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Sandia Satellite Program Summary of Operational Procedures

Space Systems Department, Space Sensors Department

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Sandia National Laboratories
Albuquerque, New Mexico 87185 and Livermore, California 94550
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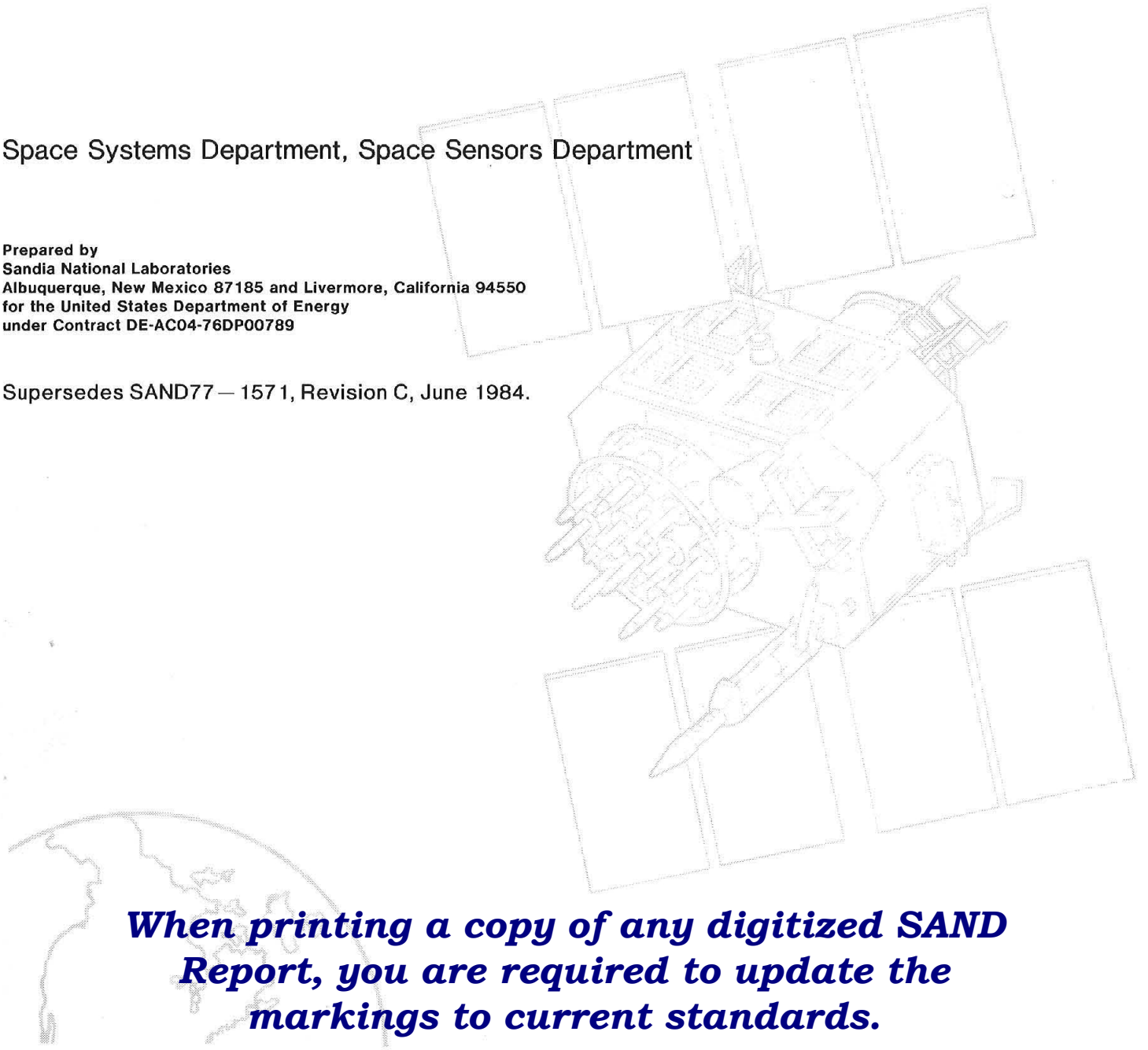

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SANDIA SATELLITE PROGRAM SUMMARY OF OPERATIONAL PROCEDURES

Space Systems Department
Space Sensors Department
Sandia National Laboratories
Albuquerque, New Mexico 87185

Abstract

Operational procedures for the Space Systems Department and Space Sensors Department are described. Departmental policies and procedures from design of systems for space applications through qualification for spaceflight are summarized.

*Supersedes SAND77-1571, Revision C, June 1984.

FOREWORD

This document, SAND89-0397, supersedes SAND77-1571, Revision C, released in June 1984. It restates policies, procedures, and individual responsibilities for the Sandia Satellite Program and brings Space Systems Department and Space Sensors Department procedures up to date in one document. Deviations from these procedures for special satellite payloads or abnormal circumstances can be authorized only by the managers of the Space Systems Department and the Space Sensors Department.

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ACRONYMS

DOE	Department of Energy
ECN	Engineering Change Notice
ESD	electrostatic discharge
FR	Failure Report
FS&L	Field Support and Logistics
FTPD	Full-System Test Program Document
GIDEP	Government Industry Data Exchange Program
MIL	military
NASA	National Aeronautics and Space Administration
NC	numerical control
NCR	Nonconformance Report
NIST	National Institute of Standards and Technology
PCB	printed circuit board
PR	Purchase Requisition
PWB	printed wiring board
QA	quality assurance
QAO	Quality Assurance Office
QAR	Quality Assurance Representative
QI	Quality Instruction
QP	Quality Procedure
QPL	Qualified Parts List
QR	Quality Report
ROA	Record of Assembly
SAR	Systems Action Request
SDDP	System Design Development Plan
SEM	Scanning Electron Microscope
SRR	Systems Repair Request
TPD	Test Program Document
TR	test requirement

SANDIA SATELLITE PROGRAM
SUMMARY OF OPERATIONAL PROCEDURES

1. INTRODUCTION

1.1 Scope

The primary mission of the Sandia National Laboratories' Satellite Program is to provide space-borne instrumentation for verification of the Limited Test Ban Treaty and for nuclear strike reporting and attack assessment. Space background radiation and other selected measurements are also provided as secondary missions. Ground data processing systems are designed and provided when necessary to support satellite flight instrumentation. The procedures outlined in this document relate to satellite flight instrumentation and general software management procedures only; specific ground processing systems procedures differ for each sponsor and for each satellite program and consequently are not described in this document.

1.2 Policy

Over the past 30 years, Sandia Satellite Program procedures have evolved into the current preferred method for providing space-qualified instrumentation systems. Because satellite instrumentation needs constantly challenge the state of radiation-hardened electronics technology, these procedures are modified periodically, but only after careful consideration and testing. Proposed changes are weighed with caution because systems designed, tested, and fabricated to these procedures have performed well and exhibited long operating lifetimes in space. Changes in these procedures must be demonstrated to improve this performance. Therefore, performance modifications can be authorized only by the manager of the Space Systems Department or Space Sensors Department and must be approved by the Director, Monitoring Systems Directorate.

This document describes current policies, procedures, and information used in the daily operations of the Space Systems Department and the Space Sensors Department. It summarizes procedures from payload design, fabrication, assembly, testing and inspection, to system integration with the host satellite, and describes the quality assurance (QA) philosophy for these procedures. Certain activities require more detailed procedures; these are listed in the appropriate section and are available from the Sandia film bank. The appendix to this document contains examples of the forms used in these procedures.

In general, these procedures meet or exceed host satellite requirements; all satellite projects should adhere to them unless specifically exempted by the Space Systems Department or Space Sensors Department manager. When a special requirement is not covered by standard procedures, special procedures needed to meet the requirement are carefully developed, documented, and distributed to concerned personnel.

The Department of Energy (DOE) requires a formal Program Quality Plan for the Sandia Satellite Program. The *Sandia Satellite Program Quality Assurance Plan* meets this requirement and is available from the department offices.

2. DESIGN ACTIVITIES

2.1 Design Requirements

Sandia satellite payloads for spaceflight applications are designed and documented for fabrication, assembly, inspection, and testing based on the sponsor's *System Requirements* document. Design requirements are divided into five areas:

1. Subsystem (digital logic, power, and sensor),
2. Printed wiring assembly (modules and motherboards),
3. Electrical component (active and passive),
4. Mechanical (structures, weight, radiation shielding, etc.), and
5. System testing.

2.2 System Design Development Plan

The design sequence normally begins with system-level design conferences to define the satellite payload required to meet the sponsor's requirements (usually defined in a *Mission Requirements* or *System Requirements* document). The system is divided into subsystems that meet these payload requirements. Once design requirements are determined, a System Design Development Plan (SDDP) is developed. The SDDP charts all design activities with estimated completion dates from breadboard through released drawings, specifications, and inspection and testing for the first production system. The SDDP also assigns department, division, and design engineer responsibilities. (Figure 1 illustrates the system design organization.)

Early in the design, the responsible department manager and design division supervisor must determine the system radiation hardness requirements. System radiation hardness principally applies to electrical semiconductor components (e.g., active integrated circuits, diodes, transistors, etc.) that are subject to total dose damage, transient radiation upset, or transient radiation latchup. For example, electrical components used in digital or analog logic circuitry designed for most space applications should withstand a minimum total dose of 1×10^5 rads (Si) with no damage. Components not meeting minimum radiation hardness requirements should be identified quickly so that alternative shielding methods can be considered, tested, and implemented.

2.3 System Design Definition Control

Once designers have defined electrical and mechanical requirements and tested breadboards to show that preliminary designs meet requirements, design schematics are submitted to drafting for formal drawings. Engineering check prints, schematics, and printed wiring board (PWB) circuit masters are generated and returned to the designer for review and sign-off approval. When the drawings and associated documents are approved, the Systems Record Center extracts pertinent information and enters it into the Systems Record Center data base, and the design definition is released for fabrication.

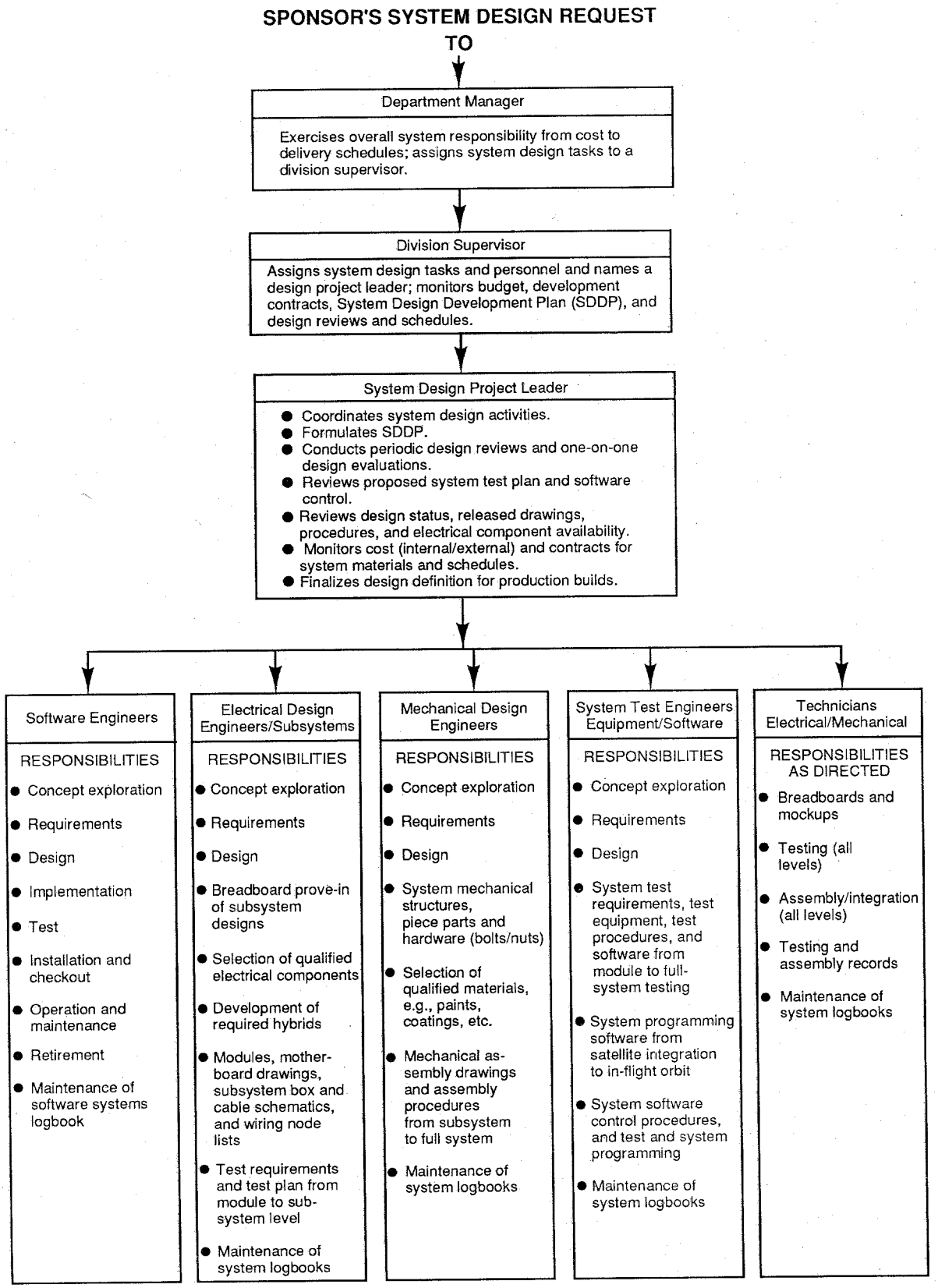

Figure 1. System Design Organizational Chart

Drawings and associated documents are released to the Sandia film bank, where they are stored for future use; copies are also distributed to the designers and the Space Systems Fabrication Development Section. The PWB circuit masters and numerical control (NC) drill tapes are available from the Sandia Micrographics Section. When design changes are required, the designer submits an Engineering Change Notice (ECN) to the Systems Record Center, where the ECN is assigned a control number and forwarded to drafting for incorporation into the appropriate drawings. If the ECN so specifies, the change is incorporated into the drawings as soon as possible, and the drawing identifiers are updated to include the ECN number. If the ECN does not indicate that the change is to be incorporated, the ECN is held until a Systems Action Request (SAR)* specifying incorporation of the ECN design change is received, and then the change is made. If the designer decides not to incorporate the ECN design change, an SAR canceling the ECN is submitted to the Systems Record Center. Outstanding ECNs must be incorporated or cancelled before the next system build.

System design definitions are controlled in the Systems Record Center, and all information on a system's design definition is processed through the Systems Record Center. ECNs are logged into the Systems Record Center data base, and contracts are reviewed for any effect these ECNs may have on current system builds. A system's current design definition can be verified through the Systems Record Center, including pinpointing any outstanding ECNs that require incorporation into the system design definition before the next system build. System design definition control is explained in detail in Section 4.

2.4 System Procurement

2.4.1 Procurement Procedures

The Design Development Division is responsible for procurement of flight components, electronic modules, box assemblies, etc., and for control and issuance of flight-quality electrical and mechanical components. To initiate procurement, a systems engineer sends an SAR to the Design Development Division. The Design Development Division procures the requested items.

Electrical components are procured and stocked by the Design Development Division. If electrical components are listed on the Qualified Parts List (QPL) as available to JAN S quality levels, they are procured to these levels. If a component is not available to JAN S levels, it is procured to the highest available quality level and subjected to screening procedures, developed by the responsible component engineer and the Quality Assurance Office (QAO), to upgrade the component to JAN S equivalent level.

Electrical components used in space systems are submitted to incoming screening and inspection, as specified by the responsible component engineer. Accepted flight-quality components are placed into flight stock inventory, protected from electrostatic discharge (ESD), and issued as required for fabrication.

*The SAR is a general-purpose request for action involving a space system activity.

Mechanical piece parts (boxes, frames, etc.) are procured from qualified precision machine shops and then coated, painted, or plated, as required. All mechanical piece parts are subject to incoming inspection and materials analysis. Accepted piece parts are placed into flight stock inventory and issued as needed for fabrication. The *Sandia Satellite Program Mechanical Procedures*, SS-R16206, describes in detail the fabrication process.

2.4.2 Testing and Documentation

When a contractor is required to perform electrical functional testing on an item (box, cable, module, subsystem, or power supply) in accordance with Sandia test requirements (TRs), the tests are performed on test equipment provided by Sandia or on equipment developed by the contractor and approved by Sandia. After fabrication, assembly, inspection, and, if required, testing of an item, the contractor is required to complete a File Card (e.g., module file card, box file card, etc.), a Record of Assembly (ROA), and the required test and inspection data forms before submitting the item to the Sandia Quality Assurance Representative (QAR). The QAR, in accordance with applicable Quality Instructions (QIs), reviews the documentation for correctness of required information, including inspection and test results, and inspects the product for mechanical and visual requirements.

Upon receipt of the product at Sandia, it is inspected for damage, and, if the product is accepted, data from the File Card, ROA, and data forms are entered into the Systems Record Center data base by system and item. The File Card remains with the item until the item is incorporated into the next assembly. If any design changes, repairs, or component changes are made to the item, they are recorded on the File Card. When items are assembled as a subsystem, the File Cards are assembled to form a deck. Once the full system is assembled, the File Cards remain in the system File Card Deck for the life of the system. Both the File Card and the ROA provide traceability for each item from as-fabricated to as-launched.

2.5 Electrostatic Discharge Damage Prevention

All active components are considered sensitive to the discharge of static electricity. ESD control is imperative in all areas where components and assemblies are present. Sandia and all qualified Sandia contractors are required to have ESD programs in effect in all areas where ESD-sensitive electronic components are stored or assembled. The QAR is required to monitor these areas on a random basis to verify compliance with ESD damage prevention procedures and report serious problems to the Space Systems Department manager.

Detailed ESD information and various procedures for damage prevention are provided in Section 6.

2.6 Design Changes and Repairs

System boxes, cables, and modules are fabricated, assembled, tested, and accepted in accordance with current released drawings. Design changes are requested with an ECN and, if specified by the ECN or subsequent SAR, are incorporated into control and assembly drawings before the next system build. Items that undergo design modifications are identified by special marking. Design definition identifiers are explained in detail in *Sandia Satellite Program Design Definition Control*, SS-S91177.

Repairs to a system include replacement of failed components, correction of fabrication errors and handling damage, etc. These repairs are documented on Space Systems Repair Requests (SRRs), File Cards, and ROAs.

Failures are tabulated by the QAO. Failure analysis is conducted if a significant failure or failure trend is detected.

Detailed design change and repair information is presented in Section 8.

2.7 Subsystem Procedures

2.7.1 Functional Test Programs

Functional test programs are designed for analog and digital subsystems. For most logic assemblies, a computer test program that runs on the subsystem test rack selects the proper interface signals to test each circuit functionally. For analog assemblies, other test methods that use a combination of analog and computer testing equipment are used.

A Test Program Document (TPD), which includes subsystem inspection and test procedures and sample check sheets, is prepared by the designer and test engineer. Environmental tests and the special qualification-level tests usually required for the first subsystem of a series are included in the subsystem TPD.

2.7.2 Assembly and Test

When the modules and box of a subsystem are available, the designer withdraws them and their File Cards from controlled storage and tests each module in accordance with its TR. If all modules are acceptable, the designer integrates them into the subsystem box and assembles the module File Cards into a File Card Deck, with the box File Card as the control card for the deck. The File Card Deck accompanies the box wherever it goes, and any anomaly, change, or failure of a module is recorded on the appropriate module File Card. If a module of the box is removed and replaced, the corresponding File Card is also removed and replaced in the File Card Deck. When boxes are finally integrated into the full system, the box File Card Decks are assembled into the full-system File Card Deck.

After assembly and visual inspection to ensure against gross errors, the subsystem is bench tested (debugged) by the designer and test engineer. Initially, both the test program and circuit functionality are checked, reviewed, and modified until the box operates as the designer intended and the test program properly verifies this operation. The TPD is updated and reissued if necessary. Any repairs or modifications to modules and boxes are made only by personnel certified for repair of flight equipment, the changes are recorded, and the modules or boxes are inspected before they are reintegrated into the subsystem.

After the debugging is complete, subsystem acceptance tests begin. The box is tested over voltage and temperature variations in accordance with the test program. Any box or module failure is recorded on the appropriate File Card and in the system logbook.

2.7.3 Box Logbook

The box logbook is initiated by the box designer at the box assembly level and is used to record all occurrences that affect assembly. The box logbook should include, at a minimum, the following information:

1. Dated and initialed procedure check sheets,
2. Module listings, including serial numbers and slot numbers for each module, and the box serial number,
3. Schematics,
4. Node lists,
5. Data and/or results from all subsystem tests,
6. Design changes, failures, anomalies, etc.,
7. Full-system acceptance test results, and
8. Full-system/host satellite integration test results.

The box logbook is maintained throughout module testing, subsystem testing, and full-system acceptance testing, and is kept current as long as there is system activity, including operation aboard a satellite in orbit. Portions of the box logbook, such as module listings and locations, are entered into the system logbook.

2.8 System Procedures

2.8.1 Full-System Testing

A full-system test program verifies subsystem and system performance. A Full-System Test Program Document (FTPD), including test procedures and sample check sheets, is prepared by the box and test engineers and the project leader. Full-system acceptance tests are included in the FTPD.

Full-system tests proceed much like subsystem tests. Subsystems are assembled to comprise the full system, and debugging proceeds until full compatibility is established between the automated program and the system. Full-system testing is designed to simulate as closely as possible the environmental conditions expected in orbit.

If the system has a tactical requirement to survive transient radiation (gamma-dot), it will be tested to that requirement at full-system level, fully powered and monitored by payload testing instrumentation. This must take place prior to thermal vacuum testing.

A burn-in requirement that specifies a minimum total operating time plus a minimum time in thermal vacuum testing is included in the full-system tests. The full system, usually without sensors, is temperature cycled before the thermal vacuum test is started. (Sensors frequently cannot withstand the temperature extremes to which the system is tested and may be temperature cycled separately. However, they must be tested to temperatures that exceed the extremes expected in orbit). The thermal vacuum test is tailored to the requirements of the host satellite and should exceed expected orbital temperature extremes.

Sandia space payloads meet two minimum periods of burn-in testing prior to delivery:

1. A minimum of 240 hours (10 days) of continuous thermal vacuum testing after system integration, and
2. A minimum of 300 hours (12-1/2 days) operating time (includes thermal vacuum testing time).

In addition, a minimum of 4 days of thermal vacuum testing is required following repair or rework of a system. Any deviations from these minimum times because of scheduling or other reasons must be approved by the Space Systems Department or Space Sensors Department manager.

2.8.2 System Logbook

A full-system logbook is maintained as the system is assembled. All test result summaries from bench testing through full-system acceptance testing are included in this logbook. This logbook includes, as a minimum, the following information:

1. Copies of module listings showing serial numbers and slot locations,
2. Configuration of full system (box and subsystem serial numbers, etc.),
3. Corrective action records, and
4. All test anomalies and test record sheets, including satellite-level testing.

The system logbook is maintained as long as the system is active; the project leader is responsible for the maintenance and completeness of the system logbook.

2.8.3 Data Analysis and Storage

Test data from full-system acceptance testing are reviewed during the test period. Pertinent test limits are checked by computer programs. After the tests are complete, the data are reviewed by the responsible test engineer. All test data are retained until the system has been launched, at which time the project leader selects critical data to be retained until the system has been retired. Additional system test procedure information is available from the project leader.

2.9 Management Instructions

Space Systems Department or Space Sensors Department written management instructions are used to provide guidance for conditions and situations not covered under the normal procedures described in this document and to provide accountability for necessary deviations from these procedures. Permanent procedural changes, made periodically to upgrade and update the procedures summarized here, require the approval of the Director, Monitoring Systems Directorate.

3. QUALITY ASSURANCE

3.1 Quality Assurance Plan

The *Sandia Satellite Program Quality Assurance Plan* describes the quality control policy, responsibilities, and activities of organizations and individuals throughout the satellite programs of the Space Systems Department and the Space Sensors Department. The plan covers space systems design, documentation control, procurement, fabrication and assembly controls, and quality inspections. The plan complies with *Quality Program Elements*, DOE AL5700.6B, and the *Sandia National Laboratories Quality Plan.*

3.2 Quality Assurance Office

The QAO maintains and controls the *Quality Assurance Plan* and this summary. Other QAO responsibilities include

1. Writing QIs for verification inspection of product in contractor facilities and for receiving inspection of product shipped directly to Sandia.
2. Supporting QAR activities at contractor facilities and providing QIs.
3. Conducting random quality audits of the activities of the Space Systems Department and the Space Sensors Department for compliance to test requirements, software documentation, and control of modules, subsystems, and full systems; conducting internal audits of space systems before shipment to verify compliance with the quality plan. (The results of all audits are documented, and quality problems are referred to responsible division supervisors along with recommended actions; after a reasonable period, follow-up inspections verify corrections.)
4. Conducting formal QA audits of contractor facilities (for compliance with SS-S61316).
5. Reporting internal (Sandia) and contractor QA deficiencies and conducting failure analyses, including proposed corrective actions.
6. Monitoring adherence to ESD protection procedures.
7. Reviewing purchase requisitions (PRs) for appropriate quality requirements.
8. Controlling satellite program documents and quality records.
9. Monitoring to ensure that instruments are calibrated as specified in *Engineering Procedure, Calibration Program*, EP401560.

3.3 QAO Design Definition Review

The QAO conducts design reviews to determine special product-qualification requirements.

3.4 Contractor Qualification

3.4.1 Component Qualification

Component manufacturers listed on the applicable device QPL are considered qualified and are evaluated only when additional processing or environmental requirements are specified.

When a required component is not available from a qualified source, the Design Development Division and the QAO will evaluate a potential contractor's manufacturing and quality operations and may place a product evaluation contract to obtain product for evaluation. The contractor is considered qualified once a capability to meet the component delivery and quality requirements has been demonstrated, and the component has successfully passed all qualification testing requirements.

3.4.2 Assembly Qualification

Prospective satellite product or service contractors are evaluated by the QAO and the Design Development Division for overall capability and commitment to meet the requirements of the system Statement of Work. The contractor must have a quality program and an operations manual and must be able to produce products to the quality required by the Sandia Satellite Program. The contractor's operation is evaluated for compatibility with satellite program requirements, including as appropriate: (1) procedures for receipt, process, and final inspection of product, (2) electrical and mechanical inspection equipment and calibration standards traceable to the National Institute of Standards and Technology (NIST) or other approved source, (3) production and manufacturing control for fabrication and assembly, (4) administration of in-house and customer contracts, purchasing, and cost control, (5) material control of purchased and customer-furnished inventory, (6) an ESD program for the protection of static-sensitive electronic assemblies and components, (7) a drawing and procedure recall system, and (8) qualified assembly and inspection personnel. The contractor is also evaluated for adequate in-house facilities, such as a PWB facility.

If a contractor appears to have the capability, commitment, and personnel to produce product in accordance with satellite program requirements, evaluation contracts are placed. If the resulting product is acceptable and the contractor demonstrates a working knowledge of system requirements, the contractor is considered qualified to provide satellite program product or services.

Qualified contractors are periodically subjected to quality audits for compliance with contractual requirements and commitment to quality procedures.

3.5 Procurement

PRs for components, boxes, cables, modules, lenses, sensors, and mechanical hardware are reviewed by the QAO for compliance with quality requirements and are approved by the appropriate division supervisor.

3.6 Inspection Requirements

The QAO provides QIs for the inspection of incoming products at Sandia and product acceptance by QARs at contractor facilities.

3.6.1 Source Inspection

The QAR inspects system boxes, cables, and modules at the contractor's facility. In addition, the QAR usually inspects pertinent quality records, including Quality Reports (QRs), ROAs, File Cards, and in-process inspection and test data, as applicable. The QR contains a complete list of product definition documents (drawings) that identify the product as-fabricated

and as-accepted by the contractor and appropriate ECNs and Nonconformance Reports (NCRs). The QAR verifies that the product is identified in accordance with the contract, reviews documentation for compliance to system requirements, visually and mechanically inspects and tests the product in accordance with the QI, and verifies the presence and location of electrical and mechanical component identifiers on the product. When a contractor is authorized to incorporate a design change or to use nonconforming material, the QAR verifies that the appropriate ECN or NCR number is recorded on the item's ROA and File Card, and that the item is marked with the proper ECN change identifier. Product and acceptance documentation is forwarded to Sandia and stored in the Systems Record Center data base.

The following source inspections of semiconductor components may be performed by the QAR or the responsible component engineer: (1) wafer certification, (2) pre-cap visual inspection, and (3) review of the contractor's lot history, scanning electron microscope (SEM) photographs, x-rays, and test data. Wafer certifications and lot tests are evaluated statistically in accordance with critical electrical parameters.

3.6.2 Incoming Inspection

All incoming product intended for use in spaceflight payloads is inspected in accordance with a QI. System boxes, cables, and modules are inspected for handling and shipping damage and for required documentation before being placed in flight stock. Electrical components are visually inspected for proper identification and damage, dimensions are verified, and lot and/or serial numbers are verified in accordance with certifications. Electrical parameters are verified in-house or by a Sandia-approved testing laboratory. Contractors for mechanical assemblies and piece parts submit dimensional inspection data and material plating analyses and certification, as specified by contract. Sandia has the option of verifying any or all of these parameters. After electrical and mechanical components have met acceptance criteria, the acceptance data package is forwarded to the QAO for review and disposition. The components are placed in bonded flight stock inventory and recorded in a flight stock inventory data base.

3.7 Bonded Flight Stock

Sandia furnishes contractors with most of the electrical and mechanical components required to fabricate and assemble system boxes, cables, and modules. Electrical and mechanical flight components are stored by the contractor in a bonded stock area with controlled access. Sandia kit parts and ESD-sensitive components are packaged in static-controlled containers and identified as ESD sensitive. The QAO periodically audits Sandia and contractor control of electrical and mechanical flight components for compliance with established procedures for protection of flight-qualified stock.

3.8 Electrical and Mechanical Component Failures

The engineer or technician who observes an electrical or mechanical component failure at the system or subsystem level is required to complete a Failure Report (FR) identifying the failure and describing the conditions under which it was observed. The QAO investigates failures to determine their cause and effect on the Sandia Satellite Program.

When a component failure appears to be lot related, components from the affected lot are screened. If a component failure is confirmed as lot related, the affected components are removed from the parts inventory and from payloads being assembled. Department alert

bulletins are issued, and the manufacturer is notified of the failure. All space systems are then screened for the affected components. If the risk is sufficient (as determined by the appropriate department manager), all affected systems are retrofitted. The QAO tabulates and maintains a historical record of all system component failures and Government Industry Data Exchange Program (GIDEP) alert bulletins on like components used in space systems and provides data to GIDEP.

3.9 Design Changes, Repairs, and Nonconforming Material

System design changes and repairs, as well as the use of nonconforming material, are carefully controlled and documented for aid in troubleshooting problems or anomalies. Details on design changes, system repairs, and nonconforming material are provided in Section 8.

3.9.1 Design Changes

Changes to released designs, as a rule, are made in accordance with an approved ECN. Each ECN is assigned a control number, entered in the Systems Record Center data base by system and item number, and incorporated into system drawings before the next system build. The assigned inspector inspects design changes to an item in accordance with the ECN, verifies that the item is marked with the proper change identifier, and verifies that the ECN number is recorded on the item's ROA and File Card. Copies of the ECN are distributed to the Systems Record Center and to the originating engineer.

3.9.2 Repairs

All items requiring electrical repair (and their File Cards) are delivered to the repair laboratory with an SRR, which carries a Failure Report number assigned by the QAO. The repair laboratory completes the following steps for each item:

1. Assigns an SRR number,
2. Performs the required repair,
3. Enters the SRR number on the item's File Card, and
4. Notifies an authorized inspector that the item is ready for inspection.

The inspector inspects the repair work and initials the File Card.

The repair laboratory then returns the repaired item (with its File Card) to the requestor. Copies of the SRR are sent to the requestor, the repair laboratory files, and the QAO. The QAO reviews the SRR and forwards it to the Systems Record Center, where information on the repair is entered into the data base.

3.9.3 Nonconforming Material

The use of nonconforming material in a space system may be authorized by an NCR, which must be approved by the project leader, the design engineer, and the QAO. The QAO tabulates all NCRs for (1) Sandia-furnished items that cause a nonconforming condition, (2) contractor workmanship errors, and (3) any process that causes material defects or circuitry of improper dimensions on a module. When review of NCRs indicates a serious or repetitive nonconforming condition, the QAO initiates a request that immediate corrective action be taken by Sandia or the contractor.

3.10 QA Audits

3.10.1 Contractor QA Audits

Contractors for system boxes, cables, and modules are audited periodically based on performance record, changes in their quality program and operations manual, and changes in Sandia system requirements. Audits cover fabrication, assembly, inspection, and, if required, testing of products. Contractor compliance to contracts, drawings, and procedural requirements, including product packaging for shipment, is evaluated. A meeting is held to discuss findings and to set completion dates for corrective action by Sandia or the contractor. Audit results are documented and are available from the QAO for review. If significant technical/quality defects are detected during the audit or if the contractor becomes delinquent in taking appropriate corrective action, the contractor may be disqualified.

3.10.2 Qualification Verification Audit

The QAO performs a Qualification Verification Audit on each spaceflight system prior to shipment to verify that the system has been designed, fabricated, assembled, tested, and documented in accordance with procedures summarized in this document and in applicable satellite specification documents. The system project leader requests this audit after all flight acceptance testing has been completed for the system and all other qualifications have been met and submits to the QAO the following substantiating documentation:

1. A system design definition that includes:
   a. Full-system title, drawing number and issue, and an applicable system build and/or spaceflight number.
   b. Subsystem box assemblies (power supply assemblies and sensors) by title, drawing number and issue, serial number, and date code; each module in a box or power supply assembly is also listed by title, drawing number and issue, serial number, and date code.
   c. Results of mass properties measurements (system weight and moments of inertia).
   d. System cables list by drawing number and issue, title, serial number, and date code.
   e. ECN number(s) for ECNs incorporated, NCR number(s) of nonconforming material accepted, and system electrical and mechanical component Failure Report and Failure Analysis Summary Report numbers.
2. System File Card Deck, logbooks, and system assembly records.
3. A listing of computer testing software and Test Limit Files, by revision, for all levels of testing from subsystem to full-system qualification.

From this information, a system, subsystem, and cable inventory is prepared, and a test data summary is produced by the test engineer. These two documents comprise the final system definition required for satellite integration.

Audit results are documented and distributed to department managers, system division supervisors, and the project engineers, as appropriate. Each system's as-shipped design definition is entered into the Systems Record Center data base by space program and system number.

Sandia Satellite Program System Preship Audit, SS-S74438, describes these audits in greater detail.

3.11 Historical Data

All data generated during the design, fabrication, assembly, testing, acceptance, and qualification of a space system are retained at Sandia for the life of the system in space. These data are stored variously in the Systems Record Center data base, on microfilm, and/or in their original form, and are available for review as needed for troubleshooting, anomaly investigations, and design verification.

3.12 Satellite Program Procedures

The QAO prepares and issues Quality Procedures (QPs) and QIs for acceptance of system product at Sandia and at contractor facilities. The Design Development Division prepares and issues product fabrication, assembly, and process procedures. Quality and product procedures are reviewed periodically.

3.13 QA Documents

The *Sandia Satellite Program Quality Assurance Plan*, along with the following quality documents, provides a more complete description of quality assurance elements and activities. These documents are available from the Sandia film bank and department offices and are provided to contractors as appropriate.

SS-R16205	*Sandia Satellite Program Application Process for Chemglaze Paint*
SS-R16206	*Sandia Satellite Program Mechanical Procedures*
SS-S61315	*Pre and Post Conformal Coat Inspection Procedure for Satellite Systems*
SS-S61316	*Sandia Satellite Program Contractor Quality Assurance Program Requirements*
SS-S68027	*Quality Assurance Inspection Procedure for Modified Space Systems*
SS-S68063	*Space Systems, Components Incoming Verification Inspection Procedure*
SS-S68075	*Space Systems, Electrical and Mechanical Failure Reports and Analysis Procedure*
SS-S74408	*Space Systems, Design Change and Repair Request Control Procedure*
SS-S74418	*Guidelines for Quality Assurance Acceptance of Product and Preparation of Quality Verification Instructions*
SS-S74419	*Space Systems, Product Procurement Procedure*
SS-S74438	*Sandia Satellite Program System Preship Audit*
SS-S80033	*Space Systems Nonconforming Product Control Procedure*
SS-S91175	*Sandia Satellite Program Quality Assurance Representative Support*
SS-S91177	*Sandia Satellite Program Design Definition Control*
SS-S91180	*Sandia Satellite Program Quality Assurance Contractor Audit*
SS346233	*Space Systems, Printed Wiring Assembly Conformal Coating Requirements*
T65535	*Space Systems, Box, Cable and Module Design Configuration Control Procedure*

4. DESIGN DEFINITION CONTROL

Design responsibilities for individual satellite systems are assigned to appropriate divisions by the Space Systems Department or Space Sensors Department manager. The assigned division supervisor(s) and project and design engineers are responsible for all phases of system design from electrical and mechanical interfaces to host satellite integration requirements. Design definition is maintained through periodic design reviews, adherence to established design procedures and standard parts lists (whenever possible), and standard operational procedures that ensure proper design and drawing control.

4.1 Design Definition Reviews

Periodic system design definition reviews are conducted by the responsible division supervisor and system project leader with the designers (electrical and mechanical), data programmers, fabrication development personnel, and the quality engineer. These reviews establish requirements for design, fabrication, assembly, and test procedures, operational data requirements in space, and quality verification and inspection requirements.

4.2 Systems Record Center

Once a design is approved, drawings are released, and release information is entered into the Systems Record Center data base by system and item numbers. The Systems Record Center data base lists all system modules by drawing number, drawing issue, and circuit master level, and lists subsystem assemblies by drawing issue, boxes and cables by wiring node list revision levels, and components by part number. The Systems Record Center data base is the reference point for defining fabrication and assembly contracts, and it provides traceability for a system's as-fabricated, as-assembled, and as-accepted design definition.

4.3 Engineering Design Changes

Once a system design definition has been generated, released by signature of the responsible engineer, and entered into the Systems Record Center data base, an approved ECN (SA 7195-ECN) is required to make a design change. The Systems Record Center assigns control numbers to all ECNs and enters them into the data base as outstanding against the system. Outstanding ECNs are incorporated into system drawings before the next system build.

4.4 Design Configuration Control

Each system box, cable, and module is required to have a File Card and ROA completed by the contractor at the time of fabrication, assembly, and acceptance. The File Card and ROA contain the following information: (1) item identifier, serial number, and date, (2) module drawing and issue, (3) circuit master and component revision levels, (4) box and/or cable drawing and issue, and (5) wiring node list revision level. When Sandia authorizes a contractor to incorporate an ECN, the contractor is required to enter the ECN number on the appropriate File Cards and ROA. The Systems Record Center enters design configuration information into the data base, and traceability is established for each system item from fabrication to system integration.

4.5 Logbooks and File Card Deck

The system logbooks and File Card Deck are a day-to-day record of the system, item by item, from as-fabricated to as-integrated into the host satellite. The logbooks and File Card Deck record ECNs, SRRs, NCRs, and component and test failures. Based on any of these documents, a system design review may be initiated for corrective action(s).

4.6 Design Procedure Documents

The following documents detail the controls placed on space systems designs from design conception to integration of a system into the host satellite:

SS-S74408	*Space Systems, Design Change and Repair Request Control Procedure*
SS-S74445	*Space Systems Procedure, File Card Deck and Log Book Set Control*
SS-S91177	*Sandia Satellite Program Design Definition Control*
T65535	*Space Systems, Box, Cable and Module Design Configuration Control Procedure*

5. PROCUREMENT

Contracts for the fabrication and assembly of system boxes, cables, and modules are placed competitively with contractors qualified (approved) by system engineers and the QAO. Contracts for electrical components, mechanical assemblies and piece parts, and electrical assemblies are placed with approved contractors who meet military (MIL) standards, National Aeronautics and Space Administration (NASA) specifications, or Sandia specifications and (preferably) have a proven quality history. System contracts fall into four categories: fabrication and assembly, electrical components, mechanical components, and materials.

PRs are written in accordance with a system's latest design definition as recorded in the Systems Record Center data base and are subject to review by the responsible division supervisor and the QAO. Systems contracts are technically administered by a technical consultant, who works with the contractor. The technical consultant reviews the product based on design definition, fabrication and assembly, and material requirements.

Guidelines for system and sensor procurement are covered in detail in *Space Systems, Product Procurement Procedure*, SS-S74419.

5.1 Fabrication and Assembly Contracts

Sandia provides contractors with most of the electrical and mechanical components and hardware for the assembly of system boxes, cables, and modules. Contractors fabricate printed circuit boards (PCBs), install components, and assemble boxes, cables, and modules in accordance with appropriate system drawings and requirements and perform inspections and tests as specified. The QAO assigns a QAR to each contractor to monitor production and quality operations and to accept product.

5.2 Electrical Components Contracts

When possible, electrical component contracts (for hybrid and integrated circuits, transistors, diodes, resistors, connectors, wires, etc.) are placed with contractors who produce components to MIL standards, NASA specifications, or Sandia specifications.

Contracts for components require, as a minimum, contractor certification that the product meets contractual specifications.

Contracts for semiconductor devices require a test data package, defined by the component engineer, that may include data collected during Group A and B testing for components from a manufacturing lot.

5.3 Mechanical Components Contracts

Contracts for system mechanical subassemblies and piece parts are controlled by the design engineer and placed with contractors who have full machine-shop and inspection capabilities. Contractors are required to submit inspection records and material and coating certifications for

all products in accordance with specified MIL standards and/or Sandia specifications. A number of system boxes and piece parts require special coatings (gold, paint, special plating, etc.). Gold and special platings or coatings are provided by contractors who specialize in these types of coatings. Certifications and physical analyses are required on gold and special platings.

5.4 Materials Contracts

Materials are purchased from sources recommended by NASA. All materials used in space systems are required to meet NASA outgassing and flash-point requirements. The potting, coatings, insulation materials, and manufacturing material for connectors, sensors, etc., are verified for outgassing and flash-point, and material that is questionable is verified in accordance with space requirements at Sandia or at an approved testing laboratory.

6. ESD DAMAGE PREVENTION

6.1 Electrostatic Discharge Damage

Most of the electronic components used in satellite modules and subassemblies can be damaged by ESD. These components have a susceptibility range of from 30 to 7,800 V; in most cases, a static discharge level that can damage ESD-sensitive components (less than 3,000 V) cannot be felt by humans. A destructive static discharge could cause immediate component failure, or it could cause latent damage that could result in a system failure or a loss of data-collecting capability in space.

Sandia provides most of the electrical components to the contractor for fabrication of space subsystems; these components can cost several thousand dollars (e.g., hybrid memory devices). Both Sandia and contractor personnel who assemble ESD-sensitive components are required to have received ESD training before handling these components. The ESD training program is repeated periodically to refresh the employees' knowledge of ESD work habits and precautionary measures.

6.2 ESD Protection Methods

ESD protection methods apply to component manufacturers, to Sandia, and to contractors who assemble, store, test, and ship static-sensitive components, modules, subsystems, and full systems.

Static-sensitive components, modules, subassemblies, and systems are packaged in static-controlled containers, bags, boxes, or wraps for shipment or transport from one work or test location to another. ESD warning labels are placed on protective enclosures, and static-sensitive items can be removed from their protective enclosures only at a static-controlled work or test station.

Static-sensitive components, modules, subassemblies, and systems are stored in protective enclosures and bonded stock areas to which access is limited. Storage cabinets are grounded, and the shelves are lined with static-controlled material. ESD warning labels are placed on cabinets to indicate that the cabinet contents are static sensitive.

All work stations and assembly, cleaning, component preparation, inspection, and test locations are required to be static-controlled environments. Work stations and test locations are kept free of static-generating materials such as styrofoam, plastic items, vinyl books and covers, and personal items (combs, purses, pens, etc.).

The QAO monitors contractor operations and in-house activities for compliance to ESD requirements as defined in *Handling Procedure, Electrostatic Sensitive Device*, SS343666, which is incorporated into fabrication, assembly, inspection, testing, packaging, and shipping instructions and procedures. These procedures are available for review from the QAO and department offices.

7. FABRICATION AND ASSEMBLY

7.1 Fabrication and Assembly Procedures

Satellite program fabrication and assembly procedures are based on methods and technology that have proved successful for over 30 years. These procedures are incorporated into all system box, cable, and module fabrication and assembly contracts. The procedures are based on, and tailored to, MIL standards and NASA and Sandia specifications as well as Sandia's standardized system design format. The procedures meet, and in most cases exceed, satellite program requirements. The Design Development Division is responsible for these procedures, which are periodically reviewed as new and proven technology is introduced. Contractors are qualified, in accordance with these procedures, to produce system boxes, cables, and modules. These procedures generate a system historical record in the Systems Record Center data base that provides detailed traceability for all flight systems.

7.2 Fabrication and Assembly Documentation

An ROA and a File Card are completed by the contractor for each system box, cable, and module. The following information, as applicable, is recorded on each item's ROA and File Card: item identifier, serial number, date code, drawing number and issue, circuit master and component revision levels, wiring node list, ECN number, and NCR number. The ROA for modules requires that all installed electrical components be recorded, as applicable, by identifier, part number and value, lot number, date code, and location on modules and in box assemblies. ROAs for boxes and cables indicate the connector identifier, the date code, and the wire size, type, and location; ROAs also indicate electrical components, modules, and motherboard(s) installed in subsystem boxes. Crimped contact connectors require additional documentation; forms are provided to record crimped contact verification data for each crimped contact connector.

7.3 Fabrication Procedures

7.3.1 Box Harness and System Cables

Sandia provides connectors, wire, hardware, and material to the contractor for the fabrication of box harnesses and system cables; a system mock-up that indicates cable routing is also supplied. In accordance with a wiring node list, box harness connectors are pigtailed for internal point-to-point terminations and harnessing. System cable connectors are wired point to point. The cable-harness fabrication procedure details all fabrication steps, inspections, and test requirements. In-process and final electrical testing, continuity verification of point-to-point termination in accordance with the wiring node list, leakage resistance, and high-voltage breakdown testing are used in final acceptance testing of harnesses and cables.

7.3.2 PWB Fabrication

Sandia provides circuit masters for contractor-fabricated PWBs. The contractor is required to have a PWB fabrication facility certified and maintained in accordance with MIL-P-55110. The PWB fabrication procedure states the process controls and inspection requirements for two-sided and multilayer PWBs. Before a PWB is released for component installation, the contractor

is required to retain and submit to Sandia, upon request, the following PWB traceability documentation: (1) certifications and analyses of baseboard material, (2) inspection records and cross-section coupons for each process lot of PWBs (verifying plating, gold and solder, copper thickness, circuitry, and through-hole coverage and condition), and (3) lot control by serial number of each type of PWB from a process lot. The contractor that fabricates the PWB also assembles the module.

7.3.3 Machined and Formed Piece-Part Fabrication

Mechanical and special material piece-part fabrication requirements are defined in a basic fabrication procedure for machined and formed piece parts. Parts are fabricated, plated, and coated in accordance with the contract line-item drawing. The contractor submits the following documentation to Sandia with the product, as applicable: (1) material certifications and requested samples, (2) dimensional inspection results and weld x-rays, and (3) plating analyses and requested samples.

7.3.4 Special Assemblies

Special assemblies, such as system motors, sensors, and telescopes, are designed and developed by the contractor in conjunction with the system design engineer. The design engineer is responsible for procuring the special assembly.

7.4 Assembly Procedures

All assembly operations are controlled by the latest issue of box and module assembly procedures, documents referenced within the procedures, and special instructions for processing. If a conflict exists between the assembly procedures for a box or module and the top assembly drawing, the assembly drawing takes precedence.

7.4.1 Box Assembly

The contractor assembles boxes in accordance with *Space Systems Integrated Box Assembly Instructions*, SS-S61340, and assembly drawings. Boxes are wired and harnessed in accordance with a wiring node list and a harness routing map. The box assembly procedures define assembly steps and in-process stage inspections, such as motherboard and connector installation and orientation, harness continuity checks, and point-to-point terminations, in accordance with the wiring node list. The contractor is required to document each box assembled as described in Section 7.2.

7.4.2 Module Assembly

Space Systems Printed Wiring Assembly Instructions, SS-S61335, imposes strict requirements on contractors for handling electronic components subject to ESD damage. ESD protection is required during all module assembly operations. Related assembly procedures for component bonding to module surfaces, installation of transistors into heat sinks, etc., have the same ESD requirements. The contractor installs module components in accordance with the assembly drawing and documents the module as-assembled configuration as described in Section 7.2. The contractor that does the assembly also fabricates the PWB.

7.4.3 System Subassemblies

A number of subassemblies, such as temperature sensors and sensor assemblies, must be assembled and installed at Sandia. System box and module assembly procedures and required documentation (Section 7.2) apply to all assembly and installation work performed at Sandia.

The responsible division supervisor and the project engineer are required to have a documented system assembly procedure for the integration of subsystem boxes into a full system for acceptance testing. A procedure is also required for integrating a space system into the host satellite.

7.5 Fabrication and Assembly Specifications

Assembly and fabrication procedures are distributed to contractors; the contractor's Drawing Control Center controls the procedures in the same way it controls product drawings. Copies of these procedures are available for reference in the fabrication, assembly, and inspection areas. The following procedures are available from the Sandia film bank and are provided to contractors as needed:

SS-R16206	*Sandia Satellite Program Mechanical Procedures*
SS-S61335	*Space Systems Printed Wiring Assembly Instructions*
SS-S61340	*Space Systems Integrated Box Assembly Instructions*
SS-S91172	*Sandia Satellite Program Box Harness and Cable Fabrication, Assembly, Inspection and Test Specification*
SS-T86569	*Space Systems Printed Wiring Board and Printed Wiring Board Assembly Specifications*

8. DESIGN CHANGES, REPAIRS, AND NONCONFORMING MATERIAL REPORTS

8.1 Design Changes

As a system's design and data requirements are defined and individual box, cable, and module designs are approved, drawings are released to the Sandia film bank for distribution and are entered into the Systems Record Center data base by system and item. Once released, the design definition cannot be changed without an approved ECN. The design engineer initiates an ECN through the Systems Record Center, where a control number is assigned, a copy is forwarded to drafting for drawing changes, and the ECN is entered into the Systems Record Center data base as outstanding against the system. Outstanding ECNs are incorporated into system drawings before the next system build. An ECN can be used to change an existing box, cable, or module; the item changed is marked adjacent to its title with a change identifier. The change identifier is added to the title on the item's File Card, and the ECN number is recorded. The item's ROA is updated when the changes are made. The design engineer records the ECN and the reason for the design change in the logbook of the modified system/subsystem.

8.2 System Repairs

When system repairs are required because of assembly errors, handling damage, component failures, etc., the requesting engineer prepares an SRR, which accompanies the item to the Systems Repair Laboratory. A control number is assigned, and the repairs are made. The SRR number is recorded on the item's File Card. When component changes are made, the Systems Record Center updates the item's ROA to show new serial numbers and date codes. The system repair is checked by a qualified inspector. The engineer enters the SRR number and reason for repair in the appropriate system logbook.

8.3 Nonconforming Material

Any material, component, or system item designed or selected for use in a satellite system that does not comply with system specifications is defective, and the degree of defectiveness determines its suitability as a nonconforming product.

Most product defects are traceable to a procedural, process, or workmanship infraction. If the nonconforming condition occurs at the contractor's facility and if the product is acceptable for use in a space system, the contractor is required to submit an NCR that describes the nonconforming condition to the technical consultant. The NCR is evaluated by the consultant, the design engineer, and the QAO for disposition. If the disposition is "use as is," the contractor assigns a control number to the NCR and records it on the item's File Card and ROA.

8.4 Nonconforming Material Documents

Engineering Change Notices (SA 7195-ECN), Space Systems Repair Requests (SA 7195-SSR), and Nonconformance Reports (SA 7195-NCR) are traceable through the Systems Record Center and the system's box, cable, and module File Card Deck and logbooks. The following procedures describe the controls placed on these forms and are available from the Sandia film bank:

SS-S74408	*Space Systems, Design Change and Repair Request Control Procedure*
SS-S74445	*Space Systems Procedure, File Card Deck and Log Book Set Control*
SS-S80033	*Space Systems Nonconforming Product Control Procedure*
SS-S91177	*Sandia Satellite Program Design Definition Control*
T65535	*Space Systems, Box, Cable and Module Design Configuration Control Procedure*

9. SYSTEM FAILURES

9.1 System Failures

For failures that occur during initial module tests, the QAO may elect to tabulate the failure to determine whether there is a failure trend or may elect to perform detailed analysis of these failures. Failures of electronic components, failures during testing from modules through full systems, and failures of mechanical fit-and-function requirements are reported to the QAO. The QAO is responsible for coordinating failure investigations with the systems engineer who observed the failure, the responsible component engineer, the designer, and the test engineers. All system failures must be resolved before a system is readied for shipment for host satellite integration. If a failure cannot be resolved, management decides the disposition of the system.

9.2 Failure Reporting

The engineer observing a failure documents the occurrence on a Failure Report (SA 7195-FFR). The Failure Report provides check blocks for failure modes and conditions to aid in the identification of a failure. The engineer includes a clear, concise description of the failure symptoms and attaches substantiating data.

9.3 Failure Analysis

When a failure occurs after module TR acceptance testing, a failure analysis is conducted. Component failures that are detected during acceptance testing do not require failure analyses; however, if a trend in these failures is detected, the QAO may conduct a failure analysis. The QAO reports failure mode, cause, and corrective action on a system Failure Analysis Summary Report.

All system electronic component failures should be resolved quickly, since, if the failure is generic, it may affect all in-house satellite programs because many components are used in all systems. Electrical component failure analyses are performed either in-house or by a Sandia-approved analysis laboratory, as determined by the QAO. The QAO tabulates all electrical component failures by component type and failure mode.

Component failures reported on GIDEP alert bulletins are monitored by the QAO. If a failure trend in a component used at Sandia is reported, the QAO issues an internal alert bulletin listing the failure symptoms to the responsible department managers and division supervisors.

Mechanical system failures are detected during the system mock-up fit, function, and alignment of subsystem boxes, motors, sensors, telescopes, etc. Mechanical defects observed at the system mock-up or final system integration are resolved by reworking or redesigning the piece part(s). A Failure Report is submitted, and an ECN is issued to update the mechanical design.

9.4 Failure Close-Outs

Once a failure analysis has been completed and corrective action identified, copies of the Failure Analysis Summary Report are distributed to appropriate engineers within the Space

Systems Department and the Space Sensors Department for review and comments. When necessary, the QAO meets with concerned parties to discuss the analysis and recommended corrective actions following distribution of copies of the Failure Analysis Summary Report. In the case of a lot-related component failure, all satellite systems in which the component is used are considered questionable until the problem is resolved to the satisfaction of the responsible department manager(s).

Space Systems, Electrical and Mechanical Failure Reports and Analysis Procedure, SS-S68075, defines individual responsibilities in failure handling procedures and is available from the Sandia film bank.

10. SOFTWARE DEVELOPMENT AND MANAGEMENT

10.1 Software Development and Management Responsibilities

Each Sandia satellite payload has specific mission requirements (defined in the sponsor's *System Requirements* document) to collect, process, display, and store event and state-of-health data from payload sensors. The satellite data systems divisions are responsible for ground data processing software, and the flight system design divisions are responsible for the payload software. The interface between responsible divisions is critical during the design of a system to ensure compatibility of ground processing and on-orbit satellite computer software.

10.2 System Design Reviews (Computer Program Software)

The flight system and ground data processing project leaders schedule periodic system design reviews with designers, flight and ground software programmers, and system test engineers. These reviews define the design requirements and a test plan for the payload in accordance with the *System Requirements* document. Unless waived by the responsible department manager, a safety net system that can reboot the flight system in orbit is required on Sandia satellite payloads that contain flight software. Design walk-throughs by designers, programmers, and test engineers provide the opportunity to discuss system problems and determine the best overall solutions during the design phase of a payload. All design reviews, formal and informal, use existing requirements, design documents, status charts, drawings, procedures, specifications, logbooks, etc., to show system design progress from baseline to as-released for build and test of satellite systems. When system design reviews are completed and the design is released for first build, the test and ground software development plans are also completed.

10.3 Software Development Plans (All Levels)

The flight system and ground data processing project leaders are responsible for generating individual software development plans. Basic requirements for each are (1) a self-check method to verify that the system, system test procedures and equipment, system integration to host satellite, system on orbit, and ground data processing are compatible with the system mission requirements and controlled by revision level and (2) a provision for system data reviews when system design changes are made, test procedures and/or test equipment are updated, or active electrical component changes are made to evaluate the effect that these changes may have on the communication link for system-to-ground data processing. Both flight and ground software development plans are available from the Space Systems Department or the Space Sensors Department offices.

11. SHIPMENT AND STORAGE

Packing Sandia satellite systems for shipping and/or storage follows strict procedures. For shipping or storage, each electronic system is packed in a box on a padded, shock-mounted assembly plate. Each sensor sunshade is packed in its own box and supported by shaped plastic foam.

To ship the assembled and tested system, the system engineer requests the Field Support and Logistics (FS&L) division to schedule the shipment on a DOE contract air carrier weekly flight. If for some reason the system cannot be shipped on the weekly flight, FS&L arranges a special flight to carry the system. At the discretion of the responsible system division, a division courier may accompany the system on the flight.

APPENDIX
Satellite Program Procedures Forms

- Box, Cable, and Module File Cards (p. 45)
- Failure Report (p. 46)
- Failure Analysis Request (p. 47)
- Space Systems Action Request (p. 48)
- Space Systems Repair Request (p. 49)
- Space Systems Engineering Change Notice (p. 50)
- Space Systems Nonconformance Report (p. 51)
- Component Record of Assembly (p. 52)
- Quality Verification Report (p. 53)
- Quality Report (pp. 54-56)
- Quality Instructions (pp. 57-58)

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BOX FILE CARD

Title	Serial No.	Date Code	Supplier Inspection Initial / Date	Sandia QAR Initial / Date

Dwg No.	ISS.	NL-Rev.	Applicable ECN NO(s).	NCR NO(s).

Mother Board Title	SN:	DC:

SYSTEM INFORMATION

SYSTEM	NO.	REMARKS

TR ACCEPTANCE INITIAL AND DATE / /

DATE	INITIAL	ENTER ECN NO(s)., REPAIR REQUEST NO(s)., FAILURE REPORT NO(s)., ETC.

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CABLE FILE CARD

Title	Serial No.	Date Code	Supplier Inspection Initial / Date	Sandia QAR Initial / Date

Dwg. No.	ISS.	NL Rev.

Applicable ECN NO(s).	NCR NO(s).

SYSTEM INFORMATION

System	No.	Remarks

TR ACCEPTANCE INITIAL AND DATE / /

Date	Initial	Enter ECN No(s)., Repair Request No(s)., Failure Report No(s)., etc.

SA 7195-NDC(2-87)

MODULE FILE CARD

Title	Serial No.	Date Code	Supplier Inspection Initial / Date	Sandia QAR Initial / Date

Drawing No.	ISS.	CM Rev.	Component Rev.

Applicable ECN No(s).	NCR No(s).

SYSTEM INFORMATION

SYSTEM	NO.	BOX	SN	SLOT NO.	REMARKS

TR ACCEPTANCE INITIAL AND DATE / /

DATE	INITIAL	ENTER ECN NO(s)., REPAIR REQUEST NO(s)., FAILURE REPORT NO(s)., ETC.

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SS-S68075
Page
No.

FAILURE REPORT

Report By: _____ Date: _____ Received By: _____ Date: _____

ELECTRICAL COMPONENT INFORMATION

Component Type: _____ Pkg. Type: _____ Case Size: _____ Date Code/Lot No.: _____

Ser. No.: _____ Mfgr.: _____ Ckt. Function: _____ Value Tol.: _____

System: _____ No.: _____ Module: _____ Ser: _____ Location: _____ Box: _____ Ser: _____

DESCRIPTION OF FAILURE

☐ Short ☐ Open ☐ Intermittent ☐ Leakage ☐ Degradation-Beta ☐ /Leakage ☐ Operating Voltage

☐ Failed Function-Completely ☐ Partial ☐ Mechanical ☐ Voltage-High ☐ Low ☐ All

TEST CONDITIONS AT TIME OF FAILURE

☐ Location-Grey Room Amb ☐ Temp. Chamber-Hot ☐ /Cold ☐ Vac. Chamber ☐ Other _____

Test-Module TR-Comformal Coated ☐ Yes ☐ No ☐ Subsystem ☐ /Full System ☐ -Temp. Amb ☐ Hi ☐ /Lo

☐ Approx _____ °F Pressure Amb ☐ Vacuum Humidity ☐ Hi ☐ /Lo ☐ Other _____

TEST HISTORY (TESTS COMPLETED)

☐ Module TR ☐ Subsystem-Amb ☐ Hot ☐ Cold ☐ Vibration ☐ Other _____

☐ Full System-Amb ☐ Hot ☐ Cold ☐ Vibration ☐ Vacuum ☐ Days _____ System Thermal Vac ☐ Days _____

☐ Sensor Acoustic ☐ /Thermal Vac ☐ Spacecraft-Acoustic ☐ /Thermal Vac ☐ Satellite-Amb ☐ /Thermal Vac

☐ /Burn-In Days _____ Other _____

☐ Location-Sandia ☐ AESC ☐ TRW ☐ Other _____

MECHANICAL FAILURE

Part: _____ Dwg. No.: _____ Iss. Mfgr.: _____ System: _____ No.: _____ Box: _____ Ser. No.: _____

☐ Failure Occured at Fit ☐ Function ☐ System Integration-Box to Box ☐ System to Telescope ☐ To Sensor ☐ To Sunshade

☐ Spacecraft ☐ Satellite ☐ Other _____

Additional Comments: _____

FAILURE ANALYSIS REQUEST

FAILURE REPORT NUMBER:_____ DATE:_____

SYSTEM:_____ SER NO:_____ BOX:_____ SER NO:_____

MODULE:_____ SER NO:_____ DATE CODE:_____

COMPONENT:_____ CKT LOC:_____ DATE CODE:_____

FAILURE DESCRIPTION:

TEST CONDITIONS WHEN FAILURE OCCURRED:

HISTORY:

ANALYSIS OBJECTIVES:

CONTACT: TELEPHONE:

SA 7195-SAR(3-87)

SPACE SYSTEMS ACTION REQUEST

No.

Sheet 1 of

☐ SNLA ☐ LANL

To: /Attn. From: Org.

☐ Elec. Comp. ☐ Mech. H/W ☐ PWA/Cable ☐ Subassembly	☐ Fabrication ☐ Release From Stores ☐ Transfer	☐ Design Definition ☐ Procurement ☐ Other	☐ Flight ☐ Non-Flight
	Program Subsys.	Sys. No. Case No.	

Description *(Add form SA 7195-SIS instruction sheet as needed)*

/ / Required Completion Date

Requesting Engineer Org.

Ext.

/ / Date

Distribution Org.

LANL DCN No.

For Record Center Use Only

PR No. Consultant Est. $ Value

Required Date Est. Completion Date

Comments:

SA 7195-SSR(3-89)

SPACE SYSTEMS REPAIR REQUEST

No. _____

Sheet 1 of _____

System _____ Sys. No. _____ Box _____ Ser. No. _____ Case No. _____

Module _____ Ser. No. _____ DC(s) _____ Cable _____ Ser. No. _____

Reason for Repair

- ☐ Initial/Select Installation
- ☐ Design Change ECN# _____
- ☐ Drawing/Layout Error
- ☐ Assembly/Manufacturing Error
- ☐ Damaged Component
- ☐ Defective Component
- ☐ Test Error
- ☐ Other: Explain

Failure Occurred During

- ☐ Module TR ☐ Bench Test
- ☐ Ambient ☐ Hot ☐ Cold
- ☐ Sub-System ☐ Full-System
- ☐ Ambient ☐ Hot ☐ Cold
- ☐ Vibration ☐ Thermal/Vac

Failure Report No. _____

List other conditions and/or characteristics beneficial to the failure analysis. (Attach additional pages if needed)

_____

_____

_____

Component Change Information

Component Type/Mfgr	Circuit Component ID	Location	Removed Date Code	Removed SN/Lot#	Installed Date Code	Installed SN/Lot#

Repair instructions: (Attach additional pages if needed) _____

_____

_____

_____

_____

_____

_____

_____

_____

_____

Required Completion _____ Requesting Engineer _____ Org. _____ Ext. _____ Date _____

Inspection Remarks _____

_____

_____

Repair Person _____ Date _____ Inspector _____ ☐ Accept ☐ Reject Date _____

SA 7195-ECN(3-87)

SPACE SYSTEMS ENGINEERING CHANGE NOTICE

No. _____

Sheet 1 of

☐ SNLA ☐ LANL

☐ Module ☐ Box ☐ Cable ☐ Software

Title _____ SN(s) _____ DC(s) _____

Program _____ Subsys. _____ Sys. No. _____ Case No. _____

Dwg. No. _____ ISS. _____ Circuit Master Rev. _____

Component Rev. _____ Wiring Node List Rev. _____

Change Approvals Elect. _____ Mech _____ RS/V _____ PL _____

Change Instructions: *(Add form SA 7195-SIS instruction sheet as needed)*

Marking:
Old _____
New _____

/ / _____ Required Completion Date

_____ Requesting Engineer Org.

_____ Ext.

/ / _____ Date

Component Change Information

Component Type	Mfgr.	Component ID	Ref Location	SN or Lot No.	Date Code

Insp. Remarks _____

☐ ACC.
☐ REJ.

_____ Repair Person _____ Date _____ Inspector _____ Date

After Sign-Off, Distribute as Follows: –Requesting Engineer –Quality Records

LANL DCN No. _____ –Repair Lab –Record Center

SA 7195-NCR(3-87)

SS-S80033

SPACE SYSTEMS NONCONFORMANCE REPORT

No. _____ ____

Sheet 1 of

SNLA

Contractor _____ Code( ) Originator _____ Date _____

Sandia P.O. No. _____ Item No. _____ ☐ Box ☐ Cable ☐ Module

☐ Artwork ☐ NC Tape ☐ Wiring Node List

Title _____ Dwg. No. _____ ISS. ____ S/N _____ D/C _____

Requirement(s)

Deviation(s)

Corrective Action Required by ☐ Contractor ☐ Sandia

Explain: _____

Sandia Instructions:

☐ Accepted per Telecon Date _____ ☐ Rework per ECN No. _____

SNLA Consultant/QAR-Signature _____ Date _____

Distribution:

Quality Verification Report
Contractor File
Contract File
System Record Center

Requesting Engineer
LANL DCN No. _____

SA 7195-NDF(1-88)

SANDIA SPACE SYSTEMS
COMPONENT RECORD OF ASSEMBLY

Page 1 of ____
Inspection Initials _____
Contractors QC _____
Sandia QAR _____

☐ Box
☐ Cable
☐ Motherboard
☐ Module

Title _____ SN _____ DC _____ Dwg. No. _____ Issue _____

Component Rev. _____ Applicable: ECNs _____ NCRs _____

Program _____ Contract No. _____ Contractor _____ Completion Date _____

Device Type	Specified Device ID	Installed Device ID	Ref. Desig.	Date Code	Serial No.	Lot Number	Insp Stmp	Remarks

SANDIA LABORATORIES

SANDIA CORPORATION

SA 6890-A(10-80)

QUALITY VERIFICATION REPORT

Sub. No.

CONTRACTOR

Contractor	Contract No.	C.A. No.
Location		Qty. Sub.
Item	Part Number/Suffix	Mfg. Lot No.

Letters, TWXs etc.	Sandia Authorized Product Definition Documents
Certification: This material meets all requirements of the contract and the listed product definition documents and correspondence. Signature: _____ Date _____ Title _____	Material Destination

QUALITY ASSURANCE REPRESENTATIVE

QOI NO	ISS.	DATA REVIEW	SAMPLE LEVEL	SAMPLE SIZE	DEFECTS	MAJOR	MINOR	INCID	ALLOWED TOTAL	OBSV TOTAL	LOT DISP
					Allowed	X50	X10				
					Observed	X50	X10	X1			

Quantity Auth. To Ship	Program/Phase	DOE Acceptance	Contract Completed
		☐ YES ☐ NO	☐ YES ☐ NO

REMARKS

DISTRIBUTION	NAME	ORG	Verified by	Org	Date
Contract Rep.					
Product Eng.					
QA Eng.					

Page of Pages

SANDIA NATIONAL LABORATORIES
SPACE SYSTEMS DEPARTMENT

SNLA Lot No._____

QUALITY REPORT

COMPONENTS

Manufacture Contract No. Amend No.

Location

Manufacturer's P/N Part Marking

Lot Size Mfg Lot No. Date Code

SANDIA QUALITY ASSURANCE OFFICE

QI No._____ Issue____ Sample Level_____ Sample Size_____

INSP CHAR NO.	REQUIREMENT	ACCEPTABILITY	DEFECT CODE
10	Data	_____	_____
20	Marking	_____	_____
30	Appearance & Finish	_____	_____
40	Assembly	_____	_____
50	Dimensional	_____	_____
60	Functional	_____	_____
70	Electrical	_____	_____

Acceptable (A) Conditionally Acceptable (CA) Not Acceptable (NA)

Quantity Accepted_____

Remarks

Verified by:_____ Date:_____

Distribution: Quality Engineer_____

Product Engineer_____

Page____of_____Pages

SANDIA NATIONAL LABORATORIES
SPACE SYSTEMS DEPARTMENT

QUALITY REPORT - DEFECT DESCRIPTION

Contract No._____Sub. No.___

SNLA Lot No._____

INSP CHAR NO.	Requirement/Specification
DEFECT CODE	
FREQ	Nonconformance
DISPOSITION	
INSP CHAR NO.	Requirement/Specification
DEFECT CODE	
FREQ	Nonconformance
DISPOSITION	
INSP CHAR NO.	Requirement/Specification
DEFECT CODE	
FREQ	Nonconformance
Disposition	
INSP CHAR NO.	Requirement/Specification
DEFECT CODE	
FREQ	Nonconformance
DISPOSITION	

Verified By (Signature)_____Date_____

Page____of____Pages

SANDIA NATIONAL LABORATORIES
SPACE SYSTEMS DEPARTMENT

QUALITY REPORT - SERIAL NUMBER SHEET

Contract No._____

SNLA Lot No._____

SER. NO.	SAMP	DISP	INSP CHAR NO.	SER. NO.	SAMP	DISP	INSP CHAR NO.

Page____of____Pages

SANDIA NATIONAL LABORATORIES
SPACE SYSTEMS DEPARTMENT

Quality Instructions

Item: Part Number:

Insp Char No	Inspection Characteristic	Requirement	n Level	Equipment

Quality Instruction No. Issue Page of

Quality Engineer Division Approval

SANDIA NATIONAL LABORATORIES
SPACE SYSTEMS DEPARTMENT

Quality Instructions

Item:	Part Number:

Special Instructions:

Quality Instruction No.	Issue	Page	of
Quality Engineer	Division Approval:		

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