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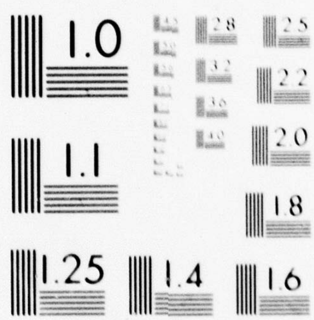

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SPECIAL REPORT NO. 4

ORGANIZATIONAL MAINTENANCE REQUIREMENTS FOR AUGMENTING FAULT-ISOLATION PROCEDURES FOR P-3C AVIONICS

May 1970

Prepared for
NAVAL AIR SYSTEMS COMMAND
WASHINGTON, D. C.
under Contract N00019-70-C-0027

ARINC RESEARCH CORPORATION

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The ability of the maintenance technician to restore malfunctioning equipment to its iperational state depends not only on his technical skill and knowledge but also on the tools available to him. Built-In Test Equipment (BITE) assists the maintenance technician in isolating faults to a unit, module, or group of modules. When the fault is isolated to a group of modules, the most logical and least time-consuming approach available for identifying the defective module is module substitution. This study was conducted to determine which P-3C avionic systems will require modules for isolation-by-substitution and what module complement will be

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required to outfit a module kit or "caddy."

This report describes the avionic systems of the P-3C aircraft for which modules are needed in troubleshooting by the substitution method, the modules needed to outfit a module caddy, alternate maintenance concepts, and the effect of using initially provisioned spares for outfitting module caddies. Thirty avionic systems peculiar to the P-3C were investigated to identify systems that could not be fault-isolated to the defective module. Six such systems were identified; these were analyzed in detail to determine which modules could not be fault isolated by BITE and standard troubleshooting procedures.

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Subsidiary of Aeronuatical Radio, Inc.
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ABSTRACT

The ability of the maintenance technician to restore malfunctioning equipment to its operational state depends not only on his technical skill and knowledge but also on the tools available to him. Built-In Test Equipment (BITE) assists the maintenance technician in isolating faults to a unit, module, or group of modules. When the fault is isolated to a group of modules, the most logical and least time-consuming approach available for identifying the defective module is module substitution. This study was conducted to determine which P-3C avionic systems will require modules for isolation-by-substitution and what module complement will be required to outfit a module kit or "caddy."

This report describes the avionic systems of the P-3C aircraft for which modules are needed in troubleshooting by the substitution method, the modules needed to outfit a module caddy, alternate maintenance concepts, and the effect of using initially provisioned spares for outfitting module caddies. Thirty avionic systems peculiar to the P-3C were investigated to identify systems that could not be fault-isolated to the defective module. Six such systems were identified; these were analyzed in detail to determine which modules could not be fault isolated by BITE and standard troubleshooting procedures.

SUMMARY

ARINC Research Corporation performed an organizational-maintenance analysis of avionic systems peculiar to the P-3C aircraft to identify the modules that cannot be fault-isolated by the use of BITE and on-board test equipment. This analysis resulted in a determination of the module requirements for troubleshooting by substitution at the organizational level.

This report describes the avionic systems for which modules are needed in troubleshooting by the substitution method, the modules needed to outfit a module caddy, alternate maintenance concepts, and the effect of using initially provisioned spares for outfitting module caddies. Thirty avionic systems peculiar to the P-3C were investigated to identify systems that could not be fault-isolated to the defective module. Six such systems were identified; these were analyzed in detail to determine which modules could not be fault-isolated by BITE and standard troubleshooting procedures. These six systems are:

AN/ASQ-114	CV-2461A	AN/ASN-84
AN/AYA-8	AN/ACQ-5	AN/APN-187

The modules were analyzed further to eliminate those which could be interchanged within the system without interfering with the testing routine.

The total module-caddy requirement for the six systems will consist of 224 modules at a total cost of $126,234.60. A module caddy will be required for each P-3C squadron for use at the organizational level.

Alternate methods of troubleshooting that could be used in lieu of the module-caddy concept were considered. One method, involving the replacement of the defective Line Replaceable Unit (LRU), would necessitate maintaining a rotatable pool of LRUs and would require Intermediate Maintenance Activity (IMA) capability. A limited evaluation showed that the LRU-replacement concept would be significantly more costly to implement than the module-caddy concept.

Another troubleshooting method consists of extending modules by the use of a special module adapter and observing waveforms to identify the defective module. Present training does not cover this method in enough detail to allow the technician to perform this type of maintenance. The formal training required would be rather extensive and time-consuming. NAESU and field-service-representatives could be employed to provide on-the-job training (OJT) in maintenance techniques that would permit fault isolation by extending modules and observing waveforms whenever feasible. This approach could be used to supplement fault isolation by module substitution.

It is recommended that the module-caddy concept be implemented for the six P-3C systems. It is also recommended that the modules required for the module caddies be purchased separately and not drawn from P-3C Initial Outfitting List (IOL) spares; however, as an interim measure, a limited number of module caddies could be assembled from IOL spares until spares production is adequate.

CONTENTS

CHAPTER ONE

INTRODUCTION

Under Contract N00019-70-C-0027, Naval Air Systems Command, the P-3C Program Manager (PMA-240) assigned ARINC Research Corporation the task of conducting an organizational-maintenance analysis of avionic systems peculiar to the P-3C aircraft. The purpose of the analysis was to identify the modules that cannot be fault-isolated by the use of BITE and on-board test equipment and thus to determine what modules would be required at the organizational level for use in troubleshooting by substitution.

The avionic systems designed specifically for the P-3C have various fault-recognition/isolation capabilities. The maintenance concept of fault isolation to the module, at the organizational level, is employed on selected systems. This permits on-board maintenance without removing and replacing the line-replaceable unit (LRU) or "black box." Fault isolation to the module level was the design objective, but sometimes the fault is isolated only to a group of modules. Isolating the faulty module can be extremely difficult in sophisticated avionic systems; therefore, in many cases, it may be necessary to substitute modules to locate the defective one even though BITE, conventional test equipment (oscilloscope and meter), and standard troubleshooting procedures are employed.

This study concentrated on systems meeting the following criteria:

- The systems were amenable to module replacement at the organizational level.
- BITE and on-board test equipment would not isolate faults to a single module.
- There was no redundant system installed on board from which modules could be used for troubleshooting by module substitution. (This criterion does not apply to the AN/ASN-84, because the use of modules from a redundant system might destroy the navigation program of the AN/ASN-84.)

CHAPTER TWO

SYSTEM ANALYSIS

Thirty avionic systems peculiar to the P-3C were analyzed to determine the module complement that would be needed to fault-isolate by module substitution. Figure 1 is a logic diagram that outlines the approach taken in analyzing these systems, which consisted of the following steps:

- Identify systems on which modules can be replaced at the organizational level.
- Eliminate redundant systems whose modules can be interchanged for fault isolation.
- Eliminate systems that can be fault-isolated to the defective module.
- Eliminate modules that can be identified as defective by BITE or by on-board troubleshooting procedures.
- Eliminate redundant modules that can be used for fault isolation.
- Finalize module-caddy requirements on the basis of this analysis and recommendations of Fleet personnel and field engineers.

Table 1 summarizes the analysis and lists the avionic systems peculiar to the P-3C, the maintenance concept of each system, the capability to isolate faults to the defective module, and the necessity for a module caddy (containing modules used for troubleshooting).

The objective of using a module caddy is to have modules available for substitution when the malfunction is isolated to a group of modules and no other practical method is available to identify the defective module. The module caddy is not intended to be used as a source of replacement modules. Using a module caddy as a troubleshooting aid theoretically eliminates returning no-defect modules to the repair faciltiy and compensates for the inability of BITE to isolate to a defective module within a group of modules.

As shown in Table 1, it was determined that the following systems would require a module caddy for troubleshooting to the defective module:

AN/ASQ-114	AN/ACQ-5
AN/AYA-8	AN/ASN-84
CV-2461/A	AN/APN-187

The following items, which serve as inputs to the logic diagram in Figure 1, were analyzed to establish the module-caddy requirements for the six systems:

- The diagnostic test procedures and corrective actions applicable to the particular system

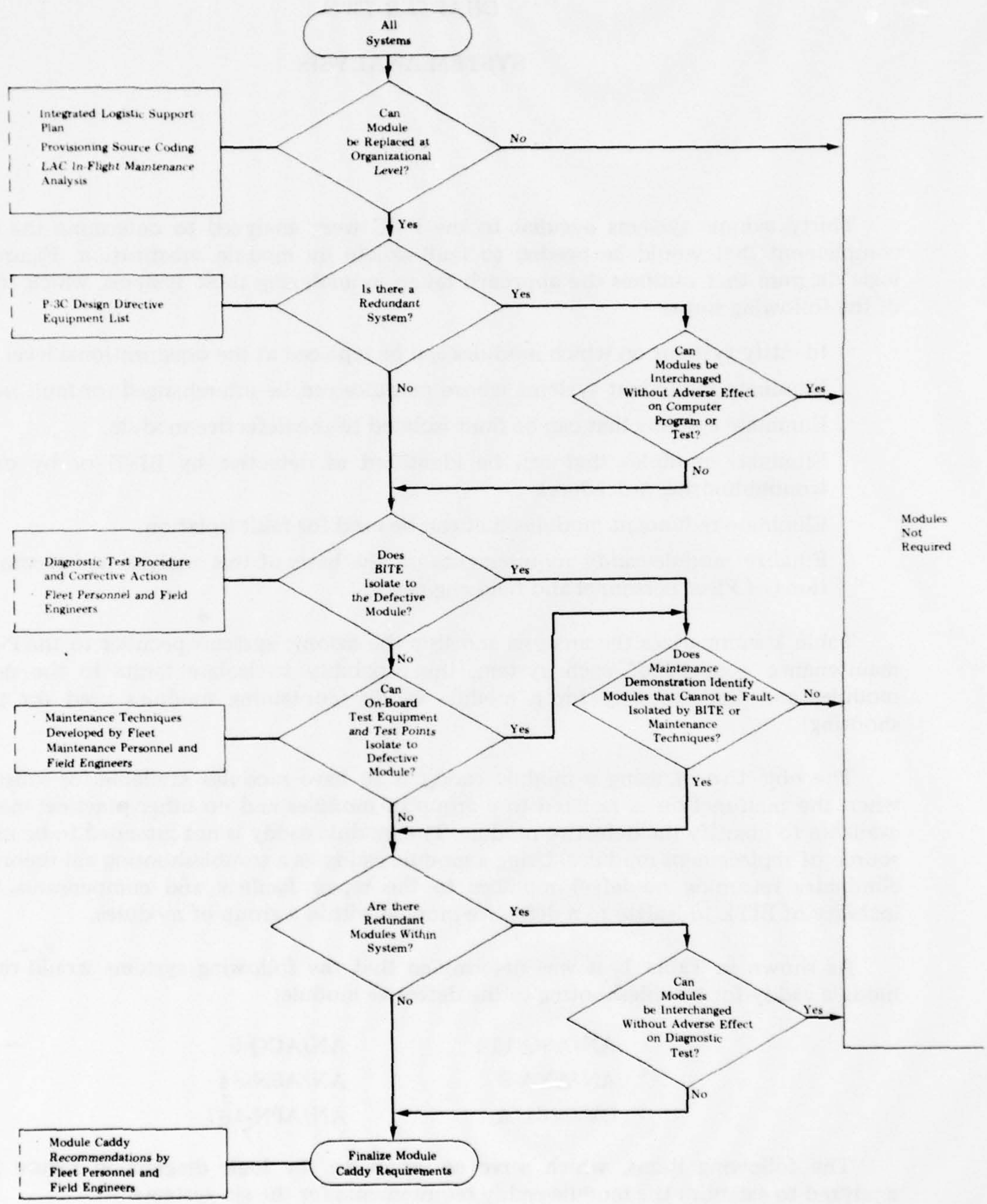

Figure 1. **APPROACH TO ANALYZING P-3C AVIONICS**

Table 1. **AVIONICS SYSTEMS PECULIAR TO P-3C**

System	Organizational Level Maintenance		Fault Isolation to Defective Module (Includes Use of BITE, On-Board Troubleshooting Procedures, and Substitution With Redundant Systems)		Redundant System	Requires Module Caddy	
	Module	Unit	Yes	No		Yes	No
AM4923A Central Repeater	X		X		X		X
AN/ACQ-5 Data Terminal	X			X		X	
AN/AGC-6 Teletypewriter	X		X				X
AN/AJN-15 Flight Director	X		X				X
AN/ARR-72 Sono Receiver	X	X	X				X
AN/ASA-69 Scan Converter	X		X				X
AN/ASA-70 Tactical Data Display	X		X				X
AN/ASQ-114 Computer	X			X		X	
AN/AYA-8 DPS	X			X		X	
CV-2461/A Signal Data Converter	X			X		X	
ID-1540 HSI		X	NA		X		X
TD-900AS Time Code Generator	X		X				X
AN/AQA-7 Computer-Recorder Group	X	X	X		X		X
AN/ASN-84 INS	X	X		X	X	X	
AN/APS-115 Radar	X	X	X				X
AN/APN-187 Doppler	X	X		X		X	
AN/ARC-142 HF Radio	X		X		X		X
AN/ARC-143 UHF Radio	X		X		X		X
AN/ASA-64 Magnetic Anomaly Group	X		X				X
AN/ASA-65 Magnetic Comp. Group	X		X				X
AN/ASA-66 Pilots Tactical Display	X		X				X
AN/AXR-13 LLLTV	X	X	X				X
51V4 Glide Slope Receiver		X	NA				X
AN/ALQ-78 ECM	X			X		X*	
AN/AQH-4 Recorder Reproducer	X		X				X
AN/ARA-50 Direction Finder Set		X	NA				X
AN/ASQ-81 Magnetic Anomaly Detector**	X	X					
AN/ASW-31 Dual AFCS	X	X	X				X
R-1651 OTPI Receiver Set		X	NA				X

*Module caddy included in IOL.
**Insufficient data for evaluation.

- Maintenance techniques developed by Fleet maintenance personnel and field engineers
- Results of maintainability demonstrations
- Recommendations by Fleet maintenance personnel and field engineers on module-caddy requirements

Malfunctions in some subassemblies can often be isolated to the defective module by the use of BITE and standard voltage checks; therefore, the discussion of individual systems in the following sections is addressed only to the subassemblies requiring modules for substitution.

2.1 AN/ASQ-114 DIGITAL DATA COMPUTER

The computer system consists of the Computer and Maintenance Control Panel. The computer is composed of seven principal units: Power Supply, Central Processor, Input/Output Unit, and four Memory Units. These units contain 526 modules representing 80 module types. Except for the power supply, it is not necessary to remove a computer unit from the frame to remove and replace modules.

The maintainability demonstration indicated that the average fault isolation by the computer diagnostic program would result in the replacement of one to three modules for corrective action. In many instances modules can be interchanged within the system for fault isolation.

2.1.1 Power Supply

The Power Supply contains five module types; it has two channels, with two of the module types in each channel. These modules can be interchanged for fault isolation. The remaining three module types are not interchangeable and can be fault-isolated only by substitution; therefore, these types should be available in the module caddy.

2.1.2 Central Processor

The Central Processor contains 55 module types. Analysis of the computer diagnostic program indicates that isolation to the defective module can involve the substitution of 52 module types.

2.1.3 Input/Output Unit

The Input/Output Unit contains 54 modules representing two module types. These modules can be interchanged with like modules within the unit for fault isolation.

2.1.4 Memory Unit

The AN/ASQ-114 contains four identical Memory Units. There are 18 module types in each memory unit. The computer diagnostic program will isolate to the malfunction in units 0 and 1. Faulty Memory Units 2 and 3 will be detected by BITE. Modules of the memory units can be interchanged for fault isolation.

2.2 AN/AYA-8 DATA-ANALYSIS PROGRAMMING GROUP

The AN/AYA-8 permits the crew to communicate with the computer, enables the computer to communicate with and control the Sonobuoy Receiver, provides navigation information to the computer, and provides the interface between computer and displays. The AN/AYA-8 consists of three Logic Units, with identical power supplies in each of them, five keysets, and two magnetic-tape-transport units. These units contain 95 module types. The AN/AYA-8 modules are readily accessible plug-in type and are interchangeable by respective type.

Often the diagnostic program only narrows the fault to an average of five modules. To isolate to the defective module within a group, it is often necessary to substitute modules. Modules can be interchanged with other logic units for troubleshooting.

Analysis of the fault indications and corrective actions shows that a wide range of module types is required. To determine the most cost-effective approach to outfitting a module caddy for the AYA-8, the complete list of required troubleshooting modules was screened. Modules that are available in at least two of the three logic units and could be used for troubleshooting were eliminated from the module-caddy requirements. Twenty-three module types are required for troubleshooting by substitution.

The Magnetic Tape Transport can be fault-isolated to the defective module by the use of BITE or substituting modules from the redundant Magnetic Tape Transport.

2.3 CV-2461/A SIGNAL DATA CONVERTER

The Signal Data Converter is an input-output device that provides an interface between the computer and synchro peripheral equipment. The Signal Data Converter has 32 synchro-to-digital (S/D) input channels and 16 digital-to-synchro (D/S) output channels. There are 69 modules, representing 40 module types, installed in the Signal Data Converter. Access to all modules is gained by removal of the side covers. The modules are removed by means of a special card puller.

Fault isolation consists of correlating the fault indications and, as a result of the correlations, identifying the module in which the malfunction has occurred. Fleet maintenance experience has indicated that the CV-2461 is extremely difficult to fault-isolate to the defective module.

Analysis of the fault indications and corrective actions reveals that 36 of 40 module types are required for troubleshooting to the defective module.

2.4 AN/ACQ-5 DATA TERMINAL SET

The Data Terminal equipment provides a high-speed digital communication link for transmission of tactical information between ground, ship, or air command centers. Computer-controlled data (serial bit-stream digital-type data) are transmitted by HF or UHF radio, as appropriate.

The Data Terminal Set consists of the following units:

- Modem/Data Control CV-2528/ACQ-5
- Digital Voice Controller

- Power Supply PP-6100/ACQ-5
- Control/Monitor C-7790/ACQ-5

These units contain 188 modules representing 161 types. Quick access to removable modules is provided by side panels.

The BITE logic for the ACQ-5 equipment isolates a failure only to a group of related modules, not to a single module. Analyzing the self-test readouts for malfunctions produces a list of functionally related modules for each fault indication. The module that is most likely to have failed is listed first, followed by the rest of the modules in descending order of failure probability. Some BITE readouts implicate as many as eleven modules. Further isolation is achieved by replacing modules one at a time until the fault is corrected; of the 161 module types, 102 are required for troubleshooting by substitution. To date, training has not been comprehensive enough to allow the technician to extend modules and isolate to the faulty module by observing signals and voltages.

2.5 AN/ASN-84 INERTIAL NAVIGATION SYSTEM

Two identical Inertial Navigation Systems (INS) are used on the P-3C operating entirely independently of each other. The INS function provides navigational information — aircraft heading (true and magnetic), aircraft attitude (pitch and roll), aircraft position, and aircraft velocity.

Each system consists of six separate units:

- Navigation Controller
- Position Indicator
- Gyroscope Assembly Controller
- Gyroscope Assembly
- Navigation Computer
- Power Supply

The INS contains 70 modules representing 46 module types. Although there are two identical INS systems aboard the aircraft, modules cannot be interchanged between systems during troubleshooting since there is a possibility of destroying the Navigation Computer program in the Destructive Readout (DRO) memory.

2.5.1 Position Indicator

The Position Indicator contains four modules, all different types. If the Position Indicator is found to be faulty through operational checks, it is repaired by replacing one of the four modules. The defective module is located by the module-substitution method.

2.5.2 Navigation Computer

The Navigation Computer consists of 19 replaceable modules. A failure in the computer will be determined by BITE and can be further isolated to one of several module groupings. The faulty card in a group will be identified by sequential substitution.

Recent efforts have resulted in the development of a carry-on test set (Loader-Verifier) for use at the organizational level of maintenance. The design objective of the Loader-Verifier is to provide the technician with the capability to fault-isolate to the

defective module in the Navigation Computer. Since this test set's fault-isolation capabilities are not currently well defined, it is recommended that purchases of troubleshooting modules for the navigation computer be delayed pending Navy evaluation of the Loader-Verifier.

2.6 AN/APN-187 DOPPLER VELOCITY ALTIMETER RADAR SET

The Doppler Radar is a modularized microelectronic, frequency-modulated, continuous-wave doppler. It measures velocity by determining the doppler frequency shift in the returned microwave energy, and altitude by determining the phase shift in the received modulating frequency.

The Doppler Radar consists of three units:

- Computer, Frequency Tracker
- Antenna, Receiver/Transmitter
- Control Indicator

BITE will detect malfunctions to the Antenna, Receiver/Transmitter or the Computer, Frequency Tracker. The Control Indicator contains a failure device that indicates to the operator that a Go-No-Go system condition exists. Electrically resettable BITE indicators on the Frequency Tracker Computer and the Receiver/Transmitter units quantify unit operability.

2.6.1 Computer, Frequency Tracker

The Computer, Frequency Tracker contains eleven modules. Three groups of these modules constitute matched sets — two sets comprising three modules each and one comprising two modules. Although these individual modules are identified by separate part numbers (P/N) and are not physically mated, they should be replaced as sets.

Modules that comprise a matched set and are required for the module caddy are listed herein by the P/N of the matched set rather than by individual module P/Ns.

Malfunctions detected in the Computer Frequency Tracker can be isolated to the Timer or Power Supply modules by standard troubleshooting procedures using a break-out box and on-board test equipment. Module substitution is required to isolate between the remaining modules.

2.6.2 Antenna, Receiver/Transmitter

The Antenna Receiver/Transmitter contains two modules — the Stabilizer module and the Microwave module.

Malfunctions in the Stabilizer module can be detected by visual observation of the antenna operation.

Problems may be encountered in isolating malfunctions to the Microwave module since fault indications will be similar to those caused by a faulty Post IF module. Since the Post IF module is recommended for the module caddy, it can be substituted to isolate the fault to either the Post IF module or the Microwave module.

CHAPTER THREE

ORGANIZATIONAL-MAINTENANCE MODULE REQUIREMENTS

3.1 COMPOSITION OF A MODULE CADDY

Organizational maintenance performed while the aircraft is on the ground is limited. Most repairs consist of detecting a malfunction and isolating it to a unit or module and making the necessary replacement. Even when all the tools at hand are used — BITE, on-board test equipment, applicable technical manuals, and technical skills — it is sometimes difficult or impossible to isolate the malfunction to a particular module in a reasonable time. For malfunctions that can be isolated only to a group of modules, module substitution will be required to identify the defective module. Analysis of the systems in this category resulted in the definition of a recommended module caddy for troubleshooting at the organizational level.

A module caddy is recommended for organizational maintenance of the following systems:

AN/ASQ-114	Digital Data Computer
AN/AYA-8	Data Analysis Programming Group
CV-2461/A	Signal Data Converter
AN/ACQ-5	Data Terminal Set
AN/ASN-84	Inertial Navigation Set
AN/APN-187	Doppler Velocity Altimeter Radar Set

The entire module-caddy complement for these six avionic systems consists of 224 modules costing $126,234.60. (This cost total does not include the module containers discussed in Section 3.2). The appendix to this report lists the recommended troubleshooting-module complement for each of the six systems.

Maintenance techniques are constantly improving, and the Diagnostic Test routines are being revised to improve the fault-isolation capabilities; therefore, it is recommended that the module caddy be re-evaluated approximately one year after it is introduced and that necessary action be taken to provide up-to-date support for Fleet squadrons and training units.

3.2 MODULE-CADDY PACKAGING

It is recommended that troubleshooting modules be packaged in separate containers for each of the six systems. The module caddy would thus be used more efficiently since troubleshooting of different systems could be performed simultaneously at different locations.

The module caddy would require the following storage volumes:

Nomenclature	Approximate Storage Dimensions (Inches)
Module Case, AN/ASQ-114	6 X 6 X 30
Module Case, AN/AYA-8	3 X 7 X 12
Module Case, CV-2461/A	7 X 7 X 20
Module Case, AN/ACQ-5	5 X10 X 24
Module Case, AN/ASN-84	8 X 8 X 6
Module Case, AN/APN-187	6 X 6 X 10

To reduce cost and provide standardization, it is recommended that module containers of the same dimensions be procured for all six systems. Molded spacers could be inserted in the containers to accommodate specific system modules. A suggested module-container configuration is shown in Figure 2.

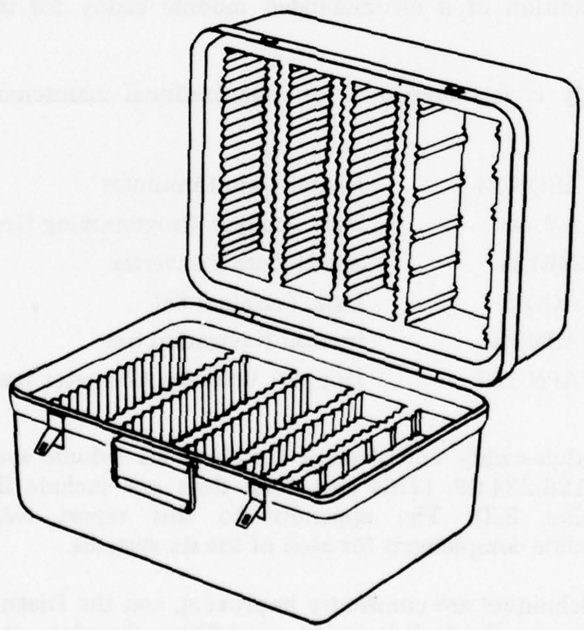

Figure 2. **SUGGESTED CADDY CONFIGURATION**

3.3 USE OF IOL SPARES FOR MODULE CADDY

Budget limitations and lead time for obtaining troubleshooting modules must be considered when a target date is being established for the module-caddy maintenance concept. As part of the analysis, ARINC Research considered IOL (Initial Outfitting List) spares as a source for the modules required for the module caddy.

Spares have been or are being purchased for the support of 13 sites. To supply a module caddy, from IOL spares, for each of the squadrons located at the 13 sites would adversely affect the ability of the supply activity to meet the normal demands from the Fleet. The appendix lists the IOL spares that are expected to be in the Navy inventory after delivery of FY-70 purchases.

To satisfy the immediate demand for troubleshooting modules, a limited number of module caddies might be outfitted initially with IOL spares providing the IOL stocks are replenished as spares become available.

CHAPTER FOUR

ALTERNATE MAINTENANCE TECHNIQUES

To determine the most cost-effective maintenance approach, alternate methods of organizational maintenance should be evaluated. To speed implementation, hardware-design changes should not be considered. The two alternate methods of troubleshooting most commonly practiced by Fleet squadrons, which would be used in lieu of the module-caddy method, are discussed in the following sections.

4.1 LRU REPLACEMENT CONCEPT

Systems selected in this analysis for module-caddy support could also be maintained by LRU replacement at the organizational level, with module isolation and replacement at the IMA level. Many factors would have an impact on the total support costs for the LRU-replacement concept, including the following:

- Quantity of LRUs in the rotatable pool
- Peculiar Ground Support Equipment (PGSE) for each P-3C IMA
- Additional personnel for IMA maintenance
- Training of IMA personnel
- Cost of spares for support of PGSE
- Lead time for establishing IMA capability

Table 2 shows some of the major costs that would be encountered in the LRU-replacement concept for two systems. It lists the cost of rotatable-pool LRUs and PGSE for IMA maintenance support. Only one of each type LRU is included in this example as rotatable-pool allowance per site. A greater number might be required, depending on the number of aircraft supported and the number of flying hours.

The cost shown in this example amounted to $666,013 for only LRUs and PGSE. The cost of a module caddy to be used as a troubleshooting aid at the organizational level amounted to $49,323 for these same systems.*

4.2 FAULT ISOLATION BY EXTENDING MODULES

The second alternate approach to maintaining the systems discussed in this report is to expand the depth of troubleshooting in the aircraft to include fault isolation by observing waveforms of suspected or associated modules. Module test points are not always accessible

*Sites that provide support for more than one squadron would require a module caddy for each additional squadron, but the LRU rotatable-pool requirements and PGSE would not increase proportionately.

Table 2. LRU AND PGSE COST FOR TWO AVIONICS SYSTEMS			
Rotatable-Pool *Line-Replaceable Units* (LRU)	**LRU Cost**	**Ground Support *Equipment Peculiar* *to* P-3C**	**Estimated Cost Per Site***
ASQ-114 Digital Data Computer			
Central Processor Assembly	$51,948.00	Power Supply Module Analyzer	$90,000.00
Input/Output Assembly	24,679.00	Logic Module Analyzer	50,000.00
Memory Chassis Assembly	62,346.00	Analog Assembly Analyzer Unit	90,000.00
Power Supply	14,002.00		
Maintenance Console	8,860.00		
Total	$161,834.00		$230,000.00
ACQ-5 Data Terminal Set			
Modem/Data Control Unit	$54,152.00	ACQ-5 Hot Bench (includes complete ACQ-5)	
Digital Voice Controller	12,197.00		$192,000.00
Power Supply	7,512.00	DTS and DVC Simulator	
Control/Monitor	8,318.00		
Total	$82,179.00		$192,000.00

*Based on recurring nonrecurring cost for 11 sites (resulting in average cost).

when the modules are installed in the system assemblies, and to gain access it is sometimes necessary to extend a module from its normal position. This can be accomplished by the use of a special module extender (adapter or cable). It is reasonable to assume that it would still not be possible to isolate all faults to a particular module; therefore, a limited number of modules would be required for substitution.

Although this appears to be a sound approach to system maintenance, the time factor must be considered carefully. Training would have to be broadened, more emphasis placed on the theory of operation of the systems involved, and maintenance manuals revised. The entire training program for these systems would have to be revised and considerably expanded to train organizational-maintenance personnel for this type of troubleshooting. Personnel currently qualified for organizational maintenance would have to be retrained. During the transition period, modules would have to be made available for troubleshooting by substitution.

To estimate costs and establish maintenance trade-offs for this type of maintenance concept, a separate study would be required. The total estimated cost would then have to be considered in comparison with the costs of the module-caddy concept.

NAESU and field service representatives could provide OJT in maintenance techniques that would permit fault isolation by extending modules and observing waveforms whenever feasible. This approach could also be used to supplement fault isolation by module substitution.

Past experience indicates that regardless of the type of maintenance concept established, new techniques for on-board maintenance are developed and used by maintenance personnel as system knowledge and maintenance experience increase.

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

5.1 CONCLUSIONS

Because of BITE's inability in many cases to isolate to a single module, it is necessary to fault-isolate by substituting modules. A module caddy, containing an assortment of selected modules, can be used as a troubleshooting aid in fault isolation by substitutiion.

The following additional conclusions have been reached:

- Six avionic systems require a module caddy to fault-isolate to the defective module.
- The fault-isolation capabilities of the ASN-84 carry-on test set are yet to be demonstrated.
- A total of 224 modules are needed to make up the module caddy for six avionic systems.
- Separate module containers for each system would permit efficient use of the module caddy.
- The LRU-replacement concept is considerably more expensive than the module-caddy concept.
- Extending modules and observing waveforms could supplement the module-caddy concept, reducing the number of modules required for troubleshooting.
- It would not be practical to use IOL spares since this would significantly reduce the number of spares available to meet Fleet demands.

5.2 RECOMMENDATIONS

As a result of this study, ARINC Research Corporation recommends the following steps:

- Implement the module-caddy maintenance concept.
- Purchase modules for organizational-level troubleshooting.
- Do not outfit the module caddy from IOL spares.
- Delay the purchase of Navigation Computer troubleshooting modules until the Navy evaluates the fault-isolating capabilities of the ASN-84 carry-on test set.
- Package troubleshooting modules in separate containers of the same dimensions for each of the six systems.
- Employ NAESU and field-service representatives to expand maintenance techniques

of Fleet personnel to permit fault isolation by observing waveforms on extended modules.

- Re-evaluate the module-caddy requirements after approximately 12 months and take the necessary action to provide support of Fleet squadrons and training units.

APPENDIX

MODULE-CADDY COMPLEMENT AND SPARES ON ORDER

Table A-1 lists all the modules required for fault-isolation by substitution in the following six avionic systems of the P-3C:

- AN/ASW-114 Digital Data Computer
- AN/AYA-8 Data Analysis Programming Group
- CV-2461/A Signal-Data Converter
- AN/ACQ-5 Data Terminal Set
- AN/ASN-84 Inertial Navigation Set
- AN/APN-187 Doppler Velocity Altimeter Radar Set

The table also lists the unit costs of repairable modules and the spares on order that could be used as an interim source of modules for the proposed module caddy.

Table A–1. **MODULE-CADDY COMPLEMENT AND SPARES ON ORDER**			
Part Number	**Description**	**Number Procured**	**Unit Cost**
	AN/ASQ-114 Digital Data Computer		
7111000-01	Active Register, Monitor Register	95	$ 300.00
7111005-01	1 Shot, Sync Register	96	300.00
7111010-01	Shift Control	36	300.00
7111015-01	APR Register	60	300.00
7111020-01	Read/Write Selectors	59	300.00
7111025-001	UL & Control Adder	39	300.00
7111030-01	Console/Control/Module	23	300.00
7111035-01	R2 & Control/Adder	39	300.00
7111041-01	Acknowledge Timing and Inter-computer Timing Out	48	300.00
7111045-01	Special Interrupt Priority	23	300.00
7111050-01	APR Select Control	48	300.00
7111055-01	P-B-RI-UU	95	300.00
7111060-01	A, Q Registers	79	300.00
7111065-01	A Registers	79	300.00
7111070-01	I Register, Adder Register	58	300.00
7111080-01	X Register Subtractor	79	300.00
7111085-01	Monitor Priority & Sequence	23	300.00
7111090-01	Add Select Sequence	36	175.00
7111095-01	I/O Sequence Control	23	300.00
7111100-01	I/O Memory Command	23	300.00
7111110-01	Address and Data Selector	38	225.00
7111115-01	Interrupt and Transfer Register	39	300.00
7111121-01	I/O Functional Code Translation	23	300.00
7111125-01	Interrupt Control	23	300.00
7111130-01	Buffer Priority	23	225.00
7111135-01	Control Logic Type 1	47	275.00
7111140-01	Control Logic Type 2	37	250.00
7111145-01	Control Logic Type 3	36	300.00
7111150-01	Clock 2 Phase	23	150.00
7111155-01	Control Logic Type 4	36	300.00

Part Number	Description	Number Procured	Unit Cost
7111160-01	Control Logic Type 5	36	300.00
7111165-01	A Q Control	23	300.00
7111170-01	Complements and Write Select Control	23	300.00
7111175-01	Read Selector Control	23	275.00
7111180-01	Subtract Control	23	300.00
7111191-01	A, Q Control	23	300.00
7111195-01	Control Logic Type 6	23	300.00
7111200-01	Control Logic Type 7	23	300.00
7111205-01	Control Logic Type 8	23	300.00
7111210-01	Control Logic Type 9	23	300.00
7111216-00	Control Logic Type 10	23	300.00
7111220-01	Control Logic Type 11	23	300.00
7111235-01	Control Logic Type 12	23	300.00
7111240-01	Control Logic Type 13	36	200.00
7111245-01	Control Logic Type 14	35	225.00
7111250-01	Control Logic Type 15	23	300.00
7111255-01	Control Logic Type 16	23	300.00
7111260-01	Control Logic Type 17	23	250.00
7111265-01	Control Logic Type 18	59	150.00
7111270-01	Control Logic Type 19	44	150.00
7112370-01	Select Matrix	19	225.00
7074072-00	Power Interrupt	20	200.00
7073781-00	Output Module 1	20	1,644.00
7073782-00	Output Module 2	21	1,502.00
7112365-01	Current Switch	34	250.00
ASQ-114 TOTAL			$17,771.00
AN/AYA-8 Data Analysis Programming Group			
7638348G2	Module Type 23	22	$ 314.00
7638341G2	Module Type 15	84	295.00
7638361G2	Module Type 37	73	221.00
7638360G2	Module Type 36	22	250.00

Table A–1. (Continued)

Part Number	Description	Number Procured	Unit Cost
7638362G2	Module Type 38	42	$ 333.00
7638364G2	Module Type 40	22	290.00
7638366G2	Module Type 42	22	291.00
7638367G2	Module Type 43	24	293.00
7638365G1	Module Type 41	28	289.00
7638363G2	Module Type 39	22	284.00
7638369G2	Module Type 45	22	275.00
7638334G2	Module Type 32	23	296.00
171F537G1	Module Type 20	41	275.00
7638346G2	Module Type 21 3A2A2	25	225.00
171F167G1	Module Type 22	47	687.00
171F536G1	Module Type 24	21	2,340.00
171F168G1	Module Type 31	29	659.00
7638350G2	Module Type 25	54	283.00
7638344G2	Module Type 19	44	414.00
7638351G2	Module Type 26	22	300.00
7638353G1	Module Type 28	39	292.00
7638354G2	Module Type 29	36	250.00
7638352G2	Module Type 27	22	270.00
	AYA-8 TOTAL		$ 9,426.00
	CV-2461/A Signal-Data Converter		
0073-081G1	Second Level MUX A209	41	$ 1,055.00
0073-075G1	Octant Decoder A215	24	898.00
0073-120G1	12 Bit D/A A212	42	1,453.00
0073-093G1	Residue Null A214	28	973.00
0073-096G1	Residue Comparator A213	30	1,015.00
0073-087G1	Off Set Control A211	43	1,073.00
0073-123G1	Quadrant Detector A216	26	956.00
0073-132G1	Phase Lock A122	28	1,035.00
0073-135G1	Timing Logic 1 A123	24	904.00
0073-138G1	Timing Logic 2 A124	24	905.00
0073-141G1	Timing Logic 3 A125	24	915.00

Part Number	Description	Number Procured	Unit Cost
	Table A–1. (Continued)		
0073-153G1	Digital/Synchro Logic A117	24	$ 921.00
0073-159G1	Digital/Synchro Format Control A120	25	935.00
0073-162G1	Digital/Synchro Update Control A119	24	908.00
0073-165G1	Line Receiver A126, 27	28	1,028.00
0073-168G1	Line Driver A129-131	34	1,065.00
0073-171G1	I/O Control A128	25	954.00
0073-084G1	Address Control A234	28	942.00
0073-192G1	Memory Cell A230-32	32	1,356.00
0073-090G1	Quadrant Residue Signal Bit Storage A233	24	1,177.00
0073-228G1	Lookup Table A A219	24	910.00
0073-231G1	Lookup Table B A220	24	992.00
0073-198G1	MSB Arithmetic A229	24	973.00
0073-195G1	CPU Arithmetic A227-28	27	958.00
0073-204G1	CP Timing Logic A223	24	925.00
0073-207G1	Tangent Gate A224	24	910.00
0073-210G1	CP Update Control A222	24	903.00
0073-216G1	Arithmetic Driver A226	24	909.00
0073-201G1	Residue Update A221	24	930.00
0073-295G1	Test Simulator A217	21	1,066.00
0073-174G1	Test Display A132	14	920.00
0073-415G1	Lamp Driver A237	14	910.00
0073-180G1	Test Logic 1 A133	14	891.00
0073-183G1	Test Logic 2 A134	16	931.00
0073-219G1	CP Logic 1 A225	14	881.00
0073-568G1	Digital/Synchro ABS Value Generator A118	19	1,058.00
	CV-2461 TOTAL		$35,535.00
	AN/ACQ-5 Data Terminal Set		
32-161860-0029	Circuit Card Assembly	20	$ 242.00
32-161860-0028	Circuit Card Assembly	20	242.00
32-161860-0035	Circuit Card Assembly	34	320.00
32-161860-0038	Circuit Card Assembly	16	250.00
32-161860-0041	Circuit Card Assembly	16	225.00

Table A—1. (Continued)			
Part Number	**Description**	**Number Procured**	**Unit Cost**
32-161860-0018	Circuit Card Assembly	17	$ 300.00
32-161860-0039	Circuit Card Assembly	16	240.00
32-161860-0094	Circuit Card Assembly	16	295.00
32-161860-0095	Circuit Card Assembly	16	325.00
32-161860-0096	Circuit Card Assembly	16	235.00
32-161860-0054	Circuit Card Assembly	16	312.00
32-161860-0067	Circuit Card Assembly	17	336.00
32-161860-0063	Circuit Card Assembly	16	320.00
32-161860-0032	Circuit Card Assembly	16	163.00
32-161860-0061	Circuit Card Assembly	16	316.00
32-161860-0049	Circuit Card Assembly	16	185.00
32-161860-0059	Circuit Card Assembly	22	325.00
32-161860-0046	Circuit Card Assembly	16	200.00
32-161860-0068	Circuit Card Assembly	16	310.00
32-161860-0047	Circuit Card Assembly	16	215.00
32-161860-0069	Circuit Card Assembly	16	309.00
32-161860-0048	Circuit Card Assembly	16	376.00
32-161860-0060	Circuit Card Assembly	16	320.00
32-161860-0042	Circuit Card Assembly	16	275.00
32-161860-0055	Circuit Card Assembly	16	290.00
32-161860-0043	Circuit Card Assembly	17	275.00
32-161860-0070	Circuit Card Assembly	16	312.00
32-161860-0008	Circuit Card Assembly	16	467.00
32-161860-0053	Circuit Card Assembly	16	290.00
32-161860-0002	Circuit Card Assembly	16	348.00
32-161860-0050	Circuit Card Assembly	16	260.00
32-161860-0006	Circuit Card Assembly	16	412.00
32-161860-0003	Circuit Card Assembly	16	285.00
32-161860-0005	Circuit Card Assembly	16	340.00
32-161860-0045	Circuit Card Assembly	21	275.00
32-161860-0011	Circuit Card Assembly	16	
32-161860-0019	Circuit Card Assembly	16	215.00
32-161860-0044	Circuit Card Assembly	16	256.00

Table A—1. (Continued)			
Part Number	**Description**	**Number Procured**	**Unit Cost**
32-161860-0036	Circuit Card Assembly	16	$ 210.00
32-161860-0071	Circuit Card Assembly	16	315.00
32-161860-0020	Circuit Card Assembly	16	184.00
32-161860-0073	Circuit Card Assembly	16	327.00
32-161860-0012	Circuit Card Assembly	16	360.00
32-161860-0072	Circuit Card Assembly	16	243.00
32-161860-0021	Circuit Card Assembly	16	300.00
32-161870-0004	Circuit Card Assembly	33	206.00
32-161870-0007	Circuit Card Assembly	22	75.00
32-161870-0006	Circuit Card Assembly	24	235.00
32-161870-0005	Circuit Card Assembly	24	300.00
32-161870-0001	Circuit Card Assembly	22	160.00
32-161860-0066	Circuit Card Assembly	16	340.00
32-161860-0065	Circuit Card Assembly	16	355.00
32-161860-0078	Circuit Card Assembly	16	320.00
32-161860-0053	Circuit Card Assembly	16	374.00
32-161860-0076	Circuit Card Assembly	16	390.00
32-161860-0084	Circuit Card Assembly	22	210.00
32-161860-0075	Circuit Card Assembly	16	290.00
32-161860-0080	Circuit Card Assembly	16	355.00
32-161860-0064	Circuit Card Assembly	16	370.00
32-161860-0034	Circuit Card Assembly	16	370.00
32-161860-0030	Circuit Card Assembly	23	438.00
32-161860-0082	Circuit Card Assembly	16	290.00
32-161860-0031	Circuit Card Assembly	20	427.00
32-161860-0099	Circuit Card Assembly	15	360.00
32-161860-0051	Circuit Card Assembly	16	312.00
32-161860-0052	Circuit Card Assembly	16	310.00
32-161860-0017	Circuit Card Assembly	16	360.00
32-161860-0079	Circuit Card Assembly	16	351.00
32-161860-0077	Circuit Card Assembly	16	320.00
32-161860-0076	Circuit Card Assembly	16	390.00
32-161860-0088	Circuit Card Assembly	20	485.00

Table A–1. (Continued)			
Part Number	**Description**	**Number Procured**	**Unit Cost**
32-161860-0015	Circuit Card Assembly	16	$ 316.00
32-161860-0086	Circuit Card Assembly	20	425.00
32-161860-0013	Circuit Card Assembly	21	330.00
32-161860-0087	Circuit Card Assembly	20	440.00
32-161860-0001	Circuit Card Assembly	50	335.00
32-161860-0089	Circuit Card Assembly	21	331.00
32-161860-0026	Circuit Card Assembly	21	324.00
32-161860-0085	Circuit Card Assembly	21	507.00
32-161860-0027	Circuit Card Assembly	16	312.00
32-161860-0025	Circuit Card Assembly	20	464.00
32-161860-0014	Circuit Card Assembly	16	315.00
32-161860-0100	Circuit Card Assembly	20	296.00
32-161860-0010	Circuit Card Assembly	16	213.00
32-161860-0098	Circuit Card Assembly	16	326.00
32-161860-0009	Circuit Card Assembly	16	328.00
32-161860-0090	Circuit Card Assembly	16	390.00
32-161860-0092	Circuit Card Assembly	16	428.00
32-161860-0056	Circuit Card Assembly	16	305.00
32-161860-0101	Circuit Card Assembly	20	225.00
32-161860-0007	Circuit Card Assembly	20	240.00
32-161860-0074	Circuit Card Assembly	16	355.00
32-161870-0018	Circuit Card Assembly	33	296.00
32-161870-0017	Circuit Card Assembly	1	365.00
32-161870-0013	Circuit Card Assembly	43	250.00
32-161870-0014	Circuit Card Assembly	35	380.00
32-161870-0015	Circuit Card Assembly	44	278.00
32-161870-0016	Circuit Card Assembly	24	315.00
32-161870-0021	Circuit Card Assembly	22	290.00
32-161870-0022	Circuit Card Assembly	22	325.00
32-161870-0057	Circuit Card Assembly	28	335.00
32-161870-0023	Circuit Card Assembly	16	245.00
	ACQ-5 TOTAL		$31,552.00

Table A—1. (Continued)			
Part Number	**Description**	**Number Procured**	**Unit Cost**
AN/ASN-84 Inertial Navigation Set			
C200060914	Circuit Card Assembly	21	$ 1,298.10
C200060915	Circuit Card Assembly	21	1,298.10
C200060916	Circuit Card Assembly	21	1,356.40
C200090580	Circuit Card Assembly	21	1,303.00
ASN-84 TOTAL			$ 5,255.60
AN/APN-187 Doppler Velocity Altimeter Radar Set			
-019-03 G7153-013	Interface Set	15	$ 7,475.00
-040-0 G7153-010	Post IF	20	3,875.00
G7153-011	Frequency Tracker	20	8,520.00
-019-01 G7153-016	Altimeter	27	6,825.00
APN-187 TOTAL			$26,695.00