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# U. S. NAVAL AIR ENGINEERING CENTER

LAKEHURST, NEW JERSEY

GROUND SUPPORT EQUIPMENT DEPARTMENT

NAEC-GSED- 104 | 02 Dec 1976

CODE IDENT. NO. 28638

## SUPPORT EQUIPMENT PROGRAM FOR AVIONICS READINESS: INITIAL PLANNING

AIRTASK NO. A3400000/051B/6F41461408

DEPARTMENT OF THE NAVY ★ NAVAL AIR ENGINEERING CENTER ★



PLATE NO. 11749A

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**LAKEHURST, NEW JERSEY 08733**

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The Support Equipment Program for Avionics Readiness has been developed to provide greater reliability and improved maintainability of avionics and support equipment than has been achieved thus far. These goals can be achieved by properly developing the necessary technology for incorporating a high degree of readiness into the design of new equipment and for providing the specialized support equipment required to maintain this equipment. In order to attain the high degree of readiness



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**ITEM 20 (Continued)**

required in future avionics systems, the Support Equipment Program for Avionics Readiness must now be instituted to insure that new technology be included when ready.

In order to provide industry with definitive specifications for improved avionics systems, the Navy must have the capacity to define readiness problems and goals, to conduct research in weak or high technological risk areas, and to apply new techniques in systems designs. These efforts must be directed toward both the new primary avionics systems and the secondary support equipment systems, which are a vital part of avionics readiness. Advanced weapons systems are of limited value without the proper advanced support equipment required to maintain them.

Proposals to accomplish these tasks for achieving avionics readiness have been incorporated into the Support Equipment Program for Avionics Readiness. The plan includes proposals for the development of management guidelines and techniques for demonstration of equipment support features as part of the primary equipment acceptance criteria and for determining the resulting influence on the cost of future systems.

The application, validation, and refinement of the readiness parameters developed within the context of this program will provide the data base for comparison with current and future avionics system developments.

# I. INTRODUCTION

A. The Support Equipment Program for Avionics Readiness (SEPAR) has been developed to close the gap that invariably exists between the introduction of new equipment and the ability to effectively utilize and maintain that equipment. All too often avionics readiness is equated with technical competence or operational performance of weapons and equipment, with little attention given to the associated support equipment required for testing and maintenance. New space-saving, function-providing, system-integrating, micro-processing technological advances are keenly pursued and rapidly implemented without thorough investigation to assure their proper application. The SEPAR has the goals of providing the corresponding technological advances for testing and maintaining new equipment through R&D of support features for use with new avionics equipment.

B. Recent studies of major weapons systems[1] indicate that military electronics expenditures are a substantial portion of the total defense budget. For example, out of a total DOD FY 74 budget of \$81.1 billion, \$15.3 billion, or almost nineteen percent, was earmarked for electronics outlays. The \$15.3 billion for electronics was apportioned \$4.1 billion for RDT&E, \$5.8 billion for procurement, and \$5.4 billion for support. Over sixty percent of the electronics budget was planned for RDT&E and support, as opposed to forty percent for actual equipment acquisition. Current trends indicate that electronics support costs will require even larger quantities of funds from future defense budgets.

C. As avionics systems increase in complexity and cost, and as their corresponding support systems do likewise, improved coordination and planning are required, from both functional and cost standpoints. Hence, the Support Equipment Program for Avionics Readiness (SEPAR) has been developed within the Avionics Readiness Program (ARP) to accomplish effective coordination between the performance and support functions of avionics equipment.

D. The Support Equipment Program for Avionics Readiness consists of four parts closely interrelated in a coordinated, unified program. These three parts are:

1. Avionics Systems Readiness. The major area of activity of the SEPAR is the improvement of avionics systems readiness. Improved reliability, maintainability, diagnostic capability, and repairability of avionics equipment will be accomplished by addressing these needs during the early development, design, and specification stages of equipment acquisition. The SEPAR will recommend readiness features to be incorporated within the avionics equipment, will specify interface requirements between the avionics and ground support equipment, and will specify the proper ground support equipment to service the avionics.

2. Avionics Ground Support Equipment Performance Augmentation. Just as the primary avionics equipment must exhibit readiness, so must the ground support equipment (GSE). Current technology will be utilized to upgrade existing ground support techniques which have typically been outpaced by the advances in the primary avionics equipment. Furthermore, the same avionics readiness approach that will be applied to avionics systems will be applied to ground support equipment so that future GSE development will parallel its associated avionics systems. Special emphasis will be placed on reliability and maintainability of the GSE.

3. Non-Avionic Ground Support Equipment Performance Augmentation. A natural outgrowth of a successful readiness program plan directed toward avionics systems and avionics ground support equipment is the extension of the program to non-avionic ground support equipment. Consequently, one part of the SEPAR will be directed toward improving readiness of non-avionic GSE.

# II. SUMMARY

## A. CONCLUSIONS

1. No cohesive program currently exists to improve avionics readiness through the technological advancement of avionics support features. The Support Equipment Program for Avionics Readiness (SEPAR) has been developed to fulfill the critical need for such a program.

2. With the increasing reliance on advanced avionics in new weapons and equipment, it is imperative that the proper direction be provided to improve avionics readiness. The SEPAR will provide this direction by developing within the Navy the technological capability, motivation, and organization to specify readiness and support requirements for future avionics systems to the same degree that performance is now specified. The SEPAR will promote supportability through evaluation of self-contained support features in future avionics, specification of interfaces between the new avionics equipment and ground support equipment, and design of advanced ground support systems to service the new avionics.

3. The Support Equipment Program for Avionics Readiness is a coordinated, unified program that will provide the necessary direction for improving avionics supportability. It consists of the following three interrelated parts:

   a. Avionics Systems Readiness

   b. Avionics Ground Support Equipment Performance Augmentation

   c. Non-Avionic Ground Support Equipment Performance Augmentation

## B. RECOMMENDATIONS

1. The Support Equipment Program for Avionics Readiness (SEPAR) is a unified support equipment plan and should be implemented as proposed. In order for this program to benefit new major weapons systems planned for the 1980-2000 time frame, its work should begin now.

# III. TABLE OF CONTENTS

# IV. SUPPORT EQUIPMENT PROGRAM FOR AVIONICS READINESS

## A. GENERAL

1. The Naval Aviation Plan has indicated that the acquisition of a number of major weapons systems is planned for the 1980-2000 time frame. These new systems will rely heavily on advanced electronics. Consequently, the Avionics Readiness Program (ARP) and the Support Equipment Program for Avionics Readiness (SEPAR) have been developed to establish a firm technology base, to provide design and management aids, and to generate procurement specifications necessary to obtain reliable and supportable avionics equipment in these new systems.

2. Electronics/avionics equipment has claimed a larger share of each new weapons system. Electronics are commonly fully integrated with each new weapons system such that the new system is fully dependent on the reliability of its electronics subsystems. Furthermore, the technological growth of electronics has been more rapid than that of any other field of military technology. Since this growth will flounder if left undirected, the ARP and SEPAR have been created to provide the basis for the necessary direction.

3. Statistics [2,3] have shown that the increasing complexity and parts counts of weapons systems electronics have resulted in decreasing systems reliability, in spite of increased reliability of each individual component. In order to reverse this trend during the 1980-2000 time frame, the SEPAR must be implemented now to achieve the necessary readiness, reliability, and supportability. The success that has been achieved in obtaining performance suggests that similar success can be obtained with respect to readiness by applying similar attention to the design, specification, and demonstration of readiness features. The Navy must be able to specify accurately and distinctly the design requirements to meet readiness goals. Industry must be responsive to the need to develop equipment that is reliable, maintainable, and supportable, with these features being demonstrated.

4. The Support Equipment Program for Avionics Readiness provides the Navy with the means to achieve substantially improved avionics readiness and to continually evaluate that readiness. The program will accomplish these goals by:

a. Including critically selected test, maintenance, and support features as an integral part of the avionics end item.

b. Developing avionics support systems simultaneously to the development of the primary avionics equipment.

c. Requiring demonstration of the supportability of the avionics end item.

d. Improving the readiness features of the support equipment.

e. Developing an effective reporting system for the continual evaluation of reliability, maintainability, and supportability.

f. Establishing a cost accounting system capable of providing data on full life-cycle costs of any avionics subsystem, including costs for research, development, testing, design, procurement, operations, and maintenance.

5. The SEPAR will be subjected to continual assessment and revision of tasks so that it maintains the flexibility to effectively attack the ever changing readiness problems. The plan is not a regimented collection of specific tasks, but rather a flexible program that is attuned to problems and developments and capable of achieving results. In order to remain progressive in nature, the SEPAR must maintain this flexibility and alertness.

6. As part of the investigation of electronics/avionics technology trends and primary equipment trends, a major function of the SEPAR is the continual assessment of the elements that affect or will be affected by the equipment, applications, and methods which are the end products of the program. Areas of this continuing assessment include the following:

a. State of the art of avionics readiness on a global basis, including both U.S. military forces and commercial air services.

b. Fleet operating procedures, requirements, limitations, manpower levels, skills quality and distribution, and training programs.

c. Logistics problems related to support.

d. Avionics growth characteristics in terms of heat per unit volume, weight per unit volume, functional density per unit volume, cost per unit volume, installation efficiency, etc. Careful attention will be paid to aircraft ability to support the additional loading.

e. Cost trends of avionics support including parts cost, personnel cost, development cost, and software cost.

7. The Support Equipment Program for Avionics Readiness has been divided into four interrelated and closely coordinated parts. These three parts and their primary functions are:

a. Avionics Systems Readiness. This activity will recommend readiness features to be incorporated within avionics equipment, will specify interface requirements between avionics and ground support equipment, and will specify the proper ground support equipment to service the avionics.

b. Avionics Ground Support Equipment Performance Augmentation. This activity will improve readiness features of avionics ground support equipment.

c. Non-Avionic Ground Support Equipment Performance Augmentation. This activity will similarly improve readiness of non-avionic GSE.

B. AVIONICS SYSTEMS READINESS

1. The main thrust of the Support Equipment Program for Avionics Readiness (SEPAR) will be directed toward improving readiness of avionics equipment by substantially increasing reliability, maintainability, and supportability of the equipment. Historical data[2, 3] has shown that as avionics systems become more complex and more costly, their readiness features (such as mean time between failure, mean time to repair, etc.) have deteriorated, and support costs have soared. This program is aimed at reversing this trend by specifically attacking the problems of reliability, maintainability, diagnostic capability, and repairability. The SEPAR will specify readiness features in the design and manufacture of new equipment and will design improved ground support equipment. At the same time, the SEPAR will promote the requirements to minimize the total life-cycle costs (LCC) of avionics systems and their support.

2. The Support Equipment Program for Avionics Readiness will provide the Navy with the technological capability, motivation, and organization to specify readiness and support requirements for future avionics systems to the same degree that performance is now specified. The SEPAR is designed to anticipate and predict future avionics equipment developments and to advance the design of support systems at a corresponding pace. The SEPAR will improve readiness by developing support concepts. This development will include evaluations of self-contained features in future avionics equipment, interfaces between the new avionics equipment and ground support equipment, and advanced ground support systems to service the new avionics. The SEPAR will interact with the ARP to recommend new technology in design when it is ready for implementation. An accurate estimate of optimum timing for technological application is a primary goal of the ARP.

3. Avionics readiness[2] is an integral part of avionics systems design. Readiness is an important consideration in all stages of implementation of avionics systems -- research and development, design and procurement, prototype and production, test and evaluation, deployment and operation, and maintenance and support. In order to meet the readiness needs of avionics systems, the Support Equipment Program for Avionics Readiness consists of the following corresponding stages:

a. Research and Definition. Review long range weapons systems planning and estimate the speed and direction of technology growth and its impact on future systems. Research electronics technology advances and evaluate their applicability to avionics. Predict readiness requirements for future avionics systems and define these as objectives to be met by the program. Develop an effective test and repair philosophy and distinguish between self-contained and shop test requirements. Develop a technology data base for program predictions, planning, cost estimates, and evaluations.

b. Development and Application. Develop basic diagnostic and maintenance procedures for the anticipated avionics. Apply new or existing technology to the anticipated weapons systems and subsystems. Optimize the interrelationships between the self-contained readiness functions and the external support systems. Develop, apply, and evaluate design concepts to achieve a maximum benefit.

c. Design and Specification. Design and specify avionics with readiness features and support systems hardware to the extent that prototypes can be built by industry or by the Navy. The self-contained readiness features must be included as an integral part of the avionics end item from the design stage forward through design verification, acceptance testing, and final production. Likewise, SEPAR must accomplish a simultaneous design of external support systems matched to the end item. It is the purpose of the SEPAR to recommend the self-contained items and requirements and to specify interfaces between the avionics end item and the external support equipment. The SEPAR will develop specifications requiring demonstration of supportability of the avionics end item. Specifications must give developers and manufacturers specific and quantized requirements, directions, goals, and limits with respect to the support objective.

d. Cost Evaluation and Tradeoffs. Total system life-cycle costs (avionics equipment plus readiness and support costs) will be evaluated repeatedly from the early research stage through deployment and operation. It is important that for systems with adequate capability that total life-cycle costs (LCC) be the criteria for evaluation, rather than initial equipment acquisition costs alone. Tradeoffs will normally be made among performance, degree of readiness, schedule, etc. so that life-cycle cost goals can be achieved. The SEPAR plays a key part in the cost evaluation and tradeoff process. Since life-cycle costs are most strongly influenced during the design and specification stage, it is imperative that the SEPAR keeps pace with or precedes the avionics equipment program.

e. Prototype and Testing. Prototypes of both the avionics equipment and its support equipment will be manufactured according to design requirements and specifications. The SEPAR will follow testing and evaluation of prototypes to ensure operational and readiness capabilities and supportability. The SEPAR will utilize these evaluations of readiness features and supportability for approval, modification, or rejection of the system.

f. Procurement and Production. When the equipment has been deemed acceptable, final specifications for production will be issued. The SEPAR will provide engineering certification at this stage to ensure that readiness and supportability are specified into the avionics equipment. The SEPAR will issue specifications for support equipment associated with the avionics.

g. Deployment and Operation. The ARP will monitor the performance and readiness of equipment during deployment and operation. Feedback on acquisition costs, operating and maintenance costs, reliability, and maintainability for both the avionics and the support equipment will be valuable for future acquisitions. This feedback will also serve as an evaluation of the Support Equipment Program for Avionics Readiness.

4. The ultimate objective of the Support Equipment Program for Avionics Readiness is to enable the Navy to develop, specify, and evaluate readiness and support requirements for future avionics systems in meaningful, quantitative terms. This capability shall enable the Navy to improve significantly the readiness of avionics systems while, at the same time, minimizing the life-cycle costs of these systems. These objectives can be fulfilled by achieving the following goals:

a. Improve reliability of avionics equipment.

b. Develop new procedures and equipment for testing existing and future avionics equipment.

c. Provide adequate self-contained testing capabilities and/or external support equipment to improve maintainability and reduce mean times to repair.

d. Develop diagnostic equipment with simplified readouts to facilitate diagnostic procedures.

e. Establish testing procedures that will isolate a fault to an easily replaceable component rather than a complete assembly.

f. Increase the partitioning of weapons replaceable assemblies and reduce specialized repair activities.

g. Determine the true value and feasibility of extended manufacturer warranties to improve readiness and maintainability.

h. Develop effective cost controls. Organize a cost management center for analysis, consultation, and guidance to support the cost effective acquisition of avionics equipment.

i. Increase utilization of commercial electronics industry practices and standard products to reduce unit costs.

j. Establish the capabilities to predict with reasonable accuracy future equipment operational requirements and directions of future technology growth.

k. Accumulate and evaluate operational data to establish a standard for evaluating and specifying readiness of avionics equipment.

C. AVIONICS GROUND SUPPORT EQUIPMENT PERFORMANCE AUGMENTATION

1. Although the basic development of new avionics ground support equipment (GSE) to support the new avionics equipment is part of the Avionics Systems Readiness task, the continual upgrading of GSE to improve its performance and readiness falls under this part of the Support Equipment Program for Avionics Readiness. Ground support equipment must exhibit a degree of readiness comparable to the primary avionics equipment, or it becomes a bottleneck to the overall operation. Avionics equipment readiness is reduced without the proper support equipment readiness to complement it.

2. Technological development of ground support equipment (GSE) has historically lagged that of weapons and equipment systems, even to the extent that the lack of GSE has severely restricted operations in some cases. This problem has been caused by lack of coordination between primary equipment and GSE development and by the mistaken opinion that GSE can be developed after the primary systems are operational. Another improper assumption has been that existing GSE used on other systems will adequately service the new systems; invariably this is not the case because of technological advances and changes in the new equipment. Consequently, the SEPAR has undertaken the duty of upgrading avionics GSE technology to keep pace with the primary avionics equipment.

3. Maintaining the readiness of avionics ground support equipment requires a two-fronted attack. First, advanced GSE must be developed parallel to the advanced avionics systems that it will service; this activity is included in the Avionics Systems Readiness part of the SEPAR. Secondly, advances in electronics technology must be applied to existing avionics ground support functions to improve readiness, usefulness, and performance. This is the charter for the Avionics Ground Support Equipment Performance Augmentation part of the SEPAR.

4. This activity will strive to improve readiness, maintainability, and operational performance of avionics ground support equipment. It consists of a staged program very similar to that for the advancement of Avionics Systems Readiness. The Avionics GSE Performance Augmentation plan consists of the following stages:

a. Research and Definition. Research electronics technology advances and evaluate their applicability to avionics GSE. Predict future technology developments and determine their impacts on GSE. Develop a technology data base for program predictions, planning, cost estimates, and evaluations.

b. Development and Application. Develop new technology and apply it to ground support equipment. Anticipate future GSE requirements and apply new technology accordingly. Develop readiness features for GSE to improve the reliability and serviceability of the GSE.

c. Design and Specification. Design and specify avionics ground support equipment with improved readiness and performance characteristics so that prototypes can be built by industry or by the Navy. The same system readiness requirements will be specified on GSE as on the avionics themselves.

d. Cost Evaluation and Tradeoffs. Life-cycle costs (LCC) of GSE will be evaluated repeatedly. Existing GSE costs and readiness will be evaluated to isolate weaknesses that should be corrected. Tradeoffs will be made among performance, degree of readiness, schedule, etc., so that acceptable life-cycle costs are achieved. Effective cost reporting and management techniques will be developed.

e. Prototype and Testing. Prototypes of improved ground support equipment will be built and tested to evaluate performance and readiness.

f. Procurement and Production. Final specifications will be issued, and the ground support equipment will be produced.

g. Deployment and Operation. The Support Equipment Program for Avionics Readiness will monitor the performance and readiness of ground support equipment during deployment and operation. Feedback on costs and operation of the GSE will become part of the data base for future projects.

5. The objective of the Avionics Ground Support Equipment Performance Augmentation plan is to improve and upgrade GSE to achieve the performance and readiness that is expected of this equipment. This objective can be fulfilled by achieving the following goals:

a. Incorporate new technology into the GSE.

b. Improve reliability, diagnostic capability, and repairability of the GSE.

c. Simplify readouts of GSE and provide for human factor considerations.

d. Develop effective engineering/readiness/cost management techniques.

e. Develop a data base of information useful in the technological improvement of avionics GSE.

## D. NON-AVIONIC GROUND SUPPORT EQUIPMENT PERFORMANCE AUGMENTATION

1. Another part of the Support Equipment Program for Avionics Readiness is directed toward the application of avionic technologies to non-avionic ground support equipment performance augmentation. This activity is a logical extension of the SEPAR efforts directed at avionics systems readiness and avionics GSE. The effectiveness of the readiness of avionics in general can be enhanced through non-avionic GSE improvement. Since the SEPAR contains many resources and capabilities for this endeavor, it is reasonable to extend its activities to non-avionic GSE.

2. Particular attention will be given to problems in non-avionic systems that may lend themselves to electronic/avionic type solutions, although efforts will not be limited to such cases. This activity will identify and investigate problems in non-avionic GSE systems, such as mechanical, electro-mechanical, hydraulic, control, power, etc., and utilize SEPAR resources to develop improvements. Included under this domain will also be the support equipment required to maintain other avionic or non-avionic support equipment.

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# APPENDIX A

A. GENERAL. This appendix contains eleven tasks that are currently proposed under the Avionics Systems Readiness part of the SEPAR. Each task is outlined in detail in the following pages.

A-1. Analog Hardware Testability

A-2. Software

A-3. Development of Test/Repair Philosophy for Future Applications

A-4. Aircraft System Test

A-5. Shop Tester Requirements

A-6. Weapons System Support

A-7. Digital Hardware Testability

A-8. Advanced Digital Test Program Generation System

A-9. Self-Contained Test (SCT)/Reliability Considerations

A-10. Self-Contained Test (SCT) Versus Shop Test

A-11. Automatic Test Program Generation (ATPG) as a Testability Evaluation Tool

# APPENDIX A-1

A. TASK TITLE: ANALOG HARDWARE TESTABILITY

B. OBJECTIVES

1. To investigate the implementation of selected traditional analog functions utilizing digital circuitry.

2. To design and implement an analog device functional simulator for overall new anolog design performance and supportability investigations.

3. To develop design guidelines for the incorporation of self-contained test (SCT) into analog devices.

4. To develop an analog hardware design classification system to allow the easy transfer of software elements for the test of analog device functions, interfaces, and circuits by categories.

C. WORK STATEMENT

1. Tasks

a. Analog Devices Investigation

(1) Develop an analog hardware design classification system.

(2) Survey current developments in analog circuit technology.

(3) Determine what subset of analog circuit technology currently being developed will mature in the 1980-2000 time frame and what subset will probably find applications in avionics and avionics GSE.

b. Switch from Analog to Digital

(1) Examine trends toward greater use of digital circuits in lieu of analog and determine to what extent this continues.

(2) Determine what circuit functions which are now analog can be expected to transition to digital. Develop guideline documents for transitioning.

(3) Investigate testing techniques for circuit elements expected to remain in the analog domain through 2000.

c. Development of an Analog Devices Simulator

(1) Develop an analog-simulating computer algorithm for fault isolation that is based on the compensation theorem.

(2) Investigate the ability to expand the size of the analog circuits to be modeled through the development of a large-scale computational capability using parallel, multiple processor techniques.

d. Development of Design Guidelines and Constraints for the Integration of SCT into Analog Circuits.

(1) Develop guidelines for on-line SCT that include consideration of operator modes, system functions, and maintenance purposes.

(2) Develop guidelines for off-line use of SCT that verifies system uses and tolerance tunnels.

2. Approach

a. ATE experience has shown that digital designs are more amenable to analysis of failure modes, fault detection, and isolation, and to the application of standardized test equipment than are analog devices. A study will therefore be made to determine which common analog functions may be replaced by digital circuitry in 1980-2000 avionics equipment, and what conditions limit this replacement.

b. For those analog functions that cannot be replaced by digital circuitry, a design tool to increase testability is required. To this end, an analog circuitry simulator will be developed which will include the capability to measure the effect of design changes on testability. Specifically, the simulator shall have outputs indicating the effectiveness of SCT and test point placement and shall be able to be used as a verification tool for equipment self-check and self-test capability, and as partial verification for any test program set delivered with the equipment.

c. Additionally, design guidelines and constraints including methods and techniques for incorporating SCT will be developed for analog equipment in a manner similar to the Advanced Avionic Fault Isolation System (AAFIS) concept developed for digital circuits. These guidelines and constraints will be prepared in a form which can easily be imposed on a contractor via procurement specification and will complement the simulator in that the methods and techniques developed for analog testability shall be readily simulated and evaluated on the simulator.

d. The following approach actions will be detailed for this development:

(1) Review recent issues of IEEE transactions on circuit design and other appropriate technical journals to determine current trends in circuit design and component circuitry.

(2) Review IR & D reports by various manufacturers for those working on component technology. Visit those operations doing the most promising work.

(3) Convene a meeting of interested industrial experts to have discussion and comment on analog circuitry developments and applicability to avionics of the 1980-2000 time frame. Submit preliminary analog design/test classifications.

(4) Prepare technical report on analog component/circuit expectations with conclusions and substantiating data.

(5) Continue and expand ongoing investigation of analog circuit modeling techniques applicable to test design and evaluation.

(6) Test the feasibility of using a combination of known, proven, analog modeling algorithms with parallel, multiple processor computational techniques.

(7) Develop an analog modeling capability suitable for test design evaluation.

(8) Develop guidelines for increased use of digital circuit techniques in lieu of analog.

(9) Develop guidelines for SCT and off-line testing of residual analog circuits.

3. Limits and Constraints. The development of an analog simulator will attempt to build on those circuit simulators in existence.

4. Required Support. The funds required for this effort cover both in-house and contractual analysis. A considerable amount of computer time for data processing is anticipated. A multi-processor computer will have to be developed or simulated for a second phase study in the development of an efficient algorithm for analog simulation. A cooperative effort of several Navy facilities will be necessary to achieve the internal and contracted goals contained herein.

5. Interfaces. This work interfaces directly with any task relating to test and repair philosophy.

D. RELATED EFFORTS. This work directly impacts SCT versus shop test considerations. It also impacts considerations of avionics testing, pre-acceptance test and demonstration, and parameterization and quantification of Fleet and avionics readiness factors.

E. MAJOR CONTRACTS

1. Estimated total contract expenditures for this task are 1104K.

2. Contract services will include the following assignments:

a. Contractor shall conduct a study to determine what common analog functions may be replaced by digital technology, and to determine the limits and constraints upon this replacement.

b. Contractor shall develop methods, techniques, and guidelines for the design of testable analog circuitry. This work shall include guidelines for the incorporation of SCT into analog designs and shall provide techniques for verification of testability.

c. Contractor shall develop an analog circuit simulator capable of being used as a design and verification tool for the performance and testability of analog circuits. An existing analog simulator shall be used as the starting point for this effort. The simulator shall simulate active and passive analog elements, at the basic component level, the functional level, or combinations of both. It shall have outputs indicating the best test point nodes, and shall also have outputs indicating the overall testability of the device being simulated.

d. Contractor shall develop software or modify existing software to formulate a nested software package for the functional testing of a compatible sequence from a classification series. Software will be adaptable to device outline specifications; e.g., pin locations and interface conditions.

F. DELIVERABLES

1. A final report will be prepared on the basis of the results of the investigations pertaining to the implementation of analog functions using digital techniques/methodologies, analog SCT implementation, and the simulation of analog devices.

2. An analog design/test classification system shall be established, and an initial nested software package developed.

3. An analog device simulator program including capability to include and measure the effects of self-contained test will be delivered.

G. FOLLOW-ON WORK

1. This effort will be integrated with, and provide inputs to, other related efforts. In particular, it is anticipated that the simulator will be used for acceptance tests of various analog devices procured by the Navy. This may require minor modification at a later date. The integration of analog testability considerations into a hybrid testing system will be a natural outgrowth of both analog and digital testability studies.

2. Depending on the outcome of multiple processor computation, a hybrid (hardware and software) analog network simulator system will be sought for analog automatic test program generation (ATPG).

3. The effectiveness of nested software for functional testing will indicate the desirability of a like technique for standardization of circuit design modules, cards, processors, and the like.

# APPENDIX A-2

A. TASK TITLE: SOFTWARE

B. OBJECTIVES

1. To investigate and develop software concepts and criteria for an integrated hardware/software/support avionics design concept which will reflect a total life-cycle cost reduction for future avionics.

2. To investigate presently existing software generation techniques and develop improved capabilities for accurate verification and cost effectiveness for future test and operational programs.

C. WORK STATEMENT

1. Tasks

a. Analysis of present directions in development of software compatible with current hardware and new technologies

(1) Survey existing software capabilities and software tools.

(2) Determine deficiencies in capabilities of existing software and tools and develop those areas of deficiency.

b. Analysis of needs for compatibility of software techniques and hardware design

(1) Develop software concepts and criteria to reflect unified design/fabrication/test philosophy for future avionic equipment.

(2) Establish design requirements for software/support coordination.

(3) Determine test techniques to optimize support/software capability during design status.

2. Approach

a. The following approach actions will be taken:

(1) Investigate literature and ongoing programs in the field.

(2) Classify requirements for and objectives of software generation (off-line, SCT, etc.).

(3) Analyze comparative methods within classifications to determine the most cost effective methods of software generation and verification.

(4) Evaluate comparative methods of software generation and verification on the basis of their utility in the cost effective design/development/support of military avionics and the procurement and support requirements of the ARP.

b. Every effort will be made to develop methodologies of design, test, and support which will allow and foster the generation of common, transferrable test software throughout all levels of test, from factory acceptance to 0-level maintenance. These concepts will be applied to the development of the analog and digital simulators of this section.

3. Limits and Constraints. The concepts and criteria developed will be based on the measurement techniques, computer capabilities, and avionic technology realistically estimated to be available in the early 1980's.

4. Required Support. The funds required for this task cover in-house and contractual analysis, date acquisition, and related travel. In-house microcomputer processing and multidimensional computer interface will be required capabilities.

5. Interfaces. This work has direct impact on Analog Hardware Testability and Digital Hardware Testability. The results of the Technology Projection Summary have impact on this effort.

D. RELATED EFFORTS. This work will have direct impact on Aircraft System Test and Weapons System Support tasks. In addition, it will impact Shifting Cost Centers and Parameterization and Quantification of Readiness Factors tasks, which have not been included in this appendix.

E. DELIVERABLES. A report shall be generated containing the survey results and conclusions, and the recommended software generation methodology, including evaluation parameters, verification techniques, and a description of any new software tools considered necessary.

F. FOLLOW-ON WORK. The survey efforts will be repeated on a periodic basis to determine the most cost effective software generation methods. Development of new software tools recommended by the study may be pursued.

# APPENDIX A-3

A. TASK TITLE: DEVELOPMENT OF TEST/REPAIR PHILOSOPHY FOR FUTURE APPLICATIONS

B. OBJECTIVE. To develop an effective test and repair philosophy for the Navy to complement the overall maintenance plan for the 1980-2000 time frame.

C. WORK STATEMENT

1. Tasks

a. Analysis of technology impacts on current test and repair concepts.

(1) Determine how level of repair will be influenced by advances in technology.

(2) Determine how costs which are established by technology will influence maintenance.

(3) Determine what modifications or adaptations upon technology can reasonably be expected to result from the requirements of test/repair.

b. Development of a test and repair philosophy utilizing inputs from item "a", above.

(1) Determine the range of maintenance requirements that will be encountered.

(2) Study the alternatives available to determine who may best accomplish what support function.

(3) Determine what techniques, tools, and training are to be provided.

2. Approach

a. The following approach actions will be taken:

(1) Investigations will be conducted to determine the level of effort and skills required to achieve shop replaceable assembly (SRA) repair.

(2) Establish when the necessity to repair is best determined by system, board, or module evaluations.

(3) Study the requirements and capabilities of self-contained test versus external testing.

(4) Monitor the hardware testability features established in other tasks of the ARP.

(5) Analyze the advantages and disadvantages to be achieved by the application of advanced technology by a study of the corresponding trade offs between design features and the support requirements.

(6) Coordinate maintenance philosophies within all tasks of the ARP.

(7) Convene a symposium, meeting, guide committee, workshop, or whatever is required among interested parties to coordinate maintenance philosophy within ARP tasks.

3. Limits and Constraints. This effort is limited by the capability to accurately predict the trends and developments of future technology. Periodic revisions will be required.

4. Required Support. The funds required for this effort cover both in-house and contractual analysis. Sufficient funds to establish a necessary task force/workshop should be allocated.

D. RELATED EFFORTS. Related efforts of SEPAR and ARP include SCT vs Shop Test, Shop Tester Requirements, Avionics Testing, and Cost Indices.

E. DELIVERABLES. A final report on Test/Repair Philosophy will be prepared.

G. FOLLOW-ON WORK. Applications of the Test and Repair Philosophy will be evaluated to revise or refine the initial developmental results.

## APPENDIX A-4

A. TASK TITLE: AIRCRAFT SYSTEM TEST

B. OBJECTIVES

1. To develop standards and guidelines for an organizational level test concept that will be adequate for the determination of aircraft readiness and will also minimize support hardware and use hardware and software SCT which is transferrable to higher levels of maintenance.

2. To investigate the capability and economy of SCT as a replacement for O-level special support equipment.

3. To determine limits of operation of aircraft equipment which will indicate the aircraft's ability to perform a mission, and to relate these limits to those specified at procurement.

C. WORK STATEMENT

1. Tasks

a. Determine limits of operation for aircraft systems sufficient to determine readiness for mission performance. Relate these to procurement specification limits.

b. Recommend best utilization of SCT to provide indication of readiness at O-level.

c. Develop methods to assure full utilization of O-level hardware and software SCT at all levels of maintenance.

d. Develop standards and guidelines for an integrated O-level test concept assuring continuity of test and upward compatible software/hardware SCT.

2. Approach

a. An initial investigation will be conducted to determine the relationship between the various levels of test, the test limits (particularly that which determines minimal mission acceptable limits), and the methods used to determine the acceptance/rejection criteria. The steps to be followed for this investigation are:

(1) Develop interfaces of new weapon systems, NAVAIR, and NADC.

(2) Review journal and papers relating to aircraft missions and mission limits.

(3) Attend meetings and conferences.

(4) Develop procedure/methodology for establishing realistic mission acceptable limits.

b. Following this investigation, the feasibility and economy of using SCT to determine if a weapons systems is within these limits of operation will be determined. SCT functional modules (at the SRA level) will be investigated and recommended if found desirable. Both hardware and software SCT will be investigated and trade off recommendations made. Some tradeoffs that must be made are:

(1) The addition of test modules (stimulus, measurement) versus SCT, as part of the functional circuitry (LSI chip).

(2) Manual versus automatic versus semi-automatic testing at O-level.

(3) Cost versus maintainability versus reliability.

(4) The numbers of test points required.

c. Concurrent with the SCT effort, methods of test specification and validation will be developed which can assure full utilization of O-level test capability at higher maintenance levels, thus minimizing proliferation of test hardware/software/documentation and providing a more effective total support concept. Towards this goal, review current aircraft programs to assess areas where SCT is used at more than one level of maintenance. Visit contractor plants to obtain ideas/methods for insertion into a specification.

d. Finally, standards and guidelines shall be developed for the specification, development and validation of an effective, integrated test and repair capability at the O-level. Determine the mix of PGSE and CGSE testers required. Investigate new guidelines for determining the level-of-repair.

3. Limits and Constraints. The main constraints on this effort are the economy of future SCT capability and the difficulty of producing compatible software that contain a real time interface. The classified and proprietary nature of mission oriented material must also be considered.

4. Required Support. The funds required for this effort cover both in-house and contractual analyses, and related travel. No special equipment or facilities are required.

5. Interfaces. In the technology application area, this effort will have impact on Shop Tester requirements and SCT versus shop test tasks.

D. RELATED EFFORTS. This effort will receive inputs from SEPAR and ARP tasks Basic Elements and Technology Projection Summary. It will provide outputs to Avionics Testing, Weapons Systems Support, Subsystem Implementation, Weapon Systems Design, and Preacceptance Test and Demonstration.

E. DELIVERABLES

1. Report: Mission acceptable limits of operation and relationship to procurement specification.

2. Report: Analysis, conclusions, and recommendations of SCT study.

3. Report: Analysis, conclusions, and recommendations of hardware/software SCT at higher maintenance levels.

4. Draft Standard: For an integrated 0-level test concept.

F. FOLLOW-ON WORK. Implement standards and guidelines for use on fleet hardware.

# APPENDIX A-5

## A. TASK TITLE: SHOP TESTER REQUIREMENTS

**B. OBJECTIVE.** The object of this task is to determine shop tester requirements based upon avionics test/support requirements and maintenance philosophies, and to further define the next generation test equipment specifications and standards.

## C. WORK STATEMENT

1. Tasks

a. Identify present day capabilities applicable to future requirements. The outputs of several present GSED programs will be analyzed to determine what present day capabilities can be carried into the future and be expected to meet the requirements. Present requirements which are not handled adequately will be investigated and documented. These will be used together with anticipated future needs as a basis for determining the capabilities required in future test equipment.

b. Determine future requirements and technologies. The NAVAIRENGCEN-GSED capability on CGSE (both ATE and non-ATE) will be utilized to determine future requirements for shop test. This effort will look at future planned avionics developments and their need for off-line support. New technologies will be investigated to ascertain the test techniques that will be needed as they present themselves in Naval avionics.

c. Define future test equipment. New developments in electronics technology will be closely followed to evaluate the potential impact they may have on the testing and support function. The new developments in the microprocessor area will be looked at to determine the effect this technology will have on test equipment. The need and feasibility of federated ATE systems will be evaluated.

2. Approach. A baseline will be established by determining the capabilities of present test equipment. Early identification of projected support requirements will be established. Specific test parameters will be identified. Present and advanced support equipment technologies will be defined to establish the potential capability of providing total system support with the lowest life-cycle cost impact. Tradeoffs will be based on both economic and non-economic consideration. This data will be utilized to establish future support requirements in each specific subsystem, i.e., processors, etc. Individual test techniques will be analyzed to establish the most expedient approach to equipment utilization, UUT (Unit Under Test), interface, and the throughput necessary to optimize the support posture.

3. Limits and Constraints. Limitations may exist in gathering advance proprietary information.

4. Required Support. The funds required for this task cover in-house, data acquisition efforts, and related travel.

5. Interfaces. This task will interface with the SCT versus shop test task.

D. RELATED EFFORTS. This task will interface with SEPAR and ARP tasks, Technology Assessment and Warranties, and will assist in the development of ATE requirements for Subsystem/System Design Effort.

E. DELIVERABLES

1. Report on projected shop level test requirements including:

a. Present capabilities to meet future requirements.

b. Future requirements and technologies.

2. Future test equipment definition.

F. FOLLOW-ON WORK. Implement results of this study into the design (specs) of a test system capable of meeting future requirements.

# APPENDIX A-6

A. TASK TITLE: WEAPONS SYSTEM SUPPORT

B. OBJECTIVE. To develop standards and procedures for weapons system support of post 1980 weapons systems.

C. WORK STATEMENT

1. Tasks

a. Development of fault detection and isolation techniques

b. Development of standard software interfaces and routines at ORG and IMA levels of test

c. Determination of test requirements for each level of test

d. Development of an overall Weapons System Support Matrix

2. Approach

a. The first step will be to examine the integrated test design specification developed in another task. The thrust of this examination will be to integrate tolerance cone testing methods into the fault detection and isolation techniques to be developed.

b. The next step will be to develop techniques for the following fault detection and isolation modes:

(1) Multiple hard failure

(2) Single and multiple soft failures

(3) Intermittent failures

(4) Nonsymptomatic failures

(5) Indirect failures

c. Identify and review current methods being practiced in industry. Combine best methods into a set of guidelines to cover the above failure modes. Standard software interfaces and routines at the ORG and IMA levels of test will be developed concurrently with the fault detection and isolation techniques outlined above. Review specifications and concepts developed for Avionics Readiness Programs and identify current method being employed in industry.

d. Following this, test requirements for each level of test will be developed. These will include but not be limited to range, accuracy, granularity, resolution, repeatability, stability, sensitivity, threshold, and reliability. Review test requirements presently used in aircraft support programs. Utilize both in-house and out-of-house sources. Generate a set of guidelines utilizing these inputs.

e. An overall Weapons System Support Matrix will be developed utilizing the test requirements, fault detection, and isolation techniques developed in this section to establish a support posture (hardware and software) for organizational and IMA levels of maintenance and associated specification requirements. Review the requirements and objectives of the avionics readiness program sections that have been completed. Identify common equipment parameters and characteristics in a matrix to optimize test redundancy and special support equipment.

3. Limits and Constraints. This task will be constrained by the ability to predict and project future avionics ATE requirements and SCT capabilities.

4. Required Support. The funds required for this task cover both in-house and contractual analysis, data acquisition efforts, and related travel. No special equipment or facilities are required.

5. Interfaces. This task utilizes outputs of Avionics Testing and will be applied to Subsystem Implementation and Weapon System Design.

D. RELATED EFFORTS. The effort in this task plan utilizes results of Aircraft System Test task.

E. DELIVERABLES

1. Fault detection and isolation techniques document

2. Standard software interfaces and routines document

3. Test requirement for each level of test

4. Overall weapons systems support matrix

F. FOLLOW-ON WORK. Implement standards and procedures for weapon system support in fleet.

# APPENDIX A-7

## A. TASK TITLE: DIGITAL HARDWARE TESTABILITY

## B. OBJECTIVES

1. To investigate and review the presently available design and testing techniques for digital circuits. Improvements for these methods will be sought. Optimum testing for each type of circuit will be determined.

2. To survey and compare presently available digital simulator programs. Ratings will be developed for the testers, simulators, and software involved in order that testability may be quantified by circuit type.

3. To develop a "Guide for Design for Digital Testability". This will aid the designer of avionic systems to include testability among his design criteria.

## C. WORK STATEMENT

1. Tasks

a. Navy experience will be utilized to determine which classes of digital circuits have been readily and thoroughly testable. Attention will be given to possible solutions for the more difficult problems.

b. The Navy inventory and projected plans will be studied to determine what are the proportions of the types of circuits involved and thus what is the magnitude of the respective testing needs.

c. Perform a literature search to determine the successful techniques which have been employed.

d. Develop a "Guide for Design for Digital Testability." This guide will include effectiveness of tests, testers, and simulators by circuit type.

e. Study present prime hardware and technology forecasts to determine a basis for commonality in digital circuitry.

f. Study available software and simulators in order to establish test software commonality.

g. Perform a comparison on available digital simulators to establish the effectiveness of ATPG by circuit type.

h. Develop a digital fault detection matrix that will permit a comparison of digital designs by circuit type, technology, and size for the effects upon testability of the testing technique, tester, and software package. The prediction of testing performance must be verified.

2. Background

a. Initially, ATE was successfully employed for the quantity testing of identical, mass-produced components. It proved especially effective where several simple checks were desired upon each testable item. As technology has advanced and the devices have become more complex, the desired tests have become more varied. This has tended to place more stringent requirements on the tester and the software designer, and to demand more versatility on the part of ATE operators and operations.

b. In the limit of this process, when ATE has been applied to medium or small numbers of vastly complex circuits, the power of computational testing has tended toward great disappointment.

c. The added requirement of providing identical testing for nearly identical prime equipments in widely separated locales has produced a proliferation of testers varying in sizes, quantities and methods. Adding to this the normal deviations in complex digital systems has created a nearly unmanageable software and configuration management difficulty.

d. Typically the most effective use of ATE for avionic support has been in the testing of digital circuitry. Here, as in the beginning, the elemental basis is that there are large numbers of identical checks to be run on large quantities of similar items, branches, gates, etc.

e. The problems remain however. There are widely differing circuit approaches, with a multiplicity of test techniques. The situation has become one where it is not always easy to define the actions that are required to solve the difficulties.

f. This task is to increase the testability of digital avionics hardware, and several efforts will be performed to complete the task.

3. Approach

a. Data will be collected from past and current programs on the success of testing various types of circuits and the use of simulators in predicting and evaluating the percentage of fault detection. This data will be based on previous investigations into the testability of circuits of various Naval avionics systems through the use of both private and Navy-owned simulators.

b. In conjunction with this data collection, a literature search will be performed to determine other methods which might have applicability in providing criteria for increasing the testability of digital designs.

c. From these efforts, a "Guide for Design for Testability" will be developed. This will contain the necessary information to incorporate testability features in the design criteria of the avionic circuitry. The guide will provide assistance with all types of logic families and reduce the high recurring costs of testing, diagnosing, and repairing of logic networks.

d. The following approach actions will be taken for this task:

(1) Classify types of digital circuits as for ease of test and of test generation.

(2) Determine the overall proportions of each class of circuit to be expected. Among these are combinational and sequential, synchronous and asynchronous, and the various varieties of logics and technologies, packaging scales, etc.

(3) Determine the applicability of the most likely testing techniques: single and multiple SA testing, insertion and simulation, path sensitizing, algorithm factoring.

(4) Review the literature for combinational circuit testing. Determine the potential benefits of SCT, parallel testing, choosing optimum circuit sizes, and test points.

(5) Review the literature for sequential circuit testing. Include determinations for effectiveness of testing due to mode conversions, statistical testing, and clocking variations.

(6) Make a review of current and oncoming hardware to develop areas of commonality. Study the impact of microprogrammable devices.

(7) Review software for areas of commonality. Include microprogramming effect.

(8) Make a survey of digital simulators to compare their characteristics and capabilities.

(9) Prepare a fault detection matrix from data acquired relating to effectiveness of tests and ATG.

(10) Determine ratings for the effectiveness of testers from a standardized method to compute ratings.

(11) Determine software effectiveness ratings from a standardized computation.

(12) Develop a "Guide for the Design of Digital Testability" from all the preceding.

4. Limits and Constraints. This task will be attacking the problem of increasing testability of digital circuits with the emphasis being placed on the type of circuitry expected to be in use in the 1980 - 2000 period.

5. Required Support. The funds required for this effort cover in-house and contractor efforts. No special equipment or facilities are required.

6. Interfaces. This work interfaces directly with tasks relating to test and repair philosophies.

D. RELATED EFFORTS

1. Aircraft Systems Test

2. SCT versus Shop Test

3. Avionics Testing/Design

4. Automatic Test Program Generation

E. MAJOR CONTRACTS

1. Estimated total contract expenditures for this task are $350K.

2. Contract services will include the following assignments.

a. Literature search

b. Study hardware

c. Study testers

d. Study software

F. DELIVERABLES

1. Reports will be prepared on the basis of the results of each of the study projects.

2. A "Guide for Design for Digital Testability" will be prepared.

G. FOLLOW-ON WORK

1. Integration into analog and hybrid circuit testing efforts.

2. Verification of design effectiveness.

3. Ongoing rating of designs, testers, and software.

4. Technology updating.

## APPENDIX A-8

A. TASK TITLE: ADVANCED DIGITAL TEST PROGRAM GENERATION SYSTEM

B. OBJECTIVE. To develop a technique which will model functional units such as shift registers, counters, multiplexers, and decoders. This would reduce the core storage requirements required by current test generation systems as technology progresses in the direction of greater packaging density. Specific functions are to be modeled with macrostatements accompanied by parameter lists. This functional modeling technique is to provide for analog type measurements in digital circuitry, providing for dynamic testing and determination of proper switching speeds, pulse rise times, and pulse durations.

C. WORK STATEMENT

1. Tasks

a. Digital Circuit Simulator

(1) Develop a digital circuit simulator which utilizes a functional modeling technique. The functional models are to constitute NSI and LSI chips comprised of shift registers, counters, multiplexers, and decoders. These chips are to be defined individually as a macroblock which may be used repeatedly. This is to be accomplished through utilization of macrostatements with parameter lists. As repeated uses of a particular circuit are encountered, its application will vary. The same statement can be used with a change in the parameter list to accommodate the change in use of the circuit.

(2) The simulator will have to handle critical timing requirements and have the capability of simulating not only stuck-at-zero or stuck-at-one fault modes but also shorts, opens, pin faults, gate faults, and intermittent faults.

b. Algorithm for Test Pattern Generation

(1) Develop an algorithm for test pattern generation for digital circuits. This algorithm must consider synchronous, asynchronous, and mixed circuitry. It must generate tests for sequential as well as combinational circuits. It must determine the percentage of fault detection for the tests it generates. Also, any undetectable faults are to be identified. Techniques of testing for analog type faults, such as proper switching speeds, pulse rise time, and pulse durations, will be incorporated. It will apply a self-initializing test and overcome other types of circuit restrictions.

2. Approach

a. Current test generation systems deal with circuit elements at the gate level, requiring that a flip-flop (multivibrator) be modeled as nine NAND gates. As technology advances, many more circuit functions are packaged in a given volume. This situation will cause the current test generation programs to require too much storage capacity to be effective. This presents the requirement for a technique which will model functional units. This will reduce storage requirements and merely necessitate a parameter list for a specific function.

b. To insure selection of the most competent organization and personnel to develop an automatic test program generation system for the Navy, it will be done competitively. Criteria will be developed in-house describing the system. These criteria will include all aspects needed to satisfy Navy requirements. Using these criteria, a request for proposals will be issued. The proposals received will be evaluated against the developed criteria.

c. Navy personnel will work closely with the contractor to ensure that upon delivery of the developed system there is adequate in-house expertise for evaluation and implementation of the system.

d. An acceptance and evaluation plan will be prepared, and upon delivery a complete evaluation will be performed on the system using Naval avionics systems with inserted faults.

3. Limits and Constraints. This task is aimed at solving the problem of automatic test program generation for digital circuitry as technology progresses and causes increased circuit density with its associated test and test generation problems.

4. Required Support. The funds required for this task will cover in-house personnel and contractor support and related travel. Contract efforts will require computer use for development. Navy computer use will be required for evaluation.

D. RELATED EFFORTS. This work is related to current work in automatic test program generation, both analog and digital. It is also related to efforts dealing with design for testability as well as work dealing with using ATPG as a testability evaluation tool.

E. MAJOR CONTRACTS

1. Estimated total contract expenditures for this task are $156K.

2. Contract services will include the development of a test generation algorithm and simulator.

F. DELIVERABLES

1. A report describing the algorithm

2. A user's manual with examples

3. A program listing

4. The source and object code on tape or cards

G. FOLLOW-ON WORK. After complete evaluation, the system should be capable of at once being utilized for test program generation. At that point it would be logical to combine the results of this task with those of similar work for analog systems and develop an ATPG system for hybrid circuits.

# APPENDIX A-9

A. TASK TITLE: SELF-CONTAINED TEST (SCT)/RELIABILITY CONSIDERATIONS

B. OBJECTIVES

1. To determine the impact on the reliability of typical avionic designs and functions resulting from the inclusion of SCT capability within the design.

2. To determine which avionic functions and technologies are most amenable to the incorporation of SCT.

3. To determine the feasibility of an algorithm that could be used in digital circuit analysis and design for the incorporation of SCT.

C. WORK STATEMENT

1. Tasks

a. Correlate results of technology projection efforts and the test requirements of typical aircraft subsystems to determine those avionic technologies and subsystem functions most amenable to incorporation of SCT.

b. Determine the feasibility of developing an algorithmic tool for SCT incorporation into digital designs.

c. Select design example of a recently designed analog SRA exemplifying the technologies and functions identified in "a" and do a paper redesign requiring SCT as an integral part of the design. Using example results and theoretical conclusions, determine impact of SCT on reliability for analog circuitry. Perform similar analysis for digital circuitry from results of AAFIS (Advanced Avionics Fault Isolation System) demonstration program.

2. Approach

a. Self-contained test capability incorporated in avionics can reduce external support requirements. However, the effect on reliability of the avionics and the aircraft missions must be considered.

b. The technologies and functions most amenable to SCT incorporation will be determined from the results of technology projection efforts and aircraft system test studies.

c. A minimal effort will be applied to determine the feasibility of an algorithmic tool for the incorporation and verification of SCT in digital designs.

d. From the results of the above efforts, a design example or examples will be chosen for the demonstration of SCT impact on reliability. Ideally, a recently designed analog avionic SRA will be redesigned, on paper, with SCT included as a fundamental design requirement. The testability, cost, and reliability of the original and new designs will be measured. The generally applicable results of this test, together with theoretical conclusions about SCT and reliability, will be used to determine the impact of 'designed in' SCT on reliability. These conclusions will also be drawn about digital SCT from the results of the presently ongoing AAFIS program, which is pursuing a similar design example for a digital SRA.

3. Limits and Constraints. This effort will be limited primarily by the difficulty of extrapolation of results of a single example to the general field of avionics.

4. Required Support. The funds required for this effort cover both in-house and contractual analyses, and related travel. A limited amount of computer time for data processing is anticipated. No special equipment or facilities are required.

D. RELATED EFFORTS

1. The results of this effort will be useful in establishing shop tester requirements.

2. This task will interface with analog and digital hardware testability and technology projection efforts.

E. MAJOR CONTRACTS

1. Estimated total contract expenditures for this task are $250K.

2. Contract services will include the following assignments.

a. Determine avionic technologies and subsystem functions most amenable to incorporation of SCT.

b. Determine the feasibility of developing an algorithmic tool for incorporation of SCT into digital designs.

c. Use a recent analog SRA design exemplifying the technologies and functions identified in item "a" and an AAFIS digital design to analyze the effect of SCT incorporation on reliability.

F. DELIVERABLES

1. Report: Analyses, conclusions, and recommendations identifying those avionic functions and technologies most suited to incorporation of SCT.

2. Report: Analyses, conclusions, and recommendations on the feasibility of developing an algorithmic tool for the incorporation and verification of SCT in digital designs.

3. Report: Design, analysis, calculations, conclusions, and recommendations determining the impact of SCT on reliability, including related cost and testability considerations.

G. FOLLOW-ON WORK. Further development of the mathematical investigation may be pursued if recommended. Additional efforts may be necessary to expand the data if results of the demonstration of SCT impact on reliability are successful. This could be accomplished by actually implementing the design with SCT in the real circuit and performing reliability testing. Algorithmic tool development might also follow.

# APPENDIX A-10

A. TASK TITLE: SELF-CONTAINED TEST (SCT) VERSUS SHOP TEST

B. OBJECTIVE. The object of this task is to define the balance between future SCT and shop test functions in terms of fault detection and isolation capability. In addition, determination will be made of the optimum life-cycle cost support posture necessary to achieve the required operational readiness of future systems.

C. WORK STATEMENT

1. Tasks

a. Integrate and utilize the results of other technology assessment efforts to determine future SCT and ATE capabilities for test at the WRA/SRA levels.

b. Conduct trade off cost studies of SCT capabilities versus projected ATE capabilities.

c. Identify parameters and/or equipment for which on-board testing is not feasible in terms of time, economic factors, and complexity, thereby requiring ATE.

d. Identify areas of potential improvement in relationship between ATE and SCT, such as cooperative testing and test interface characteristics.

e. Based on the above, determine the most cost effective balance of ATE/SCT to accomplish the total support.

2. Approach

a. Self-contained test capability incorporated in avionics can reduce external support requirements. Feasibility and complexity trade offs must be considered, however. Determinations must be made as to in what type of circuitry SCT can be used and what type requires external support equipment.

b. Initially, data shall be gathered by establishing a working relationship with the technology assessment group to implement a timely baseline for trade off analysis. Potential shop tester data will be compared to augment this baseline and to ensure that the total system support is achieved. Trade offs will be performed in terms of life cycle cost and operational availability of avionics.

3. Limits and Constraints. Limitations may exist in gathering and assessing advanced technology information.

4. Required Support. The funds required for this task cover both in-house and contractual analysis, data acquisition efforts and selected travel.

D. RELATED EFFORTS. The SCT Versus Shop Test task shall interface with tasks in both digital and analog testability.

E. MAJOR CONTRACTS

1. Estimated total contract expenditures for this task are $285K

2. Contract services will include the following assignments.

a. Using related technology assessment efforts, determine future SCT and ATE capabilities for test at the WRA/SRA levels.

b. Conduct trade off cost studies of SCT capabilities versus projected ATE capabilities.

c. Identify parameters and/or equipment requiring ATE.

d. Identify potential SCT-ATE relationship improvements.

e. Determine most cost-effective mix of SCT-ATE.

F. DELIVERABLES

1. Report of trade offs between SCT and ATE testing.

2. Identification of testability in relation to SCT versus shop test.

3. Identification of potential improvement between SCT versus shop test.

4. Report on the approach possibilities with alternatives between SCT and shop test.

5. Requirements for future shop test equipment for circuitry not suitable for SCT.

G. FOLLOW-ON WORK. Integration of concepts into hardware through selection of systems in which SCT can be applied.

# APPENDIX A-11

A. TASK TITLE: AUTOMATIC TEST PROGRAM GENERATION (ATPG) AS A TESTABILITY EVALUATION TOOL

B. OBJECTIVE. To exploit the use of ATPG as a means to determine the quality of a circuit design from a testability viewpoint. Through appropriate development, reduce the time and cost of using an ATPG system for circuit evaluation. Also, enhance the accuracy limitations of present systems. In this manner provide the Navy with a tool for indicating the testability of electronic circuitry and therefore the impact on its future availability.

C. WORK STATEMENT

1. Tasks

a. Perform a comparison of ATPG prediction of the quality of the testability of a design against the actual quality. This will document the need for further development of the evaluation capability of ATPG. These results will serve to either support or negate the indications that, in general, ATPG systems are not cost effective or accurate in an evaluation mode.

b. Based on the results of task "a", develop techniques for implementing improvements in ATPG systems. These improvements will cover the areas of reducing costs through development of methods to simplify the coding of the circuit to be simulated and decreasing the amount of run time needed. The improvements will also cover increased fault detection and fault location capability.

2. Approach

a. Present ATPG systems are used for testability evaluation; however, this appears to be a costly and time-consuming application. Also, it has been found in general that the fault detection percentages predicted by ATPG systems do not necessarily match that same information from the actual system.

b. Data will be acquired from both analog and digital ATPG systems on the amount of time and the cost required to determine the fault detection capability of a given set of stimulus signals. Also, data on the ratio of undetectable faults will be collected. Using the actual electronic circuitry and the appropriate test equipment, an evaluation will be performed of the various ATPG systems through actual fault insertion. With these results, an investigation will be performed to determine how to reduce the time and cost of running and how to improve accuracy.

c. The improvements will then be implemented in the ATPG systems. New data will be collected and a comparison with previous simulated and actual data will be made.

3. **Limits and Constraints.** To complete this task it is absolutely essential that complete details be available on the ATPG systems to be evaluated and improved.

4. **Required Support.** The funds required for this task will cover in-house personnel and contractor support and related travel. In addition, computer use will be required for the ATPG system simulations. An appropriate electronic system for implementation and test equipment will be needed.

D. RELATED EFFORTS. This work is related to current and future work in automatic test program generation, both analog and digital. It is also related to efforts dealing with design for testability.

E. MAJOR CONTRACTS

1. Estimated total contract expenditures for this task are $250K.

2. Contract services will include the following assignments.

a. Comparison of ATPG systems against actual electronic systems for time, cost, and quality.

b. Development of improvements in ATPG systems.

F. DELIVERABLES

1. Report on results effectiveness of current ATPG systems as testability evaluation tools.

2. Report on development of improvements to ATPG systems.

3. Improved ATPG systems, either on tape or cards.

G. FOLLOW-ON WORK. The results of this task can be utilized on every electronics system being delivered to the Navy to determine the adequacy of its design for testability. This will help determine its life-cycle costs (LCC) and mean time to repair (MTTR).

# APPENDIX B

A. GENERAL. This appendix contains six areas that are currently proposed under the Avionics Ground Support Equipment Performance Augmentation part of the SEPAR. Each task is outlined in detail in the following pages.

## Task Areas

1. The Classification of Technology Improvements Required for GSE.
2. A Design Area Matrix to Guide The Application of Current GSE Technology.
3. A Function Matrix to Guide The Selection of New Equipment for Use With GSE.
4. Development of Supportability Impact Statements to Anticipate The Effect of The Application of New Technologies to GSE.
5. A Specification For The Improvement of GSE Performance.
6. A Projection of Aircraft Requirements That Will Reflect on GSE.

## APPENDIX B-1

A. TITLE: TECHNOLOGY ASSESSMENT

B. OBJECTIVES

1. To identify research principles and/or actions which are relatable to electronic equipment circuitry, heat control, packaging, or man-machine interface.

2. To acquire available information concerning individual candidate research entities.

3. To screen and collate acquired information into a form which provides retrieval, filing, and updating.

4. To develop a data base of information useful in the technological improvement of avionic support equipment.

C. WORK STATEMENT

1. Tasks

a. Investigation of present and future technology, applicable to electronic equipment. A major portion of the effort is anticipated to be locating and documenting promising principles that have been noted or are the result of such actions as:

(1) Perusal of technical notes and journals.

(2) Discussion of the subject effort with industrial sources and related solicitations for information.

(3) Exploratory discussions within the government sector.

b. As the above efforts yield information leads, the specifics will be followed up. This action on a case basis will continue until sufficient information is acquired to permit assessment of feasibility and identification of possible functional application. A guideline checklist will be used as a criteria for determination of the degree of sufficiency of detail for each case. Additionally, the checklist will establish the formatting of the information thereby accommodating retrieval and access requirements.

2. Approach. The effort will be initiated by organizing a working group. The working group will be made up of personnel with day-to-day contacts with private industry and other government activities, thereby insuring direct access to potential information sources. The working group personnel will strive to derive any usable

project information that may be attainable concurrent with normal contact purposes. Additionally, specific information probe efforts will be made by group members. Group members will exchange information to ensure that all members are kept informed and that overlapping efforts are not undertaken.

3. Limits and Constraints. This task will be constrained by the ability to locate and gather proprietary information in the corporate community.

4. Interfaces. Since this is one of three concurrent efforts (Technology Assessment, Basic Design Application, and Equipment Application), it is anticipated that it will be necessary to periodically appraise the efforts to determine which items are sufficiently defined to allow initiation of the next higher definitive phase and which other items show sufficient promise to warrant continued effort.

D. DELIVERABLES. Report on identified research principles and/or actions which are applicable to avionic support equipment.

# APPENDIX B-2

A. TITLE: BASIC DESIGN APPLICATION

B. OBJECTIVES

1. To accelerate identification and application of state-of-the-art findings to new generation devices for overall upgrading of avionic support equipment.

2. To maximize the probability of utility of the principles or characteristics determined through technology assessment as promising state-of-the-art findings, by early identification of a generic application.

3. To improve avionic readiness by upgrading associated support equipment capability.

C. WORK STATEMENT

1. Task. This task area concerns the need/action to identify and initiate application of state-of-the-art research findings toward solution of current and projected support equipment deficiencies. Specific candidate phenomenon will be screened and investigated for development state and technical applicability. Promising items will be matched with areas of need and priority ratings assigned. This effort will maximize the utility of invested resources and expedite pay off by establishing bounds for application of specific candidate findings as early as possible.

2. Approach

a. The effort will be accomplished by utilization of a team consisting of a core of permanently assigned project-responsible personnel supplemented by supporting personnel. The supporting personnel will be derived from the ranks of personnel who submit ideas as possible project candidates. This approach will ensure the most viable suggestions and will allow ideas to come forward from such areas as:

(1) Related knowledge derived from previous engineering experiences.

(2) Promising research actions not yet pointed toward avionic support.

(3) Spontaneous ideas not yet explored.

b. Proposed ideas/projects will be evaluated and ranked by the team to ensure overlapping efforts are not undertaken and that specious tasks are not embarked upon. Viable undertakings will be properly documented by written proposed project plan setting forth the application, technical risk, and benefits to be derived. The project plan will be presented to the NAVAIR sponsor for disposition.

3. Limits and Constraints. This task will be constrained by the ability to gather and use proprietary information developed at corporate expense.

4. Interfaces. Since this is associated with Technology Assessment and Equipment Application tasks, it is anticipated that it will be necessary to appraise the efforts concurrently to determine the most promising findings and the priority to maximize utilization of resources.

D. DELIVERABLES. Recommend project plans for NAVAIR sponsor consideration. Prepare summary report of recommended projects and findings.

## APPENDIX B-3

A. TITLE: EQUIPMENT APPLICATION

B. OBJECTIVES

1. To accelerate identification and application of state-of-the-art findings/devices for overall upgrading of avionic support equipment.

2. To maximize the probability of utility of a device by establishing early definitive application bounds.

3. To improve avionic readiness by upgrading associated support equipment.

C. WORK STATEMENT

1. Task. This task area concerns the need/action to directly apply mature state of the art devices/techniques toward solution of current and projected support equipment deficiencies in the ECM, ASW, FCS, CNI, IFF, MCS, ACS and ALTIMS. Specific candidate devices/techniques will be identified, screened and investigated for specific applications. Promising items will be matched with areas of need and priority rating assigned. The most critical and promising items will be recommended for further development and/or hardware evaluation.

2. Approach

a. The effort will be accomplished by utilization of a team consisting of a core of permanently assigned project-responsible personnel, supplemented by supporting personnel. Supporting personnel will be assigned from the ranks of personnel who submit ideas/projects as possible candidates. This will allow a free interchange/expression of ideas to come forward from such sources as:

(1) Related knowledge derived from previous experiences.

(2) Promising research developments not yet applied in avionic support.

(3) Spontaneous ideas not yet explored.

b. Proposed ideas/projects will be evaluated and ranked by the team to ensure overlapping efforts are not undertaken and that specious tasks are not initiated. Viable undertakings will be properly documented by written proposed project plan setting forth the application, technical risk, and benefits to be derived. The project plan will be presented to the NAVAIR sponsor for disposition.

3. Limits and Constraints. This task will be constrained by the ability to gather and use proprietary information which has been developed at corporate expense.

4. Interfaces. Since this is associated with Technology Assessment and Basic Design Application tasks, it is anticipated that it will be necessary to appraise the findings concurrently to determine the most promising and the priority to maximize utilization of resources.

D. DELIVERABLES. Recommend project plans for NAVAIR sponsor consideration. Prepare summary report of recommended projects and findings.

The following list proposes task titles for work to be performed in each of the six task areas. Definitive work proposals are yet to be generated.

B-1 <u>Technology Assessment</u>
B-1.1 Technology Sectors
B-1.2 Circuitry
B-1.3 Heat Control
B-1.4 Packaging
B-1.5 Man Machine Interface

B-2 <u>Basic Design Application</u>
B-2.1 Design Area Matrix
B-2.2 Circuitry (Power, Measurement, Low Freq, Microwave, Digital, Control Devices, Rotating Devices, Optics, Connectors, Conductors)
B-2.3 Heat Control (Heat Sinks, Active Heat Dissipators, Filters, Films)
B-2.4 Packaging (Fasteners, Finishes, PCB'S, Discrete Components, Enclosures, Cases, Slides, Shock Mounts, Materials)
B-2.5 Man-Machine Interface (Marking, Displays, Printer Formats, Control Location/Size)

B-3 <u>Equipment Application</u>
B-3.1 Equipment Type Matrix
B-3.2 Electronic Counter Measures (ECM)
B-3.3 Anti-Submarine Warfare (ASW)
B-3.4 Fire Control System (FCS)
B-3.5 Communications Navigation Identification (CNI)
B-3.6 Identification Friend or Foe (IFF)
B-3.7 Missile Control System (MCS)
B-3.8 Armament Control System (ACS)
B-3.9 Altimeter-Inertial Measurement System (ALT-IMS)

B-4 <u>Application Supportability Impact</u>
B-4.1 Yield
B-4.2 Performance
B-4.3 Cost
B-4.4 Producibility

B-5 <u>Performance Enhancement</u>
B-5.1 Specification Upgrading
B-5.2 Specification Selection
B-5.3 Specification Revision
B-5.4 Specification Approval

B-6 <u>Projection of Aircraft Mission Requirements</u>

# APPENDIX C

A. GENERAL. This appendix contains one task that is currently proposed under the Non-Avionic Ground Support Equipment Performance Augmentation part of the SEPAR. This task is outlined in detail in the following pages.

It should be noted that while only one task has been proposed, many additional tasks are readily apparent but have yet to be defined in a manner suitable for inclusion at this time.

## APPENDIX C-1

A. TASK TITLE: AUTOMATED TEST STAND DEVELOPMENT FOR GTE FUEL CONTROLS

B. OBJECTIVE. To develop a "generic" gas turbine engine (GTE) fuel control test stand that can be used for a family or category of fuel controls, thereby reducing the total number of test stands required for GTE support.

C. WORK STATEMENT

1. Task

a. Traditionally, gas turbine engine fuel controls for naval aircraft are tested, calibrated, repaired, and reworked at the various naval depots or NAVAIREWORKFACS (Naval Air Rework Facilities). Usually, each GTE introduced into the Fleet has associated with it a specific and different type of fuel control requiring a dedicated depot level test stand; therefore, many different fuel control test stands exist within each depot in order to provide the total required test capability.

b. A universal GTE fuel control test stand which could test all the different types of fuel controls would preclude the proliferation of dedicated test stands and thereby reduce costs, but such a test stand is not really practical because of complexity, hardware redundancy, size, and cost. Consequently, a "generic" test stand will be developed to take advantage of the high degree of similarity between fuel controls. Fuel controls can be grouped into major categories or families in terms of flow capacity and type, and a test stand design can be optimized for each category (family) of fuel controls. While such a concept would not decrease test system proliferation to the extent of a universal system, it would be far superior, in many respects, and more cost-effective than the present dedicated test stand approach, and yet avoid the drawbacks peculiar to the universal system. Introduction of new GTE fuel controls into the Fleet would not necessarily require new and additional test stands since the generic stands would be adaptable and could be re-configured to meet the new test requirements. A generic test stand could be configured from subsystem modules which allow re-configuration of a single test stand for various types of controls within a reasonable period of time.

2. Approach. This task will develop a generic test stand system which is capable of replacing a number of dedicated test stands at one or more selected NAVAIREWORKFACS. The new generic system will be an automated system operating under the control of a mini-computer and such other automatic control circuitry as is required. The computer system will incorporate a real time operating system and be capable of controlling several test stands simultaneously (i. e., multi-test stand operation) while providing a necessary background/foreground capability which lends itself to applications software development and maintenance. Thus, the system will

take advantage of state-of-the-art capability in automatic operation and control thereby realizing additional cost savings over the operational portion of its life-cycle. In addition, the generic system will be programmable in FORTRAN IV (USASI Standard FORTRAN X3.9-1966) which is the high level programming language recommended for automated fuel control test stand applications as a Navy standard.

3. Limits and Constraints. Some manual test stands have been developed for the commercial airlines with the capability of testing several fuel controls on a single test stand. Paper studies show the generic approach to be both feasible and cost-effective, and it is known that the generic concept is within the present state-of-the-art. The automation technology required to build an automatic test system exists and has been demonstrated on many occasions. Many automated test systems are in existence and are effectively operating.

D. DELIVERABLES. A generic test stand system will be developed and demonstrated. The new generic system will be an automated system operating under the control of a programmable mini-computer.

E. FOLLOW-ON WORK. Success of this task will lead to the development of a family of generic GTE fuel control test stands.

SUPPORT EQUIPMENT PROGRAM FOR AVIONICS READINESS — NAEC-GSED-104

The Support Equipment Program for Avionics Readiness (SEPAR) has been developed to provide greater reliability and improved maintainability of avionics and support equipment than has been achieved thus far. These goals can be achieved by properly developing the necessary technology for incorporating a high degree of readiness into the design of new equipment and for providing the specialized support equipment required to maintain this equipment. In order to attain the high degree of readiness required in future avionics systems, the SEPAR must now be instituted to insure that new technology be included when ready.

To provide industry with definitive specifications for improved avionics systems, the Navy must have the capacity to define readiness problems and goals, to conduct research in weak or high technological risk areas, and to apply new techniques in systems designs. These efforts must be directed toward both the new primary avionics systems and the secondary support equipment systems, which are a vital part of avionics readiness. Advanced weapons systems are of limited value without the proper advanced support equipment required to maintain them.

Proposals to accomplish these tasks for achieving avionics readiness have been incorporated into the SEPAR. The plan includes proposals for the development of management guidelines and techniques for demonstration of equipment support features as part of the primary equipment acceptance criteria and for determining the resulting influence on the cost of future systems.

The application, validation, and refinement of the readiness parameters developed within the context of this program will provide the data base for comparison with current and future avionics system developments.

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