concept might have prevented some of the problems now being encountered in the non-DTUPC program.

4. Specifics are given in the presentation of what changes are still being made, even after the program is well into engineering development. Many of the changes are being made as the results of the Government and the contractors continuing to learn their DTUPC lessons together.

5. Reliability improvement warranties (RIW) are the subject of much discussion in procurement circles. Planned application of an RIW to the LDNS program is treated in the presentation. Draft terms and conditions of the proposed warranty clause for the initial production contract have been prepared and distributed to the two LDNS contractors. The whole subject will be treated in some detail.

6. Culmination of the presentation is a point-by-point reflection on the aspects of the LDNS DTUPC program covering the spectrum of problem areas, strong points, policy conflicts and changes, application to other programs, and other impressions as they have been received in the program thus far.

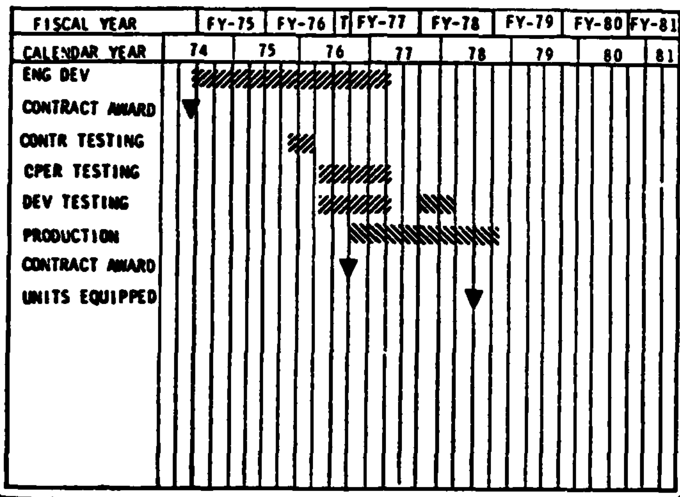




DOPPLER PROGRAM CONCEPT

- DTUPC
- TWO BOGEYS
- TWO CONTRACTORS
- FLOATING SPEC
- LRIP
- ONE CONTRACTOR IN LRIP
- COMPETITIVE FOLLOW-ON PRODUCTION
- PEP

DOPPLER PROGRAM SCHEDULE



ESSENTIAL REQUIREMENTS COMPLIANCE

REQUIREMENT: LDNS WEIGHT – 50 LB. (E)
35 LB. (D)
LDNS VOLUME – 2,500 CU. IN. (E)
2,000 CU. IN. (D)

CDU SIZE: (6.0 IN. X 5.70 IN. X 8.0 IN.) (E)

PRESENT POSITION DISPLAY: WORLD WIDE UTM (E)
LAT./LONG. (D)

CEP: 2.0% (E)
1.0% (D)

ALTITUDE: 2 TO 10,000 FT. (E)
2 TO 15,000 FT. (D)

DESTINATIONS: 6 (E)
10 (D)

DRVS INTERFACE (E)

RELIABILITY (MTBF, θ)
1,000 HRS. (E)

DOPPLER COST

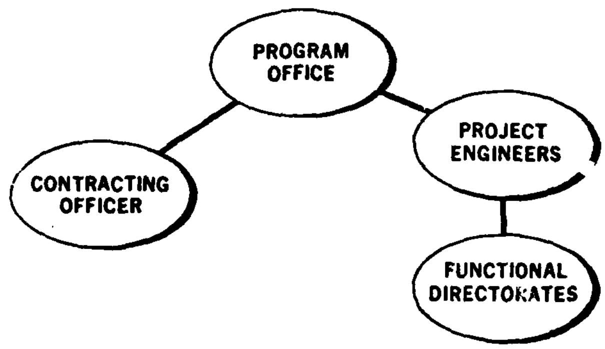
BOGEYS
- LDNS – $25,100
- DRVS – $ 9,500

CONSTANT FY-74 DOLLARS

PRODUCTION QUANTITY – 1,000

LRIP QUANTITY – 200 (LDNS)

INTERNAL ORGANIZATION



SOME CONTRACTOR PROCEDURES

- DESIGN TRADE-OFFS
- MANDATORY PRODUCTION SIGN-OFF
- CONTROL OF PARTS COSTS
- COST BOGEYS ON MODULES
- MINIMIZE MANUFACTURING COSTS

LDNS TRADE-OFF ANALYSIS

NAVIGATION COMPUTER TECHNOLOGY

TRADE-OFF FACTORS/PRIORITIES

1. HARDWARE STATUS (TECHNICAL RISK)
2. DEVELOPMENT AND PRODUCTION COST
3. OVERALL SIZE, WEIGHT AND POWER
4. RELIABILITY AND MAINTAINABILITY (LCC FACTORS)
5. COMPUTATIONAL CAPABILITY (SPEED, MEMORY, ETC.)

STUDIES CONDUCTED

- REVIEW SIX MACHINES (THREE TYPES):
  - OFF-THE-SHELF LSI CPU
  - CUSTOM LSI CPU
  - DISCRETE IC TECHNOLOGY

RESULTS

- THE OFF-THE-SHELF LSI CPU WAS SELECTED AS OPTIMUM

PRODUCIBILITY TRADE-OFFS

- CASTING VERSUS DIPPED BRAZED ASSEMBLY FOR CDU MAIN FRAME

COST ESTIMATES IN QUANTITY OF 1,000

CASTING	45
MACHINING	68
TOTAL	$113

DIPPED BRAZED HOUSING $220

SELECTED CASTING FOR LOWER PRODUCTION COST

- CDU INTERCONNECTION TRADE-OFFS

MULTI-LAYER MOTHER BOARD	$55
SOLDER INTERCONNECT WIRES	70
TOTAL	$125
WIRE WRAP PROCESS	$36

- SELECTED WIREWRAP APPROACH FOR LOWER COST

DATA STORAGE DURING POWER OFF

- PROBLEM
  - CMOS LSI RAM CHIPS LOSE CONTENTS AFTER POWER TURNED OFF
  - OPERATOR MUST RE-INITIALIZE PRESENT POSITION AND DESTINATIONS UPON POWER TURN-ON
- ALTERNATIVES:

  SERIAL CORE MEMORY-PRODUCTION COST > $2,000

  MNOS RAM (NITRIDE)

  LOW DENSITY/HIGH COST
  SLOW WRITE TIME
  STILL UNDER DEVELOPMENT

  SELF CONTAINED BATTERY POWERS RAM WHEN PRIME POWER TURNED OFF

  SMALL COST INCREASE < $20
  LOW POWER DRAIN < 0.2 milliamps
  PERIODIC MAINTENANCE REQUIRED

  RE-INITIALIZE ALL DATA EVERY POWER OFF

- APPROACH SELECTED

TRADE-OFF - MANUAL vs AUTOMATIC SPHEROID BOUNDARY DETECTION

- MANUAL DETECTION

  OPERATOR DETERMINES WHEN AIRCRAFT TRANSITIONS BOUNDARY AND CHANGES PRESENT POSITION SPHEROID DESIGNATOR

- AUTOMATIC DETECTION

  COMPUTER DETERMINES TRANSITION AND AUTOMATICALLY CHANGES SPHEROID DESIGNATOR

  COMPUTATIONAL COMPLEXITY GREATER, REQUIRES ADDITIONAL MEMORY TO STORE BOUNDARY DATA WITH RESULTANT COST INCREASE OF > $150

- APPROACH SELECTED - MANUAL DETECTION

  LOWER PRODUCTION COST

  BOUNDARY CROSSINGS OCCUR VERY RARELY IN ARMY TACTICAL ENVIRONMENT

  "OVERLAP" OF SPHEROIDS PROVIDED ON ALL UTM MAPS NEAR BOUNDARIES

PRODUCTION PROPOSAL EVALUATION CRITERIA

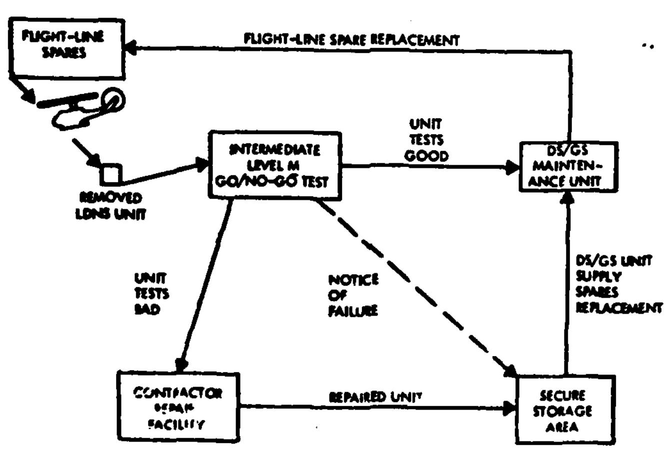
"MUST MEET" CRITERIA:

- DTUPC BOGEYS
- ESSENTIAL TECHNICAL REQUIREMENTS

OTHERS:

- COST
  - A. LRIP PRICE
  - B. COST OF OWNERSHIP
- TECHNICAL PERFORMANCE

WARRANTY PIPELINE UNDER SECURE STORAGE AREA CONCEPT



GOVERNMENT RISK CONSIDERATIONS

- BACK-UP NUCLEUS SUPPORT BASE
- INCREASE SPARES
- RESTRICT DEPLOYMENT SITES
- MANAGEMENT BY PROGRAM OFFICE
- ADDITIONAL DATA COLLECTING SYSTEM

STRONG POINTS

- ORIENTATION ON "COST"
- HELPS PREVENT GOVERNMENT DESIGNING
- ENHANCES PROGRAM SURVIVABILITY
- SHARPENS INTERNAL MANAGEMENT TEAM

LESSONS LEARNED

- STRONG, COHESIVE INTEGRATED MANAGEMENT TEAM
- PERFORMANCE SPECIFICATIONS
- CONFIGURATION CHANGE CONTROL
- WELL-DEFINED BOGEYS
- OPERATIONAL EDUCATION FOR CONTRACTORS
- ELIMINATE "TOO DIFFICULT" SPECS
- AWARD FEES

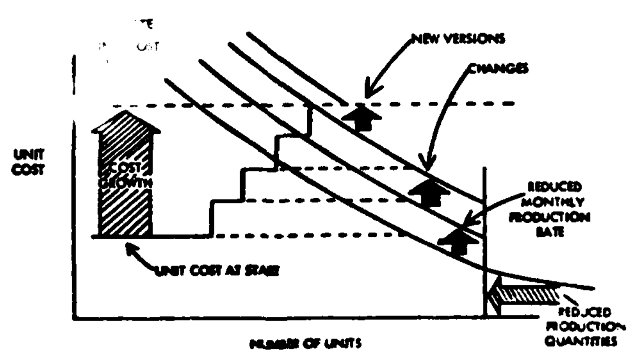
AWARD FEE CONSIDERATIONS
(LESSONS LEARNED)

- THE "REAL INCENTIVE"
- AMOUNT OF POSSIBLE FEE
- AWARD FEE EVALUATION BOARD
- NUMBER OF RATING PERIODS

LESSONS LEARNED
(CONTINUED)

- REDUCTION OF DATA ITEMS
- INFORMATION LEAKS
- UNDEFINED REQUIREMENTS
- EXPLAINING THE BOGEYS
- COMPONENT SELECTION

EFFECTS OF CHANGES ON UNIT COST



MATERIAL INSPECTION AND RECEIVING REPORT

1. PROC. INSTRUMENT IDEN (CONTRACT)	ORDER NO.	6. INVOICE	7. PAGE OF
DAAB07-77-C-2126		NO. 30-217 DATE	1 OF 2
			8. ACCEPTANCE POINT: S

2. SHIPMENT NO.	3. DATE SHIPPED	4. B/L	5. DISCOUNT TERMS
SMK0562	83MAR17B	TCN #031 144 956 to (H)RBG#031 144 964	

9. PRIME CONTRACTOR — CODE 88818

THE SINGER COMPANY
KEARFOTT DIVISION
1150 MCBRIDE AVENUE
LITTLE FALLS, N.J. 07424

10. ADMINISTERED BY — CODE S3109A

DCASPRO, SINGER
1225 MCBRIDE AVENUE
LITTLE FALLS, N.J. 07424

11. SHIPPED FROM (If other than 9) — CODE 2A508 — FOB: S

THE SINGER COMPANY
KEARFOTT DIVISION
1370 SAN MARCOS BLVD.
SAN MARCOS, CA. 92069

12. PAYMENT WILL BE MADE BY — CODE S3303A

DISBURSING OFFICER
DCASR NEW YORK
60 HUDSON STREET
NEW YORK, N.Y. 10013

13. SHIPPED TO — CODE FB2065

WARNER ROBINS ALC
ROBINS AFB, GA 31098

14. MARKED FOR — CODE FB2065

FB STOCK
DAAB07-77-C-2126

15. ITEM NO.	16. STOCK/PART NO. DESCRIPTION (Indicate number of shipping containers - type of container - container number.)	17. QUANTITY SHIP/REC'D *	18. UNIT	19. UNIT PRICE	20. AMOUNT
0001 AV	NAVIGATION SET, DOPPLER AN/ASN-128 5841-01-064-9738 CONSISTING OF 1EA 5841-01-063-1919 [redacted] RT-1193/ASN-128 RECEIVER TRANSMITTER ANTENNA, RADAR 5841-01-063-1918 [redacted] CP-1252/ASN-128 COMPUTER DISPLAY UNIT OVER 9 BOXES 1-9 WT. 132#	3	EA	$35,900.00	$107,700.00

RECEIVED
MAR 24 1983
R. J. IMFELD

21. PROCUREMENT QUALITY ASSURANCE

A. ORIGIN

[X] PQA [X] ACCEPTANCE of listed items has been made by me or under my supervision and they conform to contract, except as noted herein or on supporting documents.

83MAR17 — DATE

SIGNATURE OF AUTH GOVT REP

TYPED NAME AND OFFICE: PHYLLIS SHORT S0514A

B. DESTINATION

[ ] PQA [ ] ACCEPTANCE of listed items has been made by me or under my supervision and they conform to contract, except as noted herein or on supporting documents.

DATE — SIGNATURE OF AUTH GOVT REP

TYPED NAME AND TITLE

22. RECEIVER'S USE

Quantities shown in column 17 were received in apparent good condition except as noted.

DATE RECEIVED — SIGNATURE OF AUTH GOVT REP

TYPED NAME AND OFFICE

* If quantity received by the Government is the same as quantity shipped, indicate by (✓) mark, if different, enter actual quantity received below quantity shipped and encircle.

23. CONTRACTOR USE ONLY

(P) JC (S) HOAS

S/O 705N-670040/ITEM 0001 AV, 0060AA
S/O 7053-770002/ITEM 0029 AX

SHIPPING CHARGE....$135.58

NO. 82-034 DATED 28 JAN. 1983
REF. DEPARTMENT OF THE ARMY KO LETTER
CECOM, FT. MONMOUTH, NJ 07703

KEARFOTT SAN MARCOS

DD FORM 250 1 NOV 68 REPLACES EDITION OF 1 AUG 67 WHICH MAY BE USED

MATERIAL INSPECTION AND RECEIVING REPORT
CONTINUATION SHEET

SHIPMENT NO.	DATE SHIPPED	PROC. INSTRUMENT IDEN.	ORDER NO.	INVOICE NO.	PAGE	OF
SMK0562	83MAR17E	DAAB07-77-C-2126		30-217	2	2

ITEM NO.		STOCK/PART NO. DESCRIPTION (Indicate number of shipping containers - type of container - container number.)	QUANTITY SHIP'D/REC'D	UNIT	UNIT PRICE	AMOUNT
		5841-01-064-1841 ~~S/N SEE BELOW~~ CV-3338/ASN-128 CONVERTER, SIGNAL DATA, RADAR				
0029	AX	RELIABILITY IMPROVEMENT WARRANTY	3	EA	$1,700.00	$5,100.00
0060	AA	INCORPORATE THE REQUIREMENTS OF ECP008 INTO 211 RECEIVER TRANSMITTER ANTENNA AN/ASN-128	3	EA	30.00	90.00
		*1171B, 1172B, 1173B				

ORIGINAL INVOICE

F4273 8/77 (CONTINUATION SHEET)

1 ORIGINAL INVOICE

AWARD	QTY.	HARDWARE	RIW.
1976	200	$ 23,495.	$ 1,076.
1979	381	18,252.	674.
1981	219	18,252.	730.
1981	222	38,050.	2,077.
1981	102	37,850.	1,700.
1982	211	35,900.	1,700.
1982	327	35,900.	1,700.
1983	4	35,900.	1,700.
1983	3	35,900.	1,700.

ECP LOG

ECP NO.	CLASS	LETTER NO.	LETTER DATE	DESCRIPTION	APPROVAL METHOD	APPROVAL DATE
001	2	79267	7-25-79	NOR'S	LETTER	9-20-79
002	1	78-153	11-14-79	ILDI/S		
003	2	80084	7-23-80	NOR'S	P00029	9-10-80
004P	—	79259L	7-11-79	VECP	(ARMY LETTER 1/8/80 = RESUBMT	
005	—	CANCELLED				
006P	—	79289	10- 3-79	VECP	(ARMY LETTER 1/8/80 = RESUBMIT	
007P	1	79299	10-31-79	RTA SEALING	P00023	1-15-80
007R1	1	80040	4-22-80	RTA SEALING-REV.	LETTER	7-25-80
010	1	80068	6-20-80	CDU/SDC GAGES	P00029	9-10-80
010R1	1	80087	7-24-80	CDU/SDC GAGES	P00029	9-10-80
009	2	80093	8- 5-80	NOR'S	P00029	9-10-80
011	2	80095	8- 7-80	NOR'S	P00029	9-10-80
012	2	80096	8- 7-80	NOR'S	P00031	9-16-80
013	2	80108	8-14-80	NOR'S	P00031	9-16-80
014	2	80107	8-14-80	NOR'S	P00031	9-16-80
009C1	2	80113	8-20-80	NOR'S	P00029	9-10-80
010R2	1	80127	9- 9-80	CDU/SDC GAGES	P00034	10-27-80
015	2	80115	8-20-80	NOR'S	P00031	9-16-80
016	2	80112	8-20-80	NOR'S	P00031	9-16-80
017	2	80114	8-20-80	NOR'S	P00031	9-16-80
019	2	80118	8-25-80	NOR'S	P00031	9-16-80
018	2	80120	8-27-80	NOR'S	P00031	9-16-80
020	2	80124	9- 8-80	NOR'S	P00034	10-27-80
021	2	80125	9- 8-80	NOR'S	P00034	10-27-80
022	2	80139	9-25-80	NOR'S	P00037 LETTER	12- 5-80
023	1	80145	10-14-80	ADD CORNER LEAK PROTECT RTA	P00037 LETTER	1-14-81
008	1	80148	10-16-80	ALIGNMENT PIN ON RTA	P00056	7-28-81
024	1	80146	10-13-80	UPDATE INTERFACE CONTROL DWG.	P00037 LETTER	1-14-81
026	2	80149	10-17-80	NOR'S	P00037 LETTER	12- 5-80
029	2	80153	10-29-80	NOR'S	P00037 LETTER	1-14-81
025	1	80158	10-31-80	VECP ETI SUBSTITUTION	P00040 LETTER R	3- 6-81
027P	1	80159	10-31-80	VECP RADOME GRID MOD	WITHDRAWN	1-11-83
030	2	80164	11- 3-80	NOR'S	P00037 LETTER	1- 6-81
031	2	80165	11- 3-80	NOR'S	P00037 LETTER	1- 6-81
032	2	80163	11- 4-80	NOR'S	P00037 LETTER	1-14-81
028	2	80168	11- 5-80	NOR'S	P00040 LETTER	3- 5-81
033	2	80176	11-11-80	NOR'S	P00037 LETTER	1- 6-81
034	2	80177	11-11-80	NOR'S	P00061	9- 1-81
036	2	80194	11-24-80	NOR'S	P00037 LETTER	1- 6-81
017C1	2	80198	12- 1-80	NOR'S	P00037 LETTER	1-14-81

	ECP NO.	CLASS	LETTER NO.	LETTER DATE	DESCRIPTION	APPROVAL METHOD	APPROVAL DATE
1	035	2	80205	12-9-80	NOR'S	P00037 LETTER	1-14-81
2	037	1	80204	12-9-80	2ND SOURCE-ANTENNA REFLECTOR	P00040 R	7-28-81
3	038	1	80203	12-9-80	100% RTA AIR LEAK TEST	P00037 LETTER	3-6-81
4	039	2	80202	12-9-80	NOR'S	P00037 LETTER	1-14-81
5	040	2	80213	12-16-80	NOR'S	P00040	
6	041	2	81001	1-5-81	NOR'S	P00040	
7	042	2	80002	1-5-81	NOR'S	P00040	
8	043	2	81004	1-5-81	NOR'S	P00040	
9	044	2	81003	1-5-81	CDU/SDC GAGES	P00040 LETTER	3-5-81
10	045	2	81033	2-12-81	NOR'S	P00050 LETTER	4-30-81
11	046	2	81034	2-12-81	NOR'S	P00050 LETTER	4-30-81
12	047	2	81037	2-17-81	NOR'S	SEE 047R1	
13	040R1	2	81039	2-23-81	NOR'S	P00040	
14	050	2	81044	2-25-81	NOR'S	P00050 LETTER	4-30-81
15	048	2	81040	2-23-81	NOR'S	P00050 LETTER	4-30-81
16	049	2	81041	2-23-81	NOR'S	P00050 LETTER	4-30-81
17	052	1	81061	3-16-81	ELAPSED TIME INDICATOR DELETE	LETTER R	5-18-81
18	051	2	81068	3-24-81	NOR'S	P00050	5-29-81
19	053	2	81067	3-24-81	NOR'S	P00050	5-29-81
20	049R1	2	81075	4-3-81	NOR'S	P00050	5-29-81
21	054	2	81080	4-9-81	NOR'S	P00050	5-29-81
22	055	2	81090	4-13-81	NOR'S	P00050	5-29-81
23	056	2	81091	4-13-81	NOR'S	P00050	5-29-81
24	057	2	81092	4-13-81	NOR'S	P00050	5-29-81
25	058	2	81098	4-22-81	NOR'S	P00050	5-29-81
26	059	2	81124	6-3-81	NOR'S (ILDUS)	P00065	10-28-81
27	060	2	81123	6-3-81	NOR'S	P00061	9-1-81
28	047R1	2	81126	6-8-81	NOR'S	P00061	9-1-81
29	062	2	81127	6-10-81	NOR'S	P00061	9-1-81
30	063	2	81134	6-16-81	NOR'S	P00061	9-1-81
31	064	2	81133	6-16-81	NOR'S	P00061	9-1-81
32	061	1	81138	6-24-81	VECP DIMMER CONTROL	WITHDRAWN	1-11-83
33	065	2	81141	6-25-81	NOR'S	P00061	9-1-81
34	066	2	81156	7-20-81	NOR'S	P00061	9-1-81
35	067	2	81157	7-20-81	NOR'S	P00061	9-1-81
36	068	2	81158	7-20-81	NOR'S	P00061	9-1-81
37	069	2	81159	7-30-81	NOR'S	P00061	9-1-81
38	070	2	81160	8-3-81	NOR'S	P00061	9-1-81
39	071	2	81169	8-17-81	NOR'S	P00065	10-28-81
40	072	2	81170	8-17-81	NOR'S	P00065	10-28-81

ECP NO.	CLASS	LETTER NO.	LETTER DATE	DESCRIPTION	APPROVAL METHOD	APPROVAL DATE
073	2	81172	8-17-81	NOR'S	P00065	10-28-81
074	2	81182L	9-17-81	NOR'S	P00065	10-28-81
075	2	81200L	10-27-81	NOR'S	P00068	12-24-81
076	2	81201L	10-27-81	NOR'S	P00068	12-24-81
077	2	81203L	11-3-81	NOR'S	P00068	12-24-81
078	2	81211L	11-23-81	NOR'S	P00068	12-24-81
079	2	81221L	12-17-81	NOR'S	P00069	3-23-82
080	2	81222L	1-6-82	NOR'S	P00069	3-23-82
081	2	81223L	1-6-82	NOR'S	P00069	3-23-82
082	2	82111L	2-2-82	NOR'S	P00069	3-23-82
083	2	82121L	2-19-82	NOR'S	P00073	5-12-82
084	2	82125L	2-25-82	NORS	P00073	5-12-82
085	2	82161L	4-14-82	NORS	P00073	5-12-82
086	2	82161L	4-14-82	NORS	P00073	5-12-82
087	2	82161L	4-14-82	NORS	P00073	5-12-82
088	2	82172L	5-5-82	NORS	P00074	6-25-82
089	2	82177L	5-21-82	BEZEL MTG. CASTING	P00074	6-25-82
090	2	82179L	5-24-82	NORS	P00074	6-25-82
091	2	82207L	7-14-82	NORS	P00082	10-15-82
092	2	82207L	7-14-82	NORS	P00082	10-15-82
093	2	82207L	7-14-82	NORS	P00082	10-15-82
001	1	FP125L	6-7-82	ILDNS SOFTWARE REV.	NOT APPROVED-SEE P00016	
094	2	82212L	8-18-82	NORS	P00082	10-15-82
095	2	82214L	8-26-82	NORS	P00082	10-15-82
096	2	82214L	8-26-82	NORS	P00082	10-15-82
097	2	82223L	9-22-82	NORS	P00083	11-15-82
098	2	82226L	10-5-82	NORS	P00083	11-15-82
099	2	82229L	10-11-82	NORS	P00083	11-15-82
100	2	82229L	10-11-82	NORS	P00083	11-15-82
101	2	82229L	10-11-82	NORS	P00083	11-15-82
102	2	82239L	10-26-82	NORS	P00083	11-15-82
103	2	82239L	10-26-82	NORS	P00083	11-15-82
104	2	82247L	11-19-82	NORS	P00088	1-21-83
105	2	82253L	12-16-82	NORS	P00098	3-17-83
106	2	83009L	1-20-83	NORS	P00098	3-17-83
107	2	83018L	2-4-83	NORS	P00098	3-17-83
108	2	83032L	3-9-83	NORS		
109	2	83033L	3-15-83	NORS		
110	2	83039L	3-23-83	NORS		

DOCUMENT NO. Y257A269 REV -

ENGINEERING TECHNICAL REPORT

MAINTAINABILITY DEMONSTRATION

TEST REPORT

FOR

LIGHTWEIGHT DOPPLER

NAVIGATION SYSTEM

CONTRACT NUMBER DAAB07-74-C-0487

CDRL (DD FORM 1423) NO. F002

prepared for:

ELECTRONICS SYSTEMS PROCUREMENT

BRANCH

PROCUREMENT & PRODUCTION DIRECTORATE

U.S. ARMY ELECTRONICS COMMAND

FORTH MONMOUTH, N. J. 07703

SINGER

AEROSPACE & MARINE SYSTEMS

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MAINTAINABILITY DEMONSTRATION TEST REPORT

FOR THE

LIGHTWEIGHT DOPPLER NAVIGATION SYSTEM

(LDNS)

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1. INTRODUCTION

This report describes the Maintainability Demonstration Test performed on the Lightweight Doppler Navigation Set (LDNS). The report discusses the data collected, analysis of the data, and results of the demonstration.

2. PURPOSE OF TEST

The purpose of the test was two-fold:

1. To demonstrate the ability of the LDNS to conform to the maintainability requirements of ECOM specification EL-SS-1050-001A, and if required, to determine the corrective action necessary to conform to the specification.
2. To validate and if necessary, to update the Department of the Army Technical Manuals for the a) Organizational Maintenance and b) Direct and General Support Maintenance of the LDNS.

3. DESCRIPTION OF TEST ITEMS

The test items consisted of a Receiver-Transmitter-Antenna (RTA), a Signal Data Receiver (SDC), and a Computer Display Unit (CDU). Following is a tabulation of the LRU's, with their associated modules, which were used in the tests.

NAME	PART NO.
Receiver-Transmitter-Antenna	SM-D-858489
Gunn Oscillator	SM-A-858395
Receiver-Transmitter	SM-A-858394
Electronic Module	SM-D-858406
Antenna	SM-D-858521
Signal Data Converter	SM-D-858425
LEF	SM-D-858403
Frequency Tracker	SM-D-858400
Timer/Interface	SM-D-858444
A/D Converter	SM-D-858445
Power Supply	SM-D-858446
Computer Display Unit	SM-D-858423
CPU	SM-D-858352
RAM/ROM	SM-D-858357
I/O	SM-D-858355
Numeric Logic	SM-D-858353
Display Logic	SM-D-858354
Post Regulator	SM-D-858359

4. DOCUMENTATION

4.1 Government Documents

DEP TM 11-5841-281-20 Organizational Maintenance Manual for Doppler Navigation Set AN/ASN-128.

4.1 Government Documents (continued)

DEP TM 11-5841-281-34	Direct and General Support Maintenance Manual for Doppler Navigation Set AN/ASN-128.
MIL-STD-471A	Maintainability Verification/Demonstration/Evaluation.

4.2 Electronics Command

EL-SS-1050-001A	Development Specification, Lightweight Doppler Navigation System 2 June 1973.

4.3 Kearfott Division

Y228A337	Maintainability Demonstration Test Plan, Lightweight Doppler Navigation System (LDNS).

5. ABSTRACT

The Maintainability Demonstration Test was performed during the period 3/17/76 through 3/19/76 at the Singer Company, Kearfott Division Engineering facilities located in Plant 12, Wayne, New Jersey.

The maintenance times were demonstrated to be well below the requirements of EL-SS-1050-001A, and the maintenance manuals were validated. The tests also demonstrated the validity of

5. ABSTRACT (continued)

the maintenance concept proposed for the LDNS; i.e. BITE to isolate failures to the LRU level for Organizational Maintenance, and BITE together with standard test equipment to isolate failures to the module level for Direct Support Maintenance.

6. DESCRIPTION OF TESTS

6.1 General

The Maintainability Demonstration test was performed during the period 3/17/76 through 3/19/76 at the Singer Company, Kearfott Division Engineering facilities located in Plant 12, Wayne, New Jersey.

The tests were performed by Radar Engineering Department personnel and were witnessed by N. Romanofsky and S. Reed of ECOM.

6.2 Test System Configuration

Two system configurations were used in the performance of the tests. For the organizational level tests, all three of the LRU's were connected in their normal aircraft operational configuration. The aircraft inputs to the system were provided by an aircraft simulator which supplied a) the Pitch, Roll, Heading and TAS synchro input; b) 28 VDC primary power; c) 26 V 400 HZ synchro reference, and d) 5V 400 HZ for the

6.2 Test System Configuration (continued)

CDU panel lighting.

For the Direct Support level tests, only the SDC and CDU were used. The cable connection from the SDC to the RTA was replaced with a dummy connector which is required for test purposes when the RTA is not used. External inputs to the system consisted of 28 VDC primary power, 26V 400 Hz synchro reference and 5V 400 Hz for the CDU panel lighting. No synchro inputs were used for these tests.

6.3 Test Procedure

The following procedure was followed in the conduction of the tests:

a) A failure was selected by the ECOM observers from Table 1 - Recommended List of Induced Failures. This table is part of Y228A337, Maintainability Demonstration Test Plan, Lightweight Doppler Navigation System (LDNS), and has been included in this report for convenient reference.

b) A Kearfott Engineering technician incorporated the failure into the equipment.

c) When the equipment modification was complete, another technician started the fault isolation

6.3 Test Procedure

c) continued)

procedure using the Department of the Army Maintenance Manuals as a guide.

d) A Stopwatch was started as soon as the fault isolation period began and was stopped after 1) the fault had been isolated and 2) a repair had been effected by replacement of either the failed LRU or the failed module (depending on whether Organizational or Direct Support Levels of maintenance was being demonstrated) and 3) the repair had been verified by the performance of a system test.

e) The failed hardware was restored to its original condition and the process was repeated with another failure selected at random from Table 1.

To minimize the duration of the tests, operations which were common to all failures were timed separately and these operations were not repeated in the process of troubleshooting and repair. At the Organizational Level, these common operations consist of a) unbolting the LRU from the aircraft frame and disconnecting the cables from the LRU and b) connecting the cables to the replacement LRU and bolting the LRU to the aircraft frame. After these operations had been timed several

6.3 Test Procedure (continued)

times to obtain an average, the LRU's were held in place on the bench with a minimum of fasteners and the operation was no longer timed.

A similar procedure was followed for the Direct Support Level Tests. In this case the common operations were the removal of the covers from the SDC and CDU, the removal of the cards from the CDU, the removal of the lamps from the CDU, the removal of assembled modules from the SDC, disassembly of the cards from the SDC module frames, removal of the power supply from the SDC, and replacement of all the above items.

6.4 Data

The data accumulated in these tests is tabulated in Tables 2, 3 and 4. Table 2 lists the assembly and disassembly times for the common operations described above. The operations were timed in three tests and averaged as indicated in Table 2. These average times were then used in all the fault isolation tests.

Table 3 is a listing of all the tests performed for the Organizational Level Tests. The first column identifies the sequence in which the tests were made. The second column indicates the LRU and Fault Number as listed in Table 1. The next four columns in Table 3 are a breakdown of the maintenance task times in minutes. "Localization" is the time required to identify the failed LRU;

6.4 Data (continued)

"Disassembly" and "Re-assembly" are the appropriate times obtained from Table 2; "Checkout" is the time required to verify the repair, which consisted of the replacement of the failed LRU with a satisfactory unit. The last column is the total maintenance task time.

A total of 54 failures were induced in the system and the distribution of the failures among the LRU's was in proportion to the LRU failure rates.

Table 4 is a listing of all the tests performed for the Direct Support Level Tests. The listing is similar to that used in Table 3. "Localization" in Table 4 required removal of the subject LRU from the hot mock-up, replacing the removed LRU with the failed LRU, and identifying the failure module in the LRU.

6.5 Data Analysis

The following discusses the analysis of the data tabulated in Tables 3 and 4 to demonstrate compliance with EL-SS-1050-001A. For reference, the maintenance time requirements and acceptance criteria are repeated here from Y228A337.

6.5.1 Maintenance Times

Maintenance Level	M_{ct}	$M_{ct\ max}$
Organizational	M_{ct1} = 15 min.	$M_{ct1\ max}$ = 45 min.
Direct Support	M_{ct2} = 30 min.	$M_{ct2\ max}$ = 90 min.

6.5.2 MIL-STD-471A Parameters

The maintenance time requirements M_{ct1} and M_{ct2} shall be demonstrated in accordance with Test Method 1-B of MIL-STD-471A. The parameters for use in Test Method 1-B are defined as follows:

Organizational Level

1. Specified value for $M_{ct1} = \mu_o$ = 15 min.
2. Maximum tolerable value for $M_{ct1} = \mu_1$ = 30 min.
3. Producer's Risk = α = 0.10
4. Consumer's Risk = β = 0.10

Direct Support Level

1. Specified value for $M_{ct2} = \mu_o$ = 30 min.
2. Maximum tolerable value for $M_{ct2} = \mu_1$ = 60 min.
3. Producer's Risk = α = 0.10
4. Consumer's Risk = β = 0.10

The maintenance time requirements $M_{ct1\ max}$ and $M_{ct2\ max}$ shall be demonstrated in accordance with Test Method 3 of MIL-STD-471A. The specified maximum time for corrective maintenance $M_{ct\ max}$ shall be taken to represent the 90th percentile point of the corrective

6.5.2 MIL-STD-471A Parameters (continued)

maintenance time distribution. The parameters for use in Test Method 3 are defined as follows:

Organizational Level

1. Specified value for $M_{ct1\ max}$ = T = 45 min.
2. 90th Percentile = p_o = 0.10
3. 75th Percentile = p_1 = 0.25
4. Producer's Risk = α = 0.10
5. Consumer's Risk = β = 0.10

Direct Support Level

1. Specified value for $M_{ct2\ max}$ = T = 90 min.
2. 90th Percentile = p_o = 0.10
3. 75th Percentile = p_1 = 0.25
4. Producer's Risk = α = 0.10
5. Consumer's Risk = β = 0.10

6.5.3 Acceptance Criteria

6.5.3.1 M_{ct} Maintenance Times

The acceptance criteria using Method 1-B of MIL-STD-471A with the above parameters is as follows:

Accept if $\bar{X} \leq \mu_o + Z_\alpha \frac{\hat{d}}{\sqrt{n}}$

where

$\bar{X}$ = arithmetic mean of the sample times

6.5.3.1 M_{ct} Maintenance Times (continued)

n = the number of samples = 54

$\hat{d}$ = standard deviation of the sample times

$$= \sqrt{\frac{\sum x^2 - \frac{(\sum x)^2}{n}}{n-1}}$$

Z_α = 1.28 (from p 30 of MIL-STD-471A)

μ_o = 15 min for Organizational Level

= 30 min for Direct Support Level

6.5.3.2 $M_{ct\ max}$ Maintenance Times

The acceptance criteria using Test Method 3 of MIL-STD-471A with the parameters listed in 6.5.2 is as follows:

Accept if the Number of Sample Times exceeding T $\leq$ C

where

C = 8 (from Table B-1 of MIL-STD-471A)

T = 45 min for Organizational Level

= 90 min for Direct Support Level

6.5.3.3 Computations for Acceptance Criteria

The means, standard deviations, and number of times the maintenance times exceeded $M_{ct\ max}$ were computed from the data in Tables 2 and 3. The results of these computations and their use in the acceptance criteria are tabulated in Table 5. Examination of Table 5 shows that the demonstrated values of M_{ct} and $M_{ct\ max}$ both for the Organizational and Intermediate levels of maintenance meet the acceptance criteria of MIL-STD-471A. The demonstrated values are in fact substantially below the required values.

7. SUMMARY AND CONCLUSIONS

The Maintainability Demonstration Test has shown conclusively that the LDNS meets the maintenance time requirements defined in EL-SS-1050-001A for M_{ct} and $M_{ct\ max}$ both for the Organizational and Intermediate Levels of maintenance, and no deficiencies were found. The Department of the Army Technical Manuals for Organizational and Direct and General Support Maintenance were used to isolate the failures induced in the equipment. Except for some minor clarifications and corrections, the manuals provided the required guidance to isolate the problems in a rapid and straight forward manner. The manuals have now been updated in accordance with the required changes.

7. SUMMARY AND CONCLUSIONS (continued)

The tests have also verified the Singer maintainability concept for the LDNS. It has been demonstrated that the BITE satisfactorily identifies the failed LRU at the Organizational Level. It has also been shown that at the Direct Support Level isolation of failures to the card level is effectively accomplished by the BITE, standard test equipment (voltmeter and oscilloscope), and the procedures defined in the technical manuals.

TABLE j - RECOMMENDED LIST OF INDUCED FAILURES

LRU	TEST NO.	DESCRIPTION	APPLICABLE TO: ORG. LEVEL	INT. LEVEL
SDC	1	Short U 6 Pin 2 to 5V return on Timer/Int. Card	X	X
SDC	2	Short U6 Pin 3 to 5V return on Timer/Int Card.	X	X
SDC	3	Short AR1 Pin 7 to 15V return on A/D conv. card.	X	X
SDC	4	Connect look resistor between AR2 Pin 2 and +15 VDC on A/D conv. card.	X	X
SDC	5	Open one end of R2 on LEF card.	X	X
SDC	6	Short junction of R21 and R55 to gnd. on LEF card	X	X
SDC	7	Short U7 Pin 2 or 6 to ground on LEF card.	X	X
SDC	8	Short junction of R48 and R13 to ground on Freq. Tracker Card.	X	X
SDC	9	Open one end of R100 on Freq. Tracker Card.	X	X
SDC	10	Open one end of R36 on Freq. Tracker Card.	X	X
SDC	11	Short TP1 to ground on Freq. Tracker Card.	X	X
SDC	12	Short pin 10 to pin 13 on Power Supply Module.	X	X
SDC	13	Short pin 8 to pin 10 on Power Supply Module.	X	X

TABLE 1 -(CONTINUED)

LRU	TEST NO.	DESCRIPTION	APPLICABLE TO: ORG. LEVEL	APPLICABLE TO: INT. LEVEL
SDC	14	Short pin 7 to pin 2 on Power Supply Module	X	X
SDC	15	Open Collector of Q8 on Power Supply Module	X	X
SDC	16	Open fuse F-1 on Power Supply Module	X	X
SDC	17	Open case lead of AR2 on Power Supply Module.		X
SDC	18	Lift pin 1 of T2 on Power Supply Module		X
SDC	19	Open case lead of AR3 on Power Supply Module		X
SDC	20	Disconnect Wire(s) from Filter FL1 pin 3 on chassis.		X
RTA	1	Disconnect P2 from Solid State source	X	
RTA	2	List Pins 3 & 4 of P1 on Elecyronics Module	X	
RTA	3	Open Pines 9 & 10 of Electronics Module	X	
RTA	4	Connect TP1 to ground on Electronics Module	X	
RTA	5	Connect test diamond 4 to ground on Electronics Module	X	
RTA	6	Disconnect J2 on Electronics Module	X	
RTA	7	Connect test diamond 9 to ground on Electronics Module	X	
RTA	8	Short C16 on Electronics Module	X	
RTA	9	Open R21 on Electronics Module	X	

TABLE X - CONTINUED

LRU	TEST NO.	DESCRIPTION	APPLICABLE TO: ORG. LEVEL	APPLICABLE TO: INT. LEVEL
CDU	1	Lift pin 2 of J1 on Numeric Display card	X	X
CDU	2	Lift pin 4 of U8 on Display Logic Card	X	X
CDU	3	Lift pin 8 of U8 and connect to +5VDC on I/O card.	X	X
CDU	4	Lift pin 46 on P1 of I/O card	X	X
CDU	5	Lift crossover pin 1 (TP1) on Side 2 (UN29 side) and connect pad to ground on I/O card	X	X
CDU	6	Short C5 on Post Reg. Card	X	X
CDU	7	Short collector to emitter of Q4 on Post Reg. card	X	X
CDU	8	Short C9 on Post Reg. Card	X	X
CDU	9	Connect pin 13 of U8 to ground on CPU Card	X	X
CDU	10	Connect pin 8 of U13 to ground on CPU Card	X	X
CDU	11	Connect pin 8 of U12 to gnd. on CPU card	X	X
CDU	12	Connect pin 4 of U6 to gnd. on RAM/ROM Memory Card.	X	X
CDU	13	Connect pin 2 of U14 to gnd. on RAM/ROM Memory Card.	X	X
CDU	14	Connect pin 2 of U25 to gnd. on RAM/ROM Memory Card.	X	X

TABLE 1 -(CONTINUED)

LRU	TEST NO.	DESCRIPTION	APPLICABLE TO: ORG. LEVEL	APPLICABLE TO: INT. LEVEL
CDU	15	Disconnect both wires from terminal 4 of S10 and jumper then together to DC Gnd. on frame assembly	X	X
CDU	16	Disconnect wire on terminal 2 of S18B on frame assembly	X	X
CDU	17	Install defective "MAL" lamp on frame assembly	X	X
CDU	18	Install defective DS105 lamp on frame assembly	X	X
CDU	19	Install defective DS106 lamp on frame assembly	X	X
CDU	20	Install defective DS107 lamp on frame assembly.	X	X
CDU	21	Install a defective DS120 lamp on frame assembly.	X	X
CDU	22	Install a defective DS119 lamp on frame assembly	X	X
CDU	23	Install a defective DS108 lamp on frame assembly	X	X
CDU	24	Install a defective DS109 lamp on frame assembly	X	X
CDU	25	Install a defective DS115 lamp on frame assembly	X	X
CDU	26	Install a defective DS116 lamp on frame assembly	X	X
CDU	27	Install a defective DS110 lamp on frame assembly	X	X

TABLE 6 - (CONTINUED)

LRU	TEST NO.	DESCRIPTION	APPLICABLE TO: ORG. LEVEL	APPLICABLE TO: INT. LEVEL
CDU	28	Install a defective DS121 lamp on frame assembly	X	X
CDU	29	Install a defective DS111 lamp on frame assembly	X	X
CDU	30	Install a defective DS112 lamp on frame assembly		X
CDU	31	Install a defective DS118 lamp on frame assembly		X
CDU	32	Install a defective DS117 lamp on frame assembly		X
CDU	33	Install a defective DS113 lamp on frame assembly		X
CDU	34	Install a defective DS114 lamp on frame assembly		X

TABLE 2

SAMPLE TIMES FOR DISASSEMBLY AND REASSEMBLY

(times in minutes)

I. ORGANIZATIONAL LEVEL

	#1	#2	#3	AVG
A) Disassembly				
1) CDU	0.5	0.4	0.3	0.4
2) RTA	12	10	8	10
3) SDC	1.4	1.2	1.0	1.2
B) Reassembly				
1) CDU	0.7	0.5	0.3	0.5
2) RTA	12	10	8	10
3) SDC	2.6	2.4	2.2	2.4

II. INTERMEDIATE LEVEL

	#1	#2	#3	AVG
A) Disassembly				
1) SDC (Power Supply)	3.6	3.2	2.8	3.2
2) SDC (Cards)	4.4	4.2	4.0	4.2
3) CDU (Cards)	0.9	0.85	0.9	0.9
4) CDU (Lamps)	4.4	4.3	4.2	4.3
B) Reassembly				
1) SDC (Power Supply)	3.8	3.6	3.4	3.6
2) SDC (Cards)	6.2	5.9	5.6	5.9
3) CDU (Cards)	1.4	1.3	1.2	1.3
4) CDU (Lamps)	5.4	5.2	5.0	5.2

ORGANIZATIONAL

TABLE 3 - DEMONSTRATED TASK TIME DATA

Test No.	LRU/FAULT NUMBER	MAINTENANCE TASK TIME (MINS.)					TOTAL
		LOCALI-ZATION	DISAS-SEMBLY	REAS SEMBLY	CHECK-OUT		
1	CDU 26	0.3	0.4	0.5	0.5		1.7
2	CDU 13	0.3	0.4	0.5	0.45		1.65
3	SDC 1	0.4	1.2	2.4	8.5		12.5
4	CDU 15	1.0	0.4	0.5	0.4		2.3
5	SDC 12	0.2	1.2	2.4	8.5		12.3
6	CDU 17	0.4	0.4	0.5	0.35		1.65
7	SDC 3	0.4	1.2	2.4	8.4		12.4
8	CDU 19	0.25	0.4	0.5	0.3		1.45
9	SDC 14	0.2	1.2	2.4	8.4		12.2
10	CDU 21	0.3	0.4	0.5	0.4		1.6
11	SDC 5	0.4	1.2	2.4	8.4		12.4

ORGANIZATIONAL

TABLE 3 - DEMONSTRATED TASK TIME DATA

Test No.	LRU/FAULT NUMBER	MAINTENANCE TASK TIMES (MINS.) LOCALI-ZATION	DISAS-SEMBLY	REAS SEMBLY	CHECK-OUT		TOTAL
12	CDU 1	0.4	0.4	0.5	0.4		1.7
13	RTA 1	0.5	10	10	6.5		27
14	CDU 3	0.4	0.4	0.5	0.4		1.7
15	SDC 7	0.4	1.2	2.4	8.5		12.5
16	CDU 5	0.4	0.4	0.5	0.4		1.7
17	CDU 28	0.3	0.4	0.5	0.45		1.65
18	CDU 7	0.3	0.4	0.5	0.4		1.6
19	SDC 9	0.3	1.2	2.4	8.0		11.9
20	CDU 9	0.3	0.4	0.5	0.4		1.6
21	SDC 16	0.3	1.2	2.4	7.5		11.4
22	CDU 11	0.3	0.4	0.5	0.4		1.6

ORGANIZATIONAL
TABLE 3 - DEMONSTRATED TASK TIME DATA

Test No.	LRU/FAULT NUMBER	MAINTENANCE TASK TIMES (MINS.) LOCALI-ZATION	DISAS-SEMBLY	REAS SEMBLY	CHECK-OUT		TOTAL
23	RTA 3	0.4	10	10	7.2		27.6
24	CDU 23	0.4	0.4	0.5	0.4		1.7
25	SDC 11	0.4	1.2	2.4	7.0		11
26	CDU 25	0.4	0.4	0.5	0.5		1.8
27	RTA 2	0.4	10	10	6.3		26.7
28	CDU 27	0.3	0.4	0.5	0.5		1.7
29	SDC 13	0.2	1.2	2.4	7.2		11
30	CDU 29	0.3	0.4	0.5	0.4		1.6
31	RTA 5	0.4	10	10	7.3		27.7
32	SDC 15	0.2	1.2	2.4	7.6		11.4
33	CDU 14	0.3	0.4	0.5	0.4		1.6

ORGANIZATIONAL
TABLE 3 - DEMONSTRATED TASK TIME DATA

Test No.	LRU/FAULT NUMBER	MAINTENANCE TASK TIMES (MINS.)					TOTAL
		LOCALI-ZATION	DISAS-SEMBLY	REAS SEMBLY	CHECK-OUT		
34	CDU 2	0.4	0.4	0.5	0.4		1.7
35	RTA 4	0.4	10	10	6.8		27.2
36	CDU 6	0.5	0.4	0.5	0.4		1.8
37	SDC 2	0.4	1.2	2.4	6.6		10.6
38	CDU 4	0.4	0.4	0.5	0.4		1.7
39	RTA 7	0.4	10	10	7.2		27.6
40	CDU 10	0.4	0.4	0.5	0.5		1.8
41	SDC 4	0.4	1.2	2.4	7.0		11
42	CDU 8	0.4	0.4	0.5	0.4		1.7
43	RTA 6	0.4	10	10	6.3		26.7
44	CDU 12	0.3	0.4	0.5	0.5		1.7

ORGANIZATIONAL

TABLE 3 - DEMONSTRATED TASK TIME DATA

Test No.	LRU/FAULT NUMBER	MAINTENANCE TASK TIMES (MINS.) LOCALI-ZATION	DISAS-SEMBLY	REAS SEMBLY	CHECK-OUT		TOTAL
45	CDU 16	0.4	0.4	0.5	0.4		1.7
46	SDC 6	0.3	1.2	2.4	8.4		12.3
47	CDU 20	0.5	0.4	0.5	0.4		1.8
48	RTA 8	0.4	10	10	6.5		26.9
49	CDU 18	0.4	0.4	0.5	0.4		1.7
50	SDC 8	0.4	1.2	2.4	8.4		12.4
51	CDU 24	0.4	0.4	0 5	0.5		1.8
52	RTA 9	0.4	10	10	7 3		27.7
53	CDU 22	0.5	0.4	0.5	0.4		1.8
54	SDC 10	0.4	1.2	2.4	8.4		12.4

INTERMEDIATE

TABLE 4 - DEMONSTRATED TASK TIME DATA

Test No.	LRU/FAULT NUMBER-MODULE	MAINTENANCE TASK TIMES (MINS.)					TOTAL
		LOCALI-ZATION	DISAS-SEMBLY	REAS SEMBLY	CHECK-OUT		
1	CDU 26	0.1	4.3	5.2	8.0		17.6
2	CDU 13	2.3	0.9	1.3	7.6		12.1
3	SDC 1	0.4	4.2	5.9	0.5		11.0
4	CDU 15	1.0	4.2	6.0	8.1		19.3
5	SDC 12	0.2	3.2	3.6	0.4		7.4
6	CDU 17	0.2	4.3	5.2	8.1		17.8
7	SDC 3	0.4	4.2	5.9	0.5		10
8	CDU 19	0.1	4.3	5.2	7.5		17.1
9	SDC 14	0.2	3.2	3.6	0.4		7.4
10	CDU 21	0.2	4.3	5.2	6.8		16.5
11	SDC 5	0.8	4.2	5.9	0.4		11.3

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INTERMEDIATE

TABLE 4 - DEMONSTRATED TASK TIME DATA

Test No.	LRU/FAULT NUMBER-MODULE	MAINTENANCE TASK TIMES (MINS.)					TOTAL
		LOCALI-ZATION	DISAS-SEMBLY	REAS SEMBLY	CHECK-OUT		
12	CDU 1	0.1	7.7	10.5	6.3		24.6
13	CDU 3	0.5	0.9	1.3	8.4		11.1
14	SDC 7	0.7	4.2	5.9	0.4		11.2
15	CDU 5	0.4	0.9	1.3	6.8		9.4
16	CDU 28	0.1	4.3	5.2	7.1		16.7
17	CDU 7	3.5	0.9	1.3	7.3		13
18	SDC 9	0.8	4.2	5.9	0.4		11.3
19	CDU 9	3.8	0.9	1.3	7.8		13.8
20	SDC 16	0.2	3.2	3.6	0.5		7.5
21	CDU 11	3.8	0.9	1.3	6.5		12.5
22	CDU 23	0.1	4.3	5.2	7.0		16.6

INTERMEDIATE
TABLE 4 - DEMONSTRATED TASK TIME DATA

Test No.	LRU/FAULT NUMBER-MODULE	MAINTENANCE TASK TIMES (MINS.)					TOTAL
		LOCALI-ZATION	DISAS-SEMBLY	REAS SEMBLY	CHECK-OUT		
23	SDC 11	0.8	4.2	5.9	0.4		11.3
24	CDU 25	0.2	4.3	5.2	7.4		17.1
25	CDU 27	0.2	4.3	5.2	6.8		16.5
26	SDC 13	0.2	3.2	3.6	0.4		7.4
27	CDU 29	0.1	4.3	5.2	6.0		15.5
28	SDC 15	0.3	3.2	3.6	0.4		7.5
29	CDU 14	0.3	0.9	1.3	6.4		10.9
30	CDU 2	0.6	5.6	7.2	6.6		20
31	CDU 6	3.5	0.9	1.3	6.5		12.2
32	SDC 2	0.5	4.2	5.9	0.5		11.1
33	CDU 4	0.9	0.9	1.3	6.3		9.4

INTERMEDIATE

TABLE 4 - DEMONSTRATED TASK TIME DATA

Test No.	LRU/FAULT NUMBER-MODULE	MAINTENANCE TASK TIMES (MINS.)					TOTAL
		LOCALIZATION	DISASSEMBLY	REASSEMBLY	CHECK-OUT		
34	CDU 10	3.8	0.9	1.3	6.2		12.2
35	SDC 4	0.4	4.2	5.9	0.5		11.0
36	CDU 8	3.5	0.9	1.3	6.4		12.1
37	CDU 12	2.3	0.9	1.3	6.1		10.6
38	CDU 16	0.2	4.2	6.0	6.5		16.9
39	SDC 6	0.8	4.2	5.9	0.5		11.0
40	CDU 20	0.2	4.3	5.2	6.9		16.6
41	CDU 18	0.3	4.3	5.2	6.5		16.3
42	SDC 8	0.9	4.2	5.9	0.4		11.4
43	CDU 24	0.2	4.3	5.2	6.7		16.4
44	CDU 22	0.4	4.3	5.2	6.8		16.7

INTERMEDIATE
TABLE 4 - DEMONSTRATED TASK TIME DATA

Test No.	LRU/FAULT NUMBER-MODULE	MAINTENANCE TASK TIMES (MINS.)					TOTAL
		LOCALI-ZATION	DISAS-SEMBLY	REAS SEMBLY	CHECK-OUT		
45	SDC10	0.8	4.2	5.9	0.5		11.4
46	CDU 30	0.2	4.3	5.2	6.6		16.3
47	SDC 17	0.2	3.2	3.6	0.5		7.5
48	CDU31	0.2	4.3	5.2	6.8		16.5
49	SDC 18	0.2	3.2	3.6	0.4		7.4
50	CDU 32	0.3	4.3	5.2	6.2		16
51	SDC 19	0.2	3.2	3.6	0.4		7.4
52	CDU 33	0.2	4.3	5.2	6.3		16
53	SDC20	0.4	5.1	6.4	0.5		12.4
54	CDU 34	0.2	4.3	5.2	6.4		16.1

TABLE 5

MAINTAINABILITY COMPUTATIONS AND ACCEPTANCE CRITERIA

MAINTENANCE LEVEL	M_{ct}				M_{ct} max.	
	$\overline{X}$	d	$\mu_o + Z_\alpha \frac{\hat{d}}{\sqrt{n}}$ *	ACCEPT/ REJECT	NUMBER OF TIMES T EXCEEDED	ACCEPT/ REJECT
ORGANIZATIONAL	8.96	9.38	(μ_o = 15) 16.6	Accept	(T = 45) 0	Accept
DIRECT SUPPORT	13.2	3.9	(μ_o = 30) 30.7	Accept	(T = 90) 0	Accept

* For acceptance, $\overline{X} \leq \mu_o + Z_\alpha \frac{\hat{d}}{\sqrt{n}}$

DOCUMENT NO. Y258A416 REV A

LOGISTICS TECHNICAL REPORT

FINAL

COST OF OWNERSHIP

(LIFE CYCLE COST)

FOR

LIGHTWEIGHT DOPPLER NAVIGATION SYSTEM

PREPARED FOR:

U. S. ARMY ELECTRONICS COMMAND

CONTRACT: DAAB07-74-C-0487

CLIN0020

CDRL NO. G005

Prepared by: H. GREBE
Logistics Specialist

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SINGER
AEROSPACE & MARINE SYSTEMS

FOUO

DRR 01447 (NP) Total Number of Pages: 19

THE SINGER COMPANY
KEARFOTT DIVISION

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CODE IDENT NO. 88818

CONTROL A

REVISION RECORD

REV	DESCRIPTION	APPROVAL AND DATE
—	Original Release	AWJ 10/6/75
A	Document Updated & Retyped	AWJ 5/21/76

REV	A	A	A	A	A	A	A	A	A	A	A	A	A	—	A	—	A	A			—
PAGE	1&2	3	4	5	6	7	7A	8	9	10	11	12	12A	13	14	15	16	17			OTHER PAGES
REVISION SYMBOL OF REVISED PAGES																					

ASTERISKS (*) SHOWN LOCATE CHANGES FROM PREVIOUS REV FOR CONVENIENCE ONLY - NO LIABILITY ASSUMED

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INTRODUCTION

This Cost of Ownership/Life Cycle Cost (LCC) was prepared in accordance with CLIN0020, DD1423 item G005 of Contract DAAB07-74-C-0487 . As required this analysis is based on the existing Lightweight Doppler Navigation System (LDNS) design.

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GENERAL

Life Cycle Cost is a cumulative measurement of Research and Development costs, Investment costs and various logistics support costs (Operation and Maintenance). This Cost of Ownership/Life Cycle Cost analysis was based on the Optimum Repair Level Analysis, Document Y258A290 Rev. A which considers the above costs by employing the Generalized Electronics Maintenance Model (ECOM TR-3502).

Figure I is the output of the Generalized Electronics Maintenance Model exercised with the maintenance policies which were selected for the Lightweight Doppler Navigation System being proposed by Singer-Kearfott. The combination of Maintenance Policy Numbers 11/13 with corresponding stockage and inventory requirements from policies 21/23, proves to be the most cost effective and is used for the LCC.

MAINTENANCE POLICY

LEVEL	"O"	"DS"	"GS"	DEPOT
FUNCTION	COE, FIC		FIM (SDC, CDU)	FIM (RTA) FIP (All)
STOCKAGE	No Spares	Components (LRU's)	Modules (SRU's) for SDC, CDU Selected Bits & Pieces	Modules (SRU's) for RTA Bit & Piece to repair all SRU

The GEMM output (Figure I), when run with the selected Maintenance Policy, provides the result of a comprehensive analysis which traded off significant parameters such as maintenance levels, test equipment requirements, stockage of spares, technical data, training, transportation, etc. The preliminary result was sensitized by incrementally upgrading the stockage confidence level to arrive at the maximum cost effectiveness ratio. An 80% stockage confidence level was used for Figure I. The ORLA and the GEMM output forms a portion of the rationale for this LCC.

LIFE CYCLE COST/GEMM OUTPUT

Cost Elements	3 BOX LDNS CONFIGURATION MTBF = 2121 HRS. Maint. Policies 11/13	Maint. Policies 21/23 (For Stock At "DS")
Research & Development	2,530.607	
Production Cost	25,100,000	
Test Equipment Cost	542,470	
Publications Cost	516,000	
Stockage		
Initial		952,392
Reorder		577,526
Total Stockage		1,529,918
Inventory Cost		1,079,394
Training Cost	1,208,000	
Maint. (Manpower) Cost	30,873	
Transportation	80,327	
Overhaul Cost	N/A	
Sub-Total LCC	30,008,277	2,609,312
Total LCC	32,617,589	

Total LCC/GEMM Output	=	32,617,589
Other Costs:		
LRIP Gages & Fixtures	=	250,000
Item Management	=	960,120
First Destination Trans.	=	8,033
Grand Total 10 Yr. LCC	=	33,835,742
Operational Avail.	=	0.9684
MDT (Hrs.)	=	77.039

FIGURE I

LIFE CYCLE COST DISPLAY

The LCC display, Figure -II-, is a summarization of all cost expenditures which will be incurred throughout the life cycle of the LDNS. The life cycle being defined as: The R&D cost plus Acquisition costs plus ten years Operating and Maintenance costs. The chart is structured to show all cost elements time phased over the entire life cycle. The summarization indicates the yearly totals as well as the life cycle totals. Time value of money is treated separately in Figure III and indicates the projected constant 1974 yearly dollar expenditures at their yearly escalated costs and discounted present value costs as required by the guidelines in Section J.32 of the contract.

The LCC display totals agree in all cases with the GEMM outputs with the addition of LRIP Gages and Fixtures, Item Management and First Destination Transportation costs which are not provided for in the model.

$32,617,589. (GEMM Output) + ($250,000. LRIP Gages & Fix.; $960,120. Item Mgmt.; $ 8,033. 1st Dest. Trans.) = $33,835,742. (LCC Display Total)

G&A and profit breakdowns have not been delineated in the display due to the fact that some of the cost elements are functions of the GEMM calculations which resulted from Government input cost factors. Cost elements inputs which are S-KD prices (i.e. prime equipment, test equipment, spares, etc.) are shown at sell value and can be broken down by using the following percentage factors, except for the Research and Development costs which are explained in the display reference table.

Item/Cost	% of Sell Price	Remarks
1. Labor, Material & Overhead	73.5467	
2. G&A	15.7390	21.4% additive to Item 1.
3. Profit	10.7143	12.0% additive to Items 1 & 2.
	100.0	

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COST CATEGORY		COST ELEMENTS	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	10 Year Totals By Cost Element
			← R &D →			← 10 yr. Cost of Ownership →										
			← Total Life Cycle Cost →													
Research and Development		Engineering Prototype Fab. Sys. Test & Eval Data Training/Field Suppt.	} 2530607													
		Sub-Total	← 2530607 →													2530607
Investment	Re-curring	Prime Equip. (Acquisition)				5020000		10040000	10040000							25100000
		First Dest. Trans.				1607		3213	3213							8033
		Spares (Initial)				190478		380957	380957							952392
		Spec. T/E (LRIP & PROD.)				173477		74992	74992							323461
	Non-Re curring	Gages & Fixtures (Lrip)				250000										250000
		Data Pubs. Cost				516000										516000
		Training (Initial)				308000										308000
		Sub-Total				6459562		10499162	10499162							27457886
Operation and Maintenance		Maint. Manpower				3087	3087	3087	3087	3087	3087	3087	3088	3088	3088	30873
		Spares (Reorder)				57752	57752	57752	57752	57753	57753	57753	57753	57753	57753	577526
		Transportation				8032	8032	8032	8033	8033	8033	8033	8033	8033	8033	80327
		Std. Test Equip.				137	137	137	137	137	137	137	138	138	138	1373
		Spec. T/E Support				21763	21763	21763	21763	21764	21764	21764	21764	21764	21764	217636
		Retraining						220000	80000		220000	80000		220000	80000	900000
		Item Management				245700	79380	79380	79380	79380	79360	79380	79380	79380	79380	960120
		Inventory				107939	107939	107939	107939	107939	107939	107940	107940	107940	107940	1079394
		Sub-Total				444410	278090	498090	358091	278093	498093	358094	278096	498096	358096	3847249
		Grand Total	← 2530607 →			6903972	278090	10997252	10857253	278093	498093	358094	278096	498096	358096	33835742

LIFE CYCLE COST DISPLAY - FIGURE II

LCC DISPLAY (BY COMPONENT)

COST CATEGORIES/ELEMENTS	LDNS SYSTEM	RTA	SDC	CDU
RESEARCH & DEVELOP.	2530607	-	-	-
SUB-TOTAL	2530607			
INVESTMENT				
RECURRING				
ACQ. (PRIME EQUIP.)	25100000	4919600	6425600	13754800
FIRST DEST. TRANS.	8033	1390	2201	4442
SPARES (INITIAL)	952392	186669	243812	521911
SPEC T/E	323461	71370	96335	155756
SUB-TOTAL	26383886	5179029	6767948	14436909
INVESTMENT				
NON-RECURRING				
GAGES & FIX. (LRIP)	250000	-	-	-
DATA PUBS. COST	516000	59600	214000	242400
TRAINING (INITIAL)	308000	53284	84392	170324
SUB-TOTAL	1074000	112884	298392	412724
OPERATION				
MAINT. MANPOWER	30873	5341	8459	17073
SPARES (REORDER)	577526	113195	147847	316484
TRANSPORTATION	80327	13897	22010	44420
STD. TEST EQUIP.	1373	238	376	759
T/E SUPPORT	217636	47880	64857	104900
RETRAINING	900000	155700	246600	497700
ITEM MGMT.	960120	137160	487680	335280
INVENTORY	1079394	211561	276325	591508
SUB-TOTAL	3847249	684972	1254153	1908124
GRAND TOTAL	33835742	5976885	8320493	16757757

NOTE: Non spread items (R&D, GAGES & FIX.) must be added where applicable to obtain sub-total and grand total.

FIGURE II-A

COST SUMMARY - ESCALATED ($)

YR.	INVESTMENT COST NON-RECURR.	INVESTMENT COST RECURR.	O&M COST RECURR.	ANNUAL COST	ESCAL. FACTOR	ESCAL. ANNUAL COST
77	1,074,000	5,385,562	444,410	6,903,972	1.336	9,223,707
78			278,090	278,090	1.402	389,882
79		10,499,162	498,090	10,997,252	1.466	16,121,971
80		10,499,162	358,091	10,857,253	1.531	16,622,454
81			278,093	278,093	1.600	444,949
82			498,093	498,093	1.672	832,811
83			358,094	358,094	1.747	625,590
84			278,096	278,096	1.826	507,803
85			498,096	498,096	1.908	950,367
86			358,096	358,096	1.994	714,043

TOTAL 10 YR COST OF OWN. (ESCALATED)	46,433,577
R&D COST	2,530,607
TOTAL LIFE CYCLE COST (ESCALATED)	48,964,184

COST SUMMARY - DISCOUNTED ($)

YR.	INVESTMENT COST NON-RECURR.	INVESTMENT COST RECURR.	O&M COST RECURR.	ANNUAL COST	DIS. FACTOR	DISCOUNT. ANNUAL COST
77	1,074,000	5,385,562	444,410	6,903,972	0.954	6,586,389
78			278,090	278,090	0.867	241,104
79		10,499,162	498,090	10,997,252	0.788	8,665,835
80		10,499,162	358,091	10,857,253	0.717	7,784,650
81			278,093	278,093	0.652	181,316
82			498,093	498,093	0.592	294,871
83			358,094	358,094	0.538	192,655
84			278,096	278,096	0.489	135,989
85			498,096	498,096	0.445	221,653
86			358,096	358,096	0.405	145,029

TOTAL 10 YR. COST OF OWN. (DISCOUNTED)	24,449,491
R&D COST	2,530,607
TOTAL LIFE CYCLE COST (DISCOUNTED)	26,980,098

FIGURE III

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LCC DISPLAY REFERENCE TABLE

To support the values shown in the LCC display (Figure II), the following table was prepared which provides the Cost Element, Remarks/Derivations and References. Source of data and approach to estimating and cost distribution are included in the table.

COST ESTIMATE	REMARKS	REFERENCE
R&D	The value of $2,530,607. is the current contract value. It includes G&A and profit.	Contract DAAB07-74-C-0487
Prime Equip. Acquisition	For the purpose of this study, $25,100. (DTUPC Target) was used as the unit cost per equip. and the acquisition was spread over the prod. schedule. A configuration cost breakout is provided in Figure IV and the prod. rate schedule and site activation plan is shown in Figure V.	AMSEL-PP-C-ES-3 KO Ltr #37
Spares (Init. & Reorder)	The spares costs calculated by the GEMM based on Component, Module and Part Class price vs. Maint. Policy were separated into Investment (Initial) Cost and O&M (Reorder) Cost. The Investment cost was pro-rated to the Prime Equip. Acquisition as follows:	Figure V

Year	Prime Equip.	% of Total	Init. Spares
1977	$ 5,020,000.	20%	$190,478.
1979	10,040,000.	40%	380,957.
1980	10,040,000.	40%	380,957.
	$25,100,000.	100%	$952,392.

Reorder costs and Inventory costs were spread equally over the 10 year O&M period.

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COST ESTIMATE	REMARKS	REFERENCE
Test Equipment . Special . Gages & Fixtures . Standard . Support	The total Test Equip. value $542,470) calculated by GEMM breaks down as follows: Special T/E (Field) $187,480. Special T/E (Depot) 135,981. Std. T/E Charge 1,373. Support (All) 217,636. $542,470.	
	The Special T/E (Field) was spread in accordance with the site activation schedule (20% in '77, 40% each in '79 and '80). The Special T/E (Depot) was placed in the initial year. A $250,000. cost for LRIP Gages and Fixtures was also placed in the initial year. Standard T/E charges and all T/E support costs were spread equally over the 10 year O&M period.	Figure IV-A & V
Data - Pubs	The GEMM output of $516,000. was calculated from a per page cost of $400. and the page count allocations devoted to E/I, Component and Module. The cost was placed in the first year of operation since tech pubs. are required prior to activation of the maintenance site.	
Training (Initial & Retraining)	Total training costs were spread exactly as allocated by GEMM. See Figure VI for cost distribution. NOTE: GEMM output for training costs from Maint. Policy 21/23 were used for the LCC since Policy 11/13 when exercised on the program with the updated (2121 hour) MTBF completely <u>eliminates</u> Org. Level Training. Policy 21/23 <u>retains</u> Org. Level Training.	Figure VI

COST ESTIMATE	REMARKS	REFERENCE
Maint. Manpower	The GEMM output of $30,873. was spread equally over the 10 year O&M period.	
Spares Reorder	See: Spares (Initial and Reorder)	
Transportation	The GEMM output of $80,327. was spread equally over the 10 year O&M period. First Destination Transportation was estimated as 10% of total GEMM transportation output. Covers shipment and packaging. ($8,033.)	
Standard T/E & T/E Support	See: Test Equipment	
Retraining	See: Training (Initial and Retraining)	
Item Management	Item Management costs have been added to the total LCC figure provided by GEMM. Complete rationale for the costs (Intro., 1st year and 9 year maint.) appears in Figure VII. All Item Mgmt. costs were shown as recurring under the O&M period per AMSEL-PP-C-ES-3, KO Ltr. #37.	Figure VII
Inventory	See: Spares (Initial and Reorder)	

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LDNS CONFIGURATION DIAGRAM

INCLUDES: COMPONENT/MODULE IDENTIFIERS, MTBF & UNIT COST

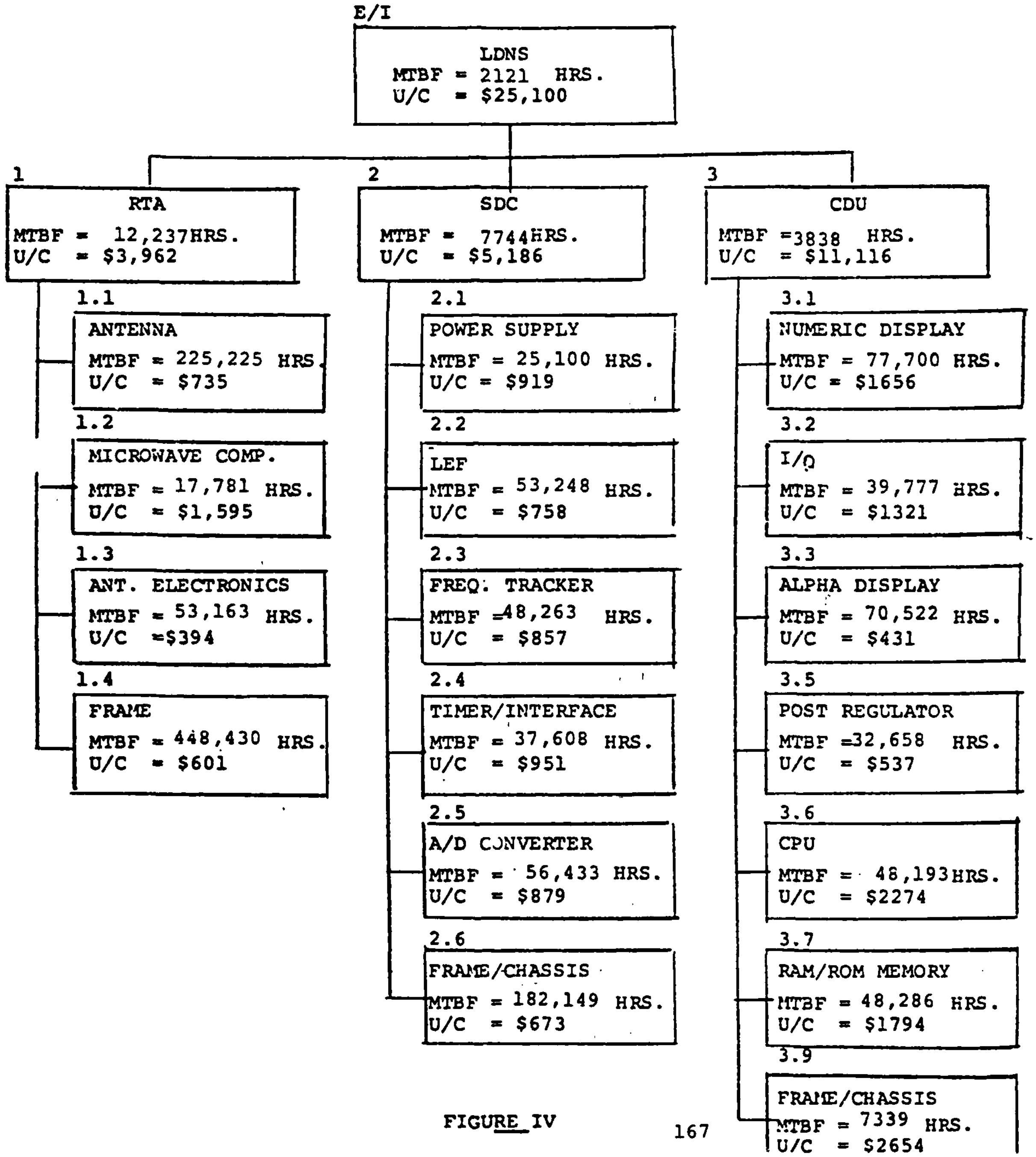

FIGURE IV

IDENTIFICATION & ANNUAL OWNERSHIP COST OF TEST EQUIP.

TEST EQUIPMENT NOMENCLATURE	PART NO.	Standard	Special	MAINT. LEVEL Org.	DS	GS	Depot	(A) UNIT PRICE	PER YR. SUPPORT COST FACTOR	(B) SUPPORT COST FOR (10) YRS	(A) + (B)	CT 21 ENTRY (-) BY (10) YRS.
1. Std. T/E Group No. 1		X					X	16,752	3.5%	5863	22,615	2262
R.F. Sign. Gen.	HP626AR	X						(6188)				
R.F. Spec. Anal.	HP855A/140T	X						(9712)				
Power Meter	HP432A	X						(852)				
2. Volt-Ohmeter	Triplett 630A	X				X	X	60	3.5%	2	62	6
3. Multimeter	HP3469B	X				X	X	818		29	847	85
4. O'scope & Plug-in	TEKRM547/1A1	X				X	X	4253		149	4,402	440
5. Spec. Anal.	HP3580A/7047A	X					X	9650		338	9,988	999
6. Pulse Gen.		X					X	2600		91	2,691	269
7. Sig. Gen.		X					X	2600		91	2,691	269
8. Dig. Voltmeter	SD7224/07	X					X	1022		36	1,058	106
9. Freq. Counter	HP5245L	X				X	X	3714		130	3,844	384
10. Sys. Hot Mock-Up	SKD-Mfr.		X			X		16302	3.5%	5706	22,008	2201
11. Cable/Maint. Kit			X			X		2446	10.0%	2446	4,892	489
12. RTA T/S			X				X	34076		34076	68,152	6815
13. Ant. Elec. T/S			X				X	4860		4860	9,720	972
14. SDC T/S			X				X	24706		24706	49,412	4941
15. Tim/Int'fce T/S			X				X	6630		6630	13,260	1326
16. Sig. Process T/S			X				X	6630		6630	13,260	1326
17. P.S. T/S			X				X	7000		7000	14,000	1400
18. CDU T/S			X				X	25500		25500	51,000	5100
19 CDU Card T/S	SKD-Mfr.		X				X	26579	10.0%	26579	53,158	5316

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KEARFOTT DIVISION

FIGURE IV-A

Y258A416 REV A

CODE IDENT NO. 88818

95E 2/72

SYS. DELIVERY & SITE ACTIVATION SCHEDULE

GEMM/ORLA DATA

1000 Systems
100 "O" Sites (10 Sys. Per)
40 "DS" Sites (25 Sys. Per)
10 "GS" Sites (100 Sys. Per)
1 Depot

SCHEDULE ASSUMPTIONS

Award Date 10/76
LRIP (200) 10/76-10/77 (FY'77)
Full Prod. (800) 10/78-10/80 (FY'79 & 80)

	FY'77				FY'78				FY'79				FY'80				
		CY'77				CY'78				CY'79				CY'80			
	4Q	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q
SYS DEL.	50	50	50	50					100	100	100	100	100	100	100	100	
SYS. DEL. (CUM)	50	100	150	200					300	400	500	600	700	800	900	1000	
"O" ACTIV.	5	5	5	5					10	10	10	10	10	10	10	10	
"O" ACTIV. (CUM)	5	10	15	20					30	40	50	60	70	80	90	100	
"DS" ACTIV.	2	2	2	2					4	4	4	4	4	4	4	4	
"DS" ACTIV. (CUM)	2	4	6	6					12	16	20	24	28	32	36	40	
"GS" ACTIV.	1	0	1	0					1	1	1	1	1	1	1	1	
"GS" ACTIV. (CUM)	1	1	2	2					3	4	5	6	7	8	9	10	
"D" ACTIV.	1	0	0	0					0	0	0	0	0	0	0	0	
"D" ACTIV. (CUM)	1	1	1	1					1	1	1	1	1	1	1	1	

NOTE: 1. Maint. site activation has been scheduled consistant with system deliveries. All levels have been shown for reference purposes even though they may not be required for all policies.

2. Cost for system deliveries has been confined to calendar years for LCC Display Chart (See Figure II).

FIGURE V

TIME PHASED DISTRIBUTION FOR TOTAL TRAINING COSTS

GEMM OUTPUT TOTAL COST = $ 1,208,000

MOS TYPES	FUNCTION	LEVEL	NO. OF LEVELS	RETRAIN. CYCLE	TRAINING COST
1	FIC	Org/DS	100/40	2-3 Yrs.	$5,500
2	FIM	GS	10	3 Yrs.	8,000
3	FIP	Depot	1	15 Yrs.	8,000

TRAINING ALLOCATION BY MOS TYPE FOR 10 YEARS

	INIT.	RETRAINING								
	1 YR	2 YR	3 YR	4 YR	5 YR	6 YR	7 YR	8 YR	9 YR	10 YR
MOS TYPE 1	220,000		220,000			220,000			220,000	
MOS TYPE 2	80,000			80,000			80,000			80,000
MOS TYPE 3	8,000									
TOTAL	308,000	0	220,000	80,000	0	220,000	80,000	0	220,000	80,000

GRAND TOTAL = $ 1,208,000

FIGURE VI

ITEM MANAGEMENT

ITEM	TOTAL PARTS	UNIQUE PARTS	"P"TYPE ITEMS	NEW "P"TYPE ITEMS	INTRO COST $530	1ST YEAR COST $770	9 YR MAINT $420x9= $3780	TOTAL 10 YEAR COST
RTA								
ANT.	8	8	8	6	3180	4620	22680	30480
M'WVE COMP.	3	3	3	3	1590	2310	11340	15240
ANT. ELEC.	104	34	30	13	6890	10010	49140	66040
FRAME	7	7	7	5	2650	3850	18900	25400
SDC								
PWR SUPPLY	101	34	30	13	6890	10010	49140	66040
POST I.F.	158	52	46	20	10600	15400	75600	101600
FREQ TRACK.	213	70	62	26	13780	20020	98280	132080
TIM/INT'FCE.	126	42	40	16	8480	12320	60480	81280
A/D CONV.	110	36	32	14	7420	10780	52920	71120
CHASSIS	16	16	12	7	3710	5390	26460	35560
DU								
NUM.DISP.	73	24	21	9	4770	6930	34020	45720
I/O	72	24	21	9	4770	6930	34020	45720
ALPHA DISP.	40	13	11	5	2650	3850	18900	25400
POST REG.	103	34	30	13	6890	10010	49140	66040
CPU	108	36	32	14	7420	10780	52920	71120
RAM/ROM	78	26	23	10	5300	7700	37800	50800
CHASSIS	51	17	15	6	3180	4620	22680	30480
TOTALS	1371	476	423	189	100170	145530	714420	960120

NOTE: "TOTAL PARTS" quantity does not include standard hardware type items (i.e. screws, washers, nuts, etc.) or structural (non-"P") items.

FIGURE VII

DESIGN & MAINTENANCE ALTERNATIVES

The design and maintenance alternatives addressed in the previous submittal of this document have been implemented and their impact relative to cost has been assessed and included in this analysis.

RISK & UNCERTAINTY

Significant cost driving parameters such as MTBF and spares stockage levels were analyzed and presented in Singer-Kearfott's Optimum Repair Level Analysis Document Number Y258A290 Revision A. MTBF was sensitized from 500 hours to 1600 hours and the ORLA reflects the cost changes associated with each. Spares stockage was analyzed at each maintenance level with the resultant recommendation showing spare LRU's at the Direct Support Level in lieu of the Organizational Level.

QUANTITY-PRICE RELATIONSHIP

The Quantity - Price Relationship Chart, Figure VIII, represents a projection of system per unit prices based on quantities of 200 or 560 or 1,000 or 5,000 or 10,000. Detailed resource labor and material estimates were developed by our Estimating Methods and Production Engineering personnel for quantities of 200, 560 and 1,000 systems. These prices were then increased by developing the factor from the resource estimate for 1,000 quantity to the $25,100 per unit price and factoring the resource estimated prices for 200 and 560 accordingly.

The prices for the quantities of 5,000 and 10,000 were developed by extending the curve from the 1,000 quantity on the same slope (88%).

QUANTITY-PRICE RELATIONSHIP

Based on the unit price per system of $25,100 (Qty. 1,000-1974 Dollars) used in this LCC analysis, Fig. VIII is the quantity-price relationship curve for cumulative lot builds of 200 or 560 or 1,000 or 5,000 or 10,000.

Projected Unit Price:	At Quantity Of:
$16,750	10,000
19,000	5,000
25,100	1,000
27,900	560
37,170	200

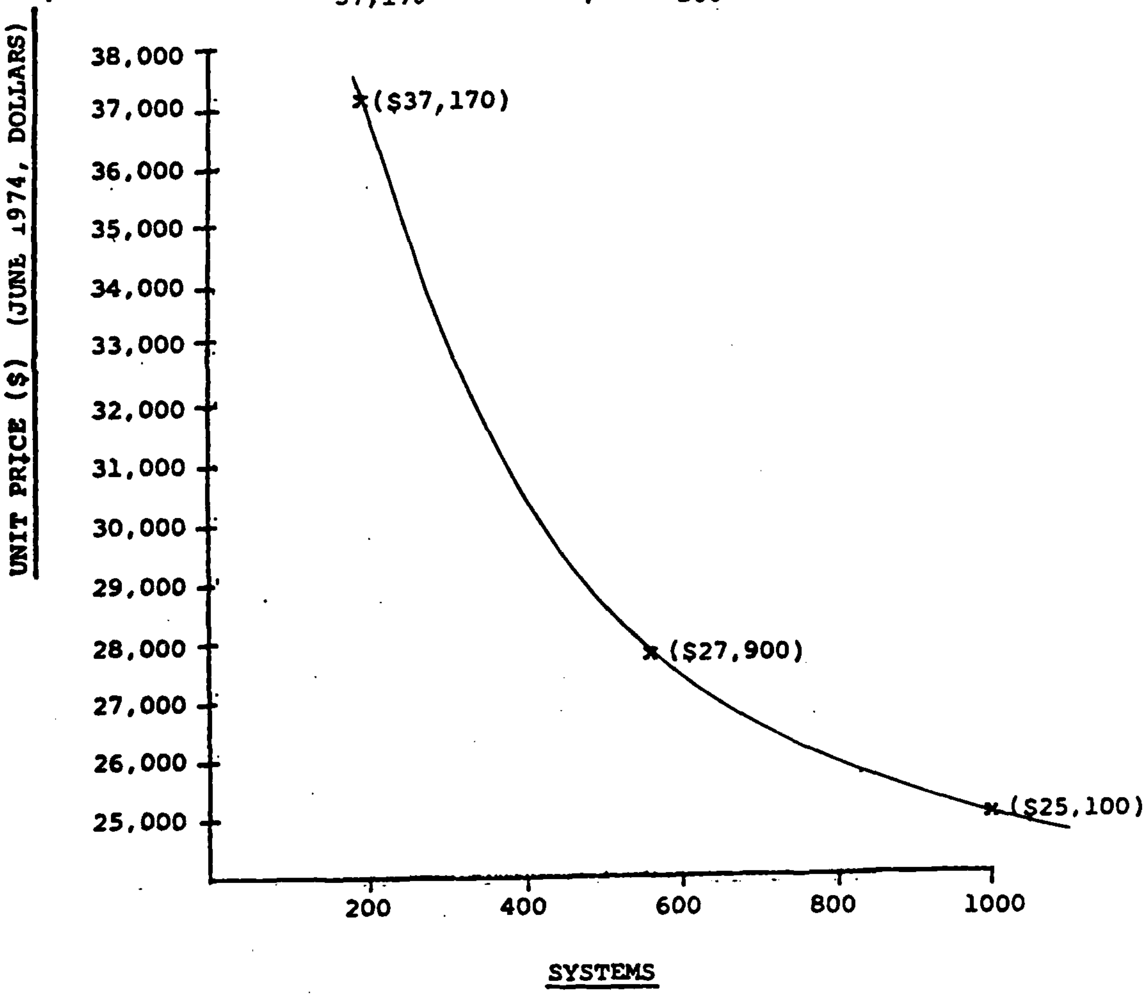

FIGURE VIII

END

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