CANDIDATE TECHNOLOGIES FOR THE INTEGRATED HEALTH MANAGEMENT PROGRAM

FINAL REPORT

Prepared For:
NASA
Marshall Space Flight Center
Contract: P.O. H-18763D

February 26, 1993

(NASA-CR-192520) CANDIDATE TECHNOLOGIES FOR THE INTEGRATED HEALTH MANAGEMENT PROGRAM Final Report, 30 Oct. 1992 - 26 Feb. 1993 (General Dynamics Corp.) 16 p

N93-22655

Unclas

G3/52 0150344

GENERAL DYNAMICS
Space Systems Division

TABLE OF CONTENTS

SECTION PAGE

TABLE OF CONTENTS ii

LIST OF FIGURES iii

ACRONYMS AND ABBREVIATIONS iv

1.0 Scope 1

2.0 Need for VHM 1

3.0 VHM Benefits 3

4.0 VHM Demonstration Plans 3

5.0 Highest Priority Demonstration Plan 3
- 5.1 Methodology of Plan Selection 4
- 5.1.1 Benefits of Avionics VHM 5
- 5.2 Detailed Plan Description 6
- 5.2.1 Built-In-Test Capabilities 7
- 5.2.2 Test and Maintenance Buses 8
- 5.2.3 Demonstration Hardware 9
- 5.3.4 Demonstration Software 9
- 5.4 Demonstration Schedule & ROM Estimated Cost 10

6.0 Report Conclusions 10

LIST OF FIGURES

FIGURE		PAGE
1.	Bridging VHM Technology Evolution	2
2.	Avionics BIT Quad Chart	4
3.	VHM Demonstration Analysis	5
4.	JIAWG Common Modules	6

ACRONYMS AND ABBREVIATIONS

ADP	Advanced Development Program
BIT	Built-In-Test
CTV	Cargo Transfer Vehicle
ELV	Expendable Launch Vehicle
EMA	Electromechanical Actuator
GSE	Ground Support Equipment
HLLV	Heavy Lift Launch Vehicle
H/W	Hardware
IHM	Integrated Health Management
I/O	Input/Output
JIAWG	Joint Integrated Avionics Working Group
JSC	Johnson Space Center
LeRC	Lewis Research Center
LRM	Line Replaceable Module
LRU	Line Replaceable Unit
LTV	Lunar Transfer Vehicle
MAST	Marshall Avionics Simulation Testbed
MPRAS	Multi-Path Redundant Avionics Suite
MSFC	Marshall Space Flight Center
NLS	National Launch System
NRA	NASA Research Announcement
OSF	Office of Space Flight
SATWG	Strategic Avionics Technology Working Group
SEI	Space Exploration Initiative
SGI	Silicon Graphics
SSRB	Shuttle Solid Rocket Booster
STM	System level Test & Maintenance
S/W	Software
TM	Test & Maintenance
TVC	Thrust Vector Control
USAF	United States Air Force
VAC	Volts Alternating Current
VHM	Vehicle Health Management

1.0 Scope

The purpose of this report is to assess Vehicle Health Management(VHM) technologies for implementation as a demonstration. Extensive studies have been performed to determine technologies which could be implemented on the Atlas and Centaur vehicles as part of a bridging program. This paper discusses areas today where VHM can be implemented for benefits in reliability, performance, and cost reduction. VHM Options are identified and one demonstration is recommended for execution.

2.0 Need for VHM

All launch vehicles, including manned and expendable, have required extensive testing to insure system integrity, reliability, and operability. Testing was performed when the vehicle was on the pad weeks and days before launch. Vehicle sensors, Ground Support Equipment (GSE), and manpower were required to perform the vehicle testing.

The existing vehicles require large standing armies to process each vehicle for launch. Reducing costs for the Atlas vehicles is a goal to improve the competitive standing in the commercial markets. Efforts were first started in avionics and post flight data analysis but have spread to all vehicle systems. The new technologies being developed are known as Vehicle Health Management. However, VHM is not a new system but rather a new way of doing business.

A major goal of new vehicles, such as the Spacelifter or National Launch System(NLS) family, is to reduce operations a factor of 5 to 10 over existing vehicles. Improving on present vehicles is a driving force in the creation of new vehicles. Testing of the new vehicles using existing methods would not meet cost objectives. Thus, the new programs require better testing in order to achieve their goals. A solution is found in the VHM designs to upgrade existing vehicles. Systems proven on today's vehicles can be implemented on tomorrow's. The advantage the new programs have is that benefits can be designed in rather than retrofitted. On some systems retrofitting is too expensive and benefits will only occur in a new clean sheet vehicle design.

The need for VHM technologies is widely recognized by the USAF, NASA, and industry members. On the recent NLS program VHM was considered a key element to achieve program goals. NASA considers VHM the highest priority of 21 key technology requirements of current and future OSF missions. NASA Code M and Code R created the Strategic Avionics Technology Working Group(SATWG) composed of government and industry members in 1990. One SATWG panel is focused on planning and developing VHM with NASA/industry cooperation. The SATWG effort has already made progress in determining needs, requirements, goals, and objectives for VHM at NASA. Work is currently underway on VHM projects within groups at NASA's Johnson Space Center (JSC), Marshall Space Flight Center (MSFC), and Lewis Research Center(LeRC).

The progress bridging program demonstrations can accomplish for VHM is shown in Figure 1. The program begins with a demonstration on the Atlas and Centaur vehicles. In the current propulsion system on the Atlas IIAS no hold down health monitoring or automated pre-launch checkout exists. If that demonstration were carried out the potential benefits such as improving reliability and cost savings would be proven. The designs and processes created in the program could then be incorporated into a new vehicle design such as the HLLV or Spacelifter. The demonstration begins a progression toward the expected need for on-board propulsion system verification needed for a Lunar Transfer Vehicle (LTV), part of the Space Exploration Initiative (SEI). Although there are additional steps required, the bridging program builds confidence in the new technology for continued development.

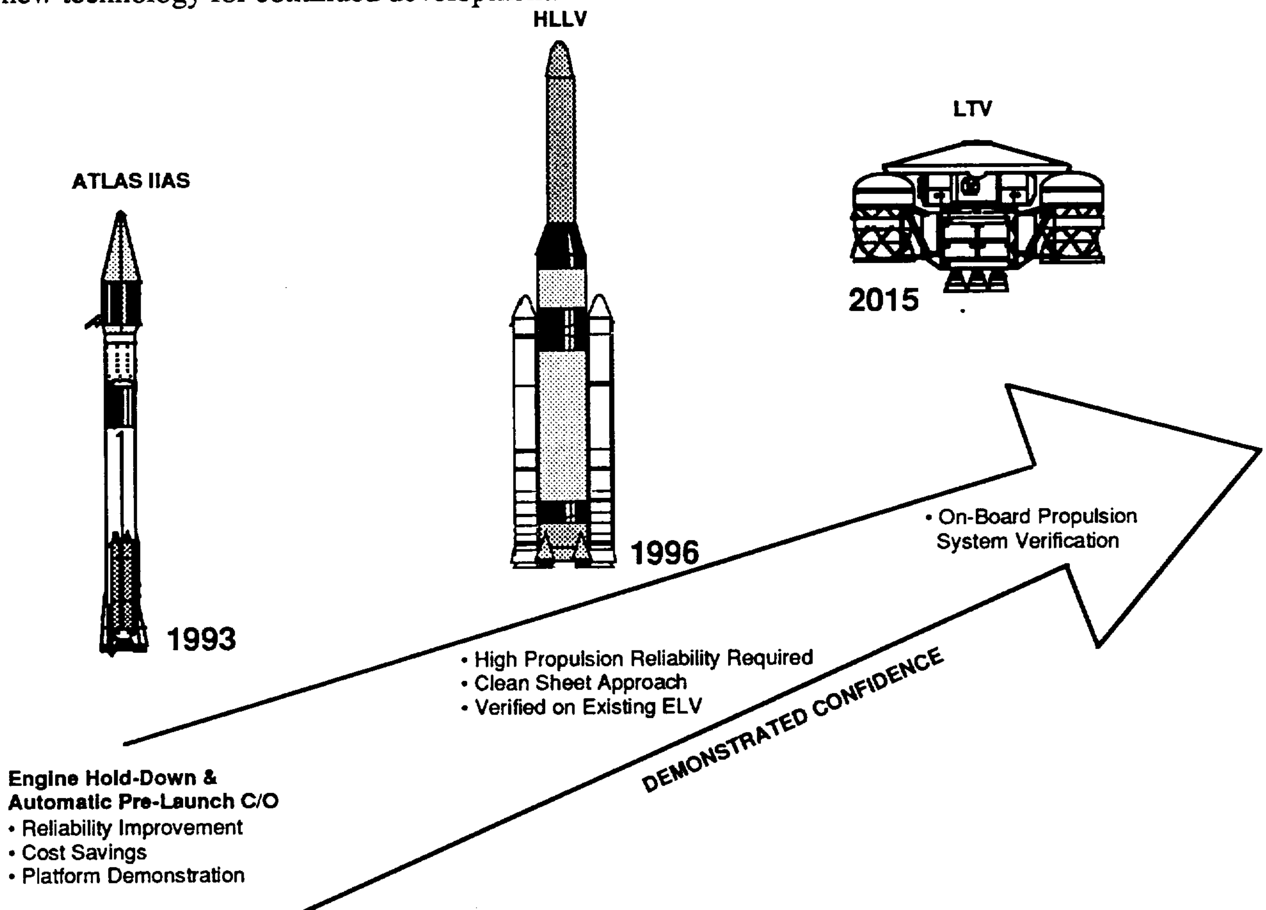

Figure 1. Bridging VHM Technology Evolution

A VHM system is designed to monitor the health status of vehicle subsystems in the most cost efficient manner. VHM automates tasks performed manually. In addition, VHM can be described as the major component in an Integrated Health Management (IHM) system. VHM allows IHM to detect and manage any component failures in a redundant system. The components include but are not limited to valves, pumps, sensors, software, and ground systems. VHM is not specifically an avionics system, but rather uses Avionics to accomplish its tasks. For example, a subsystem would communicate using an data bus, but the subsystem could be located in the propulsion system. An entire test would begin with a command being sent to a system, the system's health status would be determined, and the status sent back to the test conductor. The system would be automated to the maximum amount possible to reduce labor costs.

The efforts underway for the Atlas, Centaur, and new vehicles focus on developing promising technologies for different subsystems and identifying requirements. Specifically, efforts on Atlas and Centaur have occurred in the avionics, pneumatics, propulsion, and operations areas. Specific plans have been created in order to develop and demonstrate the applications on real systems. The technology which we believe is the highest priority is described with a plan for implementation.

3.0 VHM Benefits

The benefits of VHM development are reduction of costs, reliability improvements, and performance improvements. The goal of the VHM demonstrations is to prove the VHM benefits using actual hardware. Once the technology is proven then insertion into existing or new programs can follow. This demonstration can also lead to other technologies with further savings. VHM will be a requirement for many missions which will have a long duration such as SEI. The systems for these vehicles requires the additional performance that only VHM can provide.

The reduction of costs for VHM will occur from automating vehicle checkout functions for vehicle operations. Automation reduces or eliminates the impacts of launch delays, aborts, and recycling. Additionally, fewer people are required to perform tests. An example for achieving operations savings is replacing the hydraulic Thrust Vector Control (TVC) system with an Electromechanical Actuator (EMA) on the Shuttle Solid Rocked Boosters (SSRB). This would reduce TVC operations from 16 shifts down to 3 with fewer technicians required at each step. The EMA design takes maximum advantage of automated testing systems. With VHM vehicle checkouts will take a shorter time to execute thereby decreasing launch processing, increasing launch availability, and reducing launch cycling time.

Reliability improvements will occur due to enhanced system designs. Redundancy is one method used to increase system reliability, but redundancy requires extra system testing. VHM provides for testing an entire system easily. VHM allows for testing and re-configuring to isolate faults in redundant systems. Another example of increasing reliability is holding down the Atlas booster to test proper propulsion system operation. If any system monitors detect anomalies the engines can be shut-down to prevent loss of mission. This hold down monitoring was estimated to raise ascent reliability 2 - 3% for the NLS program.

With increased testing done by VHM systems performance margins can be improved. Present margins can be increased from analysis of additional data. VHM allows for storage and analysis of vehicle parameters. The data can be used to create a history of system operation to determine sub optimal operation. In addition, the data then can be used to improve understanding and capabilities of the vehicle.

4.0 VHM Demonstration Plans

Although VHM must be designed in over the entire vehicle, each system has some VHM component within. Potential VHM improvements are possible for every major vehicle subsystem. However, in order to minimize expected demonstration cost and because of the underdeveloped status of VHM the suggested demonstrations are focused at the subsystem level. The subsystems considered for VHM demonstrations include ground equipment, data analysis, fluids, thrust vector control, avionics, and propulsion.

Information on the majority of the plans is not included with this report due to the proprietary nature of the demonstrations and plans . However, this report will described the detailed plan for the demonstration considered to be the highest priority.

5.0 Highest Priority Demonstration Plan

After considering available hardware, schedules, costs, risks, and benefits the avionics demonstration is the plan with the highest priority. The avionics system demonstration is known as Avionics Built-In-Test (BIT). In this section the methodology of selecting the demonstration is explained, a detailed plan is described, and the benefits versus costs are listed. In addition, hardware, lab facilities, schedule, and costs are described. The demonstration plan is shown in Quad Chart format in Figure 2.

Task Objectives/Benefits

Objective(s):
Develop & demonstrate an IVHM architecture for launch vehicles to include the avionics system and its interfaces with other vehicle subsystems

Applicable Vehicles:
ELV, ETO-LV, Upper Stages, SEI

Benefits:
- Enhances system reliability & reduces checkout time, manpower & cost
- Improved IVHM efficiency by addressing subsystem interface issues
- Reduce risk when applied to flight program

Demonstration/Bridging Approach

Task(s):
1. Develop integrated VHM architecture requirements
2. Generate avionics architecture using NLS ADP Technology
3. Test & demonstrate avionic capabilities
4. Integrate avionics with other lab facilities
5. Test & demonstrate integrated vehicle systems

Available Facilities:
MSFC: MAST, TTB, Actuator Lab, Flight Sim Lab

Technology Description

NASA Technology Readiness Level:

Specifications:
- Fault tolerant avionics architecture including hardware & software designs
- Health management interface issues between subsystems addressed/demonstrated
- Demonstrations will use existing test facilities & simulations
- MAST Lab will provide central facility for test/demo of total integrated system

Schedule/Cost

TASK	FY94	FY95	FY96
1			
2			
3			
4			
5			
Resources	200K	400K	700K

1-2745-2-283

Figure 2. Avionics BIT Quad Chart

5.1 Methodology of Plan Selection

The Avionics BIT demonstration was decided over the other demonstrations on the basis of reduced risk, costs, potential benefits, and available facilities. Each option was given a weight in the four categories. The resultant matrix is shown in Figure 3. The four discriminators were to generate distinctions between the options for purposes of evaluation.

The avionics program has less risk than the other projects because this task modifies and demonstrates developed avionics hardware. The estimated cost of the project is among the lowest. The benefits from this project are in line with the majority of the other demonstrations. Finally, the demonstrations is flexible with all available facilities. The demonstration hardware could potentially be relocated to many sites around the country. The BIT program is also important in that it creates the vehicle infrastructure for many of the other plans.

The fluids and GSE systems require designing and building new unique hardware. Costs are higher for these other projects due to the new hardware. The propulsion plan has tremendous benefits but the costs at this time seem excessive. The second alternate is developing an EMA Health Management system, but similar work is already underway within NASA.

DISCRIMINATORS	FLUIDS	AVIONICS	EMA HMS	GND SPRT EQP	DATA ANALYSIS	PROPULSION
RISK	2	3	2	2	2	2
COST	2	3	3	2	3	1
BENEFITS	3	3	3	3	2	3
AVAILABLE FACILITIES	2	3	3	2	3	2
Totals	9	12	11	9	10	8

Figure 3. *VHM Demonstration Analysis*

5.1.1 Benefits of Avionics VHM

The checkout of on-board avionics systems is time consuming and reliability improvements could be gained by utilizing BIT technologies. Operational costs can be reduced and checkout benefits can extend to other vehicle systems(propulsion, fluids & EMA) using VHM BIT components.

Current launch vehicles incorporate limited automated test capability and take an approach to checkout that is time consuming and labor intensive. Factory checkout is accomplished today using manual methods to verify continuity and function. On the pad, many support technicians are needed to monitor the system and make go/no-go decisions. Ground test equipment is used intrusively during the checkout operations. Intrusive testing physically disturbs vehicle signal lines and components and thereby reduces the overall reliability of the test operations. When problems are identified, usually through tedious examination of test or telemetry data, fixes tend to be expensive and time consuming. Hardware repairs generally require replacement of an entire electronics assembly, a process that often requires multiple technicians working in tight quarters. Since numerous connectors must be removed and replaced to replace the assembly, the integrity of the complete system must be reverified after the repair.

Factory closeout and pad checkout of avionics systems could be improved by utilizing avionics technologies such as multi-level Built-In-Test (BIT) functions and independent Test and Maintenance buses. These technologies would be demonstrated as part of a proposed Avionics Built-In-Test Demonstration.

In addition to performing avionics checkout, an avionics system can be extensively used to automate the operations of other major subsystems, such as propulsion and fluids. Additionally, avionics BIT technologies can enable operations that cannot be performed manually, such as for long duration missions, or highly autonomous systems.

In order to automate the checkout of avionics and non-avionics subsystems, the avionics architecture must contain the attributes to enable this automation. Present day avionics systems do not have the components required to support highly automated checkout of vehicle subsystems. Only a few BIT capabilities currently are used, and the test results are not distributed system-wide for fault analysis or configuration management.

In order to fully utilize avionics for automated operations, the avionics architecture must have the required attributes designed into the system. Among the technical requirements needed to perform automated operations are improved data processing, storage and distribution capabilities, smart instrumentation and effectors, multi-level Built-In-Test functions, and independent Test and Maintenance buses.

An avionics Built-In-Test demonstration would show the benefits that an automated BIT capability has over conventional item-by-item check-out and replace/remove/re-verification procedures.

Demonstration hardware will consist of a selection of Joint Integrated Avionics Working Group (JIAWG) Common Modules (see figure 4). These common modules are the result of the Pave Pillar Avionics Architecture development effort at the USAF Wright Research and Development Center. This common module architecture has been baselined for the F-22, AH-64, and various military aircraft upgrades.

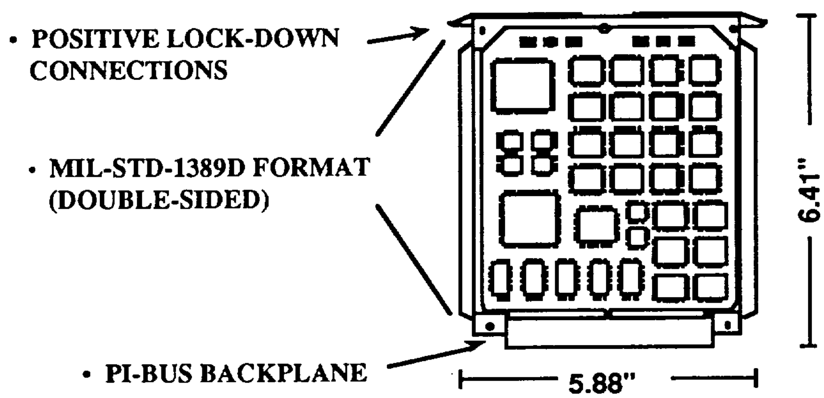

Figure 4. JIAWG Common Modules

The JIAWG common modules contain extensive BIT capabilities that enable subsystem level testing and fault isolation down to a line replaceable module (LRM). At system power-up, BIT functions detect failures in such module resources as processor chip sets, backplane bus chip sets, maintenance & controller chip sets, memory and supporting logic. In background mode, BIT is constantly monitoring module health during operation. The common module BIT architecture maintains module health status in on-board error logs and status registers. These logs and registers can be accessed via a calling program for analysis. If the avionics architecture has an appropriate databus system, the BIT information can be available across the system and to ground systems. When applied to launch vehicle avionics, the JIAWG Common Module BIT capabilities greatly reduces fault isolation and replacement time in the factory and on the pad.

The Avionics BIT Demonstration would have direct applicability to next generation Health Management Systems. In particular Space Station Freedom, Spacelifter, CTV and SEI would benefit.

5.2 Detailed Plan Description

The Avionics Built-In-Test Demonstration will show the operational advantages of using BIT technologies to automate the system-level checkout of avionics. The demonstration goal is to show how an avionics can aid operations by using Built-In-Test technologies to automate checkout operations and monitor system health during operation. It will be shown how avionics common module BIT technologies are used to determine component, module, subsystem, and system level health.

The Marshall Avionics Simulation Testbed (MAST) Lab at NASA's Marshall Space Flight Center is the proposed site for the first demonstration. The goal in the first year will be to demonstrate BIT capabilities of a single-string avionics system. The program will begin by generating requirements for the architecture. Next, the architecture will be configured into a single-string system. Demonstrations the following years will incorporate fault tolerant system designs. Additional systems which interface to the avionics system will be integrated. Additional hardware to be potentially integrated include equipment from the JSC VHM NRA and EMA hardware at MSFC labs.

First year demonstration hardware will consist of a selection of JIAWG common modules, a common module chassis with a PI-bus/TM-bus backplane, a Micro VAX software development processor and controller, a 6U chassis with VMEbus backplane, a simulation computer, and a host of coding and display terminals. The configuration will be linked together by a combination of a local area network, backplane system buses, and a main system bus. Flight software for the common module hardware will be in the Ada language. Software on the simulation computer will be written in the C language using a real-time Unix operating system. The host system for display of the demonstration data is to be determined. Potential display systems could be a PC system, a Silicon Graphics system (SGI), or a Sun workstation.

The following subsections describe the built-in-test and data networking technologies used in the demonstration as well as the hardware and software requirements.

5.2.1 Built-In-Test Capabilities

The JIAWG common module test and monitor capabilities minimize intrusive testing to provide higher hardware reliability and reduce the risk of operator induced errors. This is accomplished through the use of several levels of self-diagnosis and check out, starting with the capabilities that are built into the common modules.

Extensive BIT is in place today in JIAWG common modules:

Power-up BIT detects failures of module resources such as:

- Processor Chip Set
- Resource Controller / Backplane Bus Chip Set
- System Data Bus Chip Set
- Maintenance Controller Chip Set
- Local/Bulk Memory

– Supporting Module Logic

Performance Monitoring BIT operates in background mode and consists of three different packages.

- Applications Self-test Software
- Initiated Self-test Software
- Maintenance Controller Firmware

Off-Line BIT is designed to do complete testing of a module without interfering with system operation.

All faults, whether permanent of intermittent, are logged by the maintenance controller in error log memory.

Different levels of testing are accomplished in each BIT mode.

Level 1:	Tests all available module capabilities without stimulating any external output line or requiring any external stimuli.
Level 2:	Verifies the intermodule capabilities and busses which require intermodule coordination (e.g. TM-bus)
Level 3:	Verifies intersubsystem capabilities and busses requiring intersubsystem coordination.

The common module BIT program architecture covers level 1 and 2 testing. The overall system performs level 3 testing to verify intersubsystem capabilities, buses and network verification. It also performs non-avionics checkout of other subsystems such as electromechanical actuators, fluids and propulsion systems and various pieces of instrumentation on the vehicle.

5.2.2 Test and Maintenance Buses

Currently, system testing is performed using manual methods to check continuity and functionality. Often this is a labor intensive, time consuming process. Test data is usually transferred over existing system databuses. A failure of these buses would result in the subsequent failure of system testing. This problem is alleviated if there is independence between test buses and standard system buses.

Test and maintenance buses provide an independent path for the distribution of health, maintenance and built-in-test information. They also provide a clean interface for external test equipment and test data retrieval. A test bus structure ensures that test information does not interfere with normal system operations and enables test procedures to be performed in a variety of modes (powered-down, degraded, full-up, etc.) In addition to system checkout, test buses can exchange health information during normal system operation independently from standard system operations.

JIAWG Common Modules make use of a Multi-level Test and Maintenance bus (TM-bus) structure. This structure includes system-level TM-buses, subsystem (backplane) TM-buses, and chip and module level TM-buses. This structure enables verification of a system on multiple levels and permits isolation of faults to the smallest possible component. For a modular architecture, this permits isolation a line replaceable module (LRM). The system-level TM-bus (STM) is typically a serial, master/slave bus configuration. Control of the STM bus resides in the primary avionics computer subsystem. JIAWG Common Modules contain module-level TM buses. These buses exchange test and maintenance data among the modules in a given subsystem.

5.2.3 Demonstration Hardware

The following list of equipment will be used in the demonstration as discussed within this document.

JIAWG Common Module Chassis – With a complement of JIAWG common modules, this chassis is representative of a flight control computer. The chassis contains a PI-bus, TM-bus and IEEE-488 bus backplane. Data on the PI-bus and TM-bus is linked to the simulation computer via the 1553 system bus interface. The IEEE-488 is used primarily for module software load and debug operations.

JIAWG Common Modules – The common modules housed in the chassis are tested and monitored for fault information. As a minimum, the modules in the chassis will consist of a 1750A processor, a 1553 bus interface, and a power supply. The 1750A processor module performs the primary processing required to support the demonstration. The 1553 bus interface module provides the interface to the system bus, which provides the communication link between the modules and demonstration controller. The power supply provides the power needed by the common module suite.

VME Chassis – A 6U chassis with a VME backplane may be used as the simulation computer. In this capacity, its responsibility would be to coordinate the test demonstration and provide an interface between the common modules under test and the display computer. If a different computer system is chosen to be the simulation host, then the VME chassis may be required to serve as a interface between that computer and the common modules.

PC Display Hardware – The display computer emulates a Ground System. If a PC is used to display the demonstration data, it will consist of a RS-232 digital I/O board and a PC compatible 80386 type processor (as a minimum).

SGI or SUN Display Hardware – If an SGI or Sun system is chosen as the display host, the display information will be transferred via Ethernet buses

5.3.4 Demonstration Software

Demonstration software will be developed to support the demonstration of the automated test concepts. Code for the processor modules will be developed using Ada and loaded via the IEEE-488 bus. Software hosted on the display computer and simulation computer will be written in C.

JIAWG Common Modules – Each common module contains Applications Self-Test Software, Initiated Self-Test Software, and Maintenance Controller Firmware to support BIT operations. A calling program will be resident on the system bus interface module, which will serve as the on-board test coordinator. The purpose of the calling program is to interrogate the various fault logs and status registers on each of the modules in the cluster and report over the 1553 system bus to the Test Coordinator (simulation computer).

Display Computer – The display computer hosts a C language program with the function of receiving health status information over the System Test & Maintenance Network (Ethernet or RS-232) and displaying it in graphical form.

Simulation Computer – This computer will host a C language program to perform the Test Coordinator function, interface the System Bus with the System Test & Maintenance Network, monitor the health of the System Bus, and translate BIT information to graphical form for the Display Computer.

5.4 Demonstration Schedule & ROM Estimated Cost

The estimated cost and schedule for the three year Avionics BIT program is shown, by year, in the lower right of the quad chart in Figure 8. The estimates are rough order of magnitude (ROM),and should be used for planning purposes only. The estimates for FY94, FY95, and FY96 are $200K, $400K, and $700K respectively, with the total program estimated to be $1.3M.

The estimate is presented in inflation-adjusted, Real Year dollars, and reflects estimated contract labor only. This estimate assumes all hardware required for performance of this demonstration will be provided by either the contractor or the government at no cost to the contract. In addition, all deliverables are assumed to be tests and demonstrations, and data and reports, with no specified hardware or software deliverables. The program builds on each prior year's developments to accomplish additional items each year. Although not shown on the schedule, demonstrations would occur at the end of the first year and every six months following the first demonstration.

6.0 Report Conclusions

The potential benefits for VHM apply not only to today's vehicles but tomorrow's as well. Implementing the highest priority demonstration will help achieve the benefits in operations. The greatest benefits for VHM occur with the completion of all projects. However, confidence in the improvements in costs and reliability will be shown with this first program.

The avionics BIT demonstration will begin the reduction of operations costs using automated VHM. The avionics system will be the foundation for adding VHM in propulsion, pneumatics and data analysis. The project should be completed within three years. The plan has been developed after considering many alternatives. Its implementation is strongly recommended.

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY *(Leave blank)*	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	26 February 1993	Final; 30 Oct '92- 26 Feb '93

4. TITLE AND SUBTITLE
Candidate Technologies for the Integrated Health Management Program.

5. FUNDING NUMBERS
P.O. H-187630

6. AUTHOR(S)
Neal F. Johnson, Jr
Fred H. Martin

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
General Dynamics
Space Systems Division
P. O. Box 85990
San Diego, CA 92186-5990

8. PERFORMING ORGANIZATION REPORT NUMBER
93H-C-006

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
NASA
Marshall Space Flight Center
MSFC, AL 35812

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT
Unclassified - Unlimited

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

Existing launch vehicles require a large amount of checkout tests before and during launch. Many tests are performed manually with technicians and engineers. A new method of automating tests, known as Vehicle Health Management (VHM), enhances system reliability, reduces costs, and improves performance. Many techniques are being pursued to implement VHM on the Atlas and Centaur Expendable Launch Vehicles. Any technology proven on existing vehicles can be included in designs of future programs. A number of different plans were reviewed for possible development and demonstration. The demonstration considered to be the highest priority is determined and described. The selected VHM demonstration utilizes technology developed under the Advanced Development Program (ADP). The benefits of executing this demonstration are detailed. Principles, procedures, and methods of application for the demonstration are included.

14. SUBJECT TERMS
Launch Vehicles
Avionics
Launch Operations
Integrated Health Management

15. NUMBER OF PAGES
15

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	