4.4.4 Receiving Inspection Records

Material routed to receiving inspection will have the results documented on inspection records (BR 49). These records are maintained in receiving inspection files. (QP 609, QP 610, QP 619, QP 635).

4.4.5 Nonconforming Material

Discrepancies noted during receiving inspection are documented on a Material Discrepancy Report (MDR) (BR-4/067) and may result in the issuance of a Corrective Action Request or Supplier Deficiency Notification (BR-114) (QP 502).

5.0 MANUFACTURING CONTROLS

5.1 DRAWINGS AND SPECIFICATIONS

Engineering Released (controlled) drawings and specifications will be used to fabricate, inspect, and test all flight production parts, components, and assemblies.

5.2 PRODUCTION PROCESSING AND FABRICATION

5.2.1 Production and Inspection Planning and Documentation

Production Orders (BR-122) and Certification Logs (BR 443) will be prepared by a production planner inserting quality inspection points defined by the PAM. These documents identify production operations, and test operations, and all nonconformances found during any of these operations.

5.2.2 In-Process Inspection

QA performs selected in-process inspections including solder and general workmanship. In addition, QA monitors the potting, bonding, surface finish, staking, conformal coat, dimensional and torquing inspections performed by certified peer inspectors. Additional QA and peer inspections are performed when circumstances make it mandatory or cost effective. All inspections are pre-planned in the build paperwork and the results documented.

5.2.3 Process Controls

Processes such as soldering, potting, staking, bonding, conformal coat, and surface finishing are performed and inspected by trained/certified personnel in accordance with applicable written Ball Production Support Procedures, Ball Process Standards, Ball Material Standards, Ball Selected Process Specifications and industry process standards.

QA personnel will routinely audit compliance with these standards and inspect the finished assemblies for workmanship. Samples of potting materials will be available for testing to verify proper mixture and cure. Process testing procedures determine the adequacy of process solutions and application. Records of personnel and process certifications in disciplines such as soldering, welding and nondestructive testing will be maintained (QP 623,).

Clean rooms and clean benches are regularly inspected for conformance to requirements. (QP 603).

5.2.4 Control of Special Tooling

Tools, gauges, jigs, and fixtures used for acceptance inspection will be inspected and calibrated before use. These devices, when used repeatedly, are checked at a designated time period to ensure continued accuracy.

5.2.5 Final Inspection and Configuration

Final acceptance inspection will confirm performance and acceptance of all manufacturing and inspection operations. This inspection will include a configuration check to verify that the as-built configuration recorded in the production order and cert log is the same as the as-designed mandatory configuration specified by the item's Configured Article List (CAL). The cert log will then be submitted to the PAM. The PAM will sign the "okay-to test" entry. This is considered a test readiness review.

5.2.6 Training and Certifications

BASD provides all operators of special operations (soldering, potting, etc.) training for certification. This training and certification is documented and verified by the quality organization. Certification will be either project specific or BASD company certification.

Recertification is periodically required but may be waived if the operator has a history of continuous work in the specialized field. Personnel (engineers/technicians/ operators) will not be allowed to handle hardware without proper documented training. Audits will be performed on a periodic basis to verify the operators acceptable performance (QP 204).

5.2.7 Testing

Acceptance tests will be witnessed or monitored by QA inspectors to released and approved test procedures (QP 702). Final QA acceptance is withheld if there are anomalies in the test procedure pending release of an engineering order and QA verification that the changes have been incorporated. Clarification and changes require the signature approval of the project test engineer and the PAM. The following will be performed by the inspector or responsible individual to ensure compliance with test requirements (QP 703):

- Verify "okay to test" has been signed off in the cert log
- Verify that the test setup is in accordance with the approved test procedure
- Verify test equipment calibration, GSE certification and software validation
- Monitor or witness to assure tests are performed per test procedures
- Witness any "critical" hardware moves
- Review all test data for completeness and compare to specification limits
- Document all nonconformances on action item lists (AILs), CPRs or MDRs and bring to the attention of the PAM immediately

Portions of tests where data is being measured and recorded automatically (charts, plotters, computer printouts) will be monitored by QA.

Software used during testing is subject to development and configuration control according to the QA Software Assurance Requirements. After software is baselined, all revisions are subject to CCB control, as are drawings and specifications.

Nonconformances and failures are reported by the QA representative or test conductor. The PAM is responsible to ensure proper resolution of noted problems and control of hardware during the resolution period.

The reliability engineer is notified of a failure by the PAM, starting with Acceptance test of components and a copy of the Material(s) Discrepancy Report (MDR) is supplied to the reliability engineer. The reliability engineer will conduct a failure investigation and analysis, advise the MRB of required corrective action and generate the failure report. The MDR will be held open until the failure report is complete and closed.

5.2.8 Handling and Storage

Company and departmental procedures identify proper methods to be used to handle sensitive, as well as non-sensitive articles. Movement of hardware is normally accomplished by the use of tote boxes or carts. The handling of electrostatic sensitive electronic piece-parts requires the use of special packaging materials and conductive work stations. BASD handles these types of parts per MIL-STD-1686 and/or PSP 120211 prepared specifically for the purpose of defining the specific procedures, materials and equipment requirements for the BASD Electrostatic Discharge (ESD) control program.

Articles and materials are stored to preclude loss, damage, or deterioration. Articles are protectively packaged, identified, and stored in compartmentalized cabinet drawers or shelves. Raw materials are stored on separated shelves or racks. Special storage facilities are provided for items such as optical components which may be easily damaged. Limited-life materials will be identified on the MIT in bold red letters stating: "Limited-Life Material, Expiration Date: _" (QP 609, QP 619).

Non-flight articles are identified as "NON-FLIGHT" on the MIT and stored in an area specifically designated for Non-Flight items.

5.2.9 Preservation, Marking, Labeling, Packaging, and Packing

Techniques and materials used for the preservation of articles during fabrication, storage, and shipment are described in the applicable BPS. Engineering drawings and specifications list these BPSs as requirements.

Special requirements for marking and labeling of critical, sensitive, dangerous, and high-value articles are given on engineering and procurement documents.

Packaging methods used on the program may include sealing the articles in nitrogen gas-purged bags, cushioning material in tote boxes or carts while transporting articles within BASD, and performed trays surrounding and separating each part from its neighbor. Articles sensitive to handling damage will be identified by gummed labels placed on the containers alerting all personnel to the special packaging and handling requirements for them.

5.2.10 Shipping

QA is responsible for the inspection of outgoing articles and materials. The PAM will verify that documentation and package requirements are met (QP 706). A pre-shipment checklist will verify containers contain all required sensors and are adequate to protect the RS2000 Bus.

5.3 MANUFACTURING, INSPECTION AND TEST RECORDS

Upon completion of manufactured piece-parts, the corresponding production order gets final acceptance concurrence and is then filed in the production program file, which is retained in accordance with contractual requirements.

Upon QA acceptance of manufactured and tested assemblies and subassemblies, the corresponding certification log is stamped by the QA inspector and signed by the PAM. The certification log is then filed in the QA program file which is retained in accordance with contractual requirements (QP 708).

The original copy of acceptance test data will be used to make copies for the end-item data package, placed in the QA program file, and retained.

The records are retained and available for customer review and per contractual requirements.

5.4 INDICATION OF INSPECTION STATUS

Inspection stamps or signatures are used to indicate acceptance/rejection by the quality representatives of any audit or inspection of in-process manufacturing operations, end-item tests, and supportive functions.

QA maintains a stamp control system which governs the use of these stamps. Stamps designate distinct and recognizable symbols which include and indicate in-process acceptance, reject, final acceptance, calibration, X-ray, tool, and scrap. New symbols or applications will be generated and controlled by the same procedures. A stamp control log is maintained by QA inspection, listing the stamp number and stamp holder's signature. All stamps are audited quarterly. A number vs. name list is provided by the QA department. Stamps will not be impressed on the articles themselves but on accompanying tags, labels, travelers, and other inspection records (QP 203).

5.5 END-ITEM DATA PACKAGE

An End-Item Data Package will be supplied with deliverable flight hardware components and will meet the contractual requirements. It will include the following:

- Certificate of Conformance
- As-run test procedure and test data
- Material(s) Discrepancy Report and Failure Report on end-item
- Waivers/Deviations

5.6 CUSTOMER SOURCE INSPECTION

In accordance with contractual requirements, authorized customer representatives may inspect products and inspection records at agreed upon stages of manufacture. BASD will permit them access to our manufacturing and test facilities. BASD will notify the designated customer representative in advance of any mandatory source inspection points identified after review of BASD's quality documentation. All mandatory inspection points will be entered directly in BASD's build and test documentation as specific operations to ensure that these inspections are identified.

5.7 CONTROL OF CUSTOMER-FURNISHED PROPERTY

QA will inspect upon receipt all customer-furnished property supplied for our use. Inspection will check for shipping damage, identification, quantity, proper documentation, type, size, and grade. Acceptable articles will be identified, packaged, and sent to stores

All customer-furnished property received at BASD that is damaged, inoperative or inadequate for intended use, will be held in a material review area or in a controlled project area pending notification to, and written disposition by, the cognizant customer representative. The article's defects will be recorded and disposition will be noted on the commercial production records

(CPR) or material(s) discrepancy report (MDR) and identified on the documentation as "Customer-Furnished Property"

6.0 NONCONFORMING MATERIAL CONTROL

6.1 NONCONFORMANCE CONTROL

All nonconformances shall be documented, usually in the appropriate certification log (cert log). Quality will periodically audit cert log commercial CPRs to verify correctness and applicability of the dispositions. BASD's material review board (MRB) shall consist of the PAM (chairperson) and the responsible engineer. In the case of test anomalies, the PAM and test engineer will make the dispositions. If the disposition involves specification changes, the system engineer or deputy program manager will participate in the disposition. Customer's specification nonconformance that is presented for acceptance will require generation of a waiver/deviation for customer's approval (QP 908).

6.2 NONCONFORMANCE DOCUMENTATION

A description of the nonconformance will be initially documented on an AIL ,CPR, PO or MDR.

All failures identified during an end-item acceptance/qualification test will also be documented on the Material(s) Discrepancy Report (BR/4/067). A failure is defined as the inability of the end-item assembly to perform within the limits of its specifications.

6.3 PRELIMINARY (INITIAL) REVIEW DISPOSITIONS

Nonconformances identified at receiving, machine shop, assembly, and in-process functional testing (acceptance/qualification test excluded) will be initially reviewed by the production engineer or responsible engineer. Dispositions may include, but are not limited to the following:

- Rework to specification
- Scrap
- Return to supplier

- Troubleshoot (limited)
- Rework to standard procedures
- Submit to MRB

Nonconformances identified by the machinist or machine shop in-process inspections will be initially reviewed by production engineer. Preliminary dispositions not involving board repair or major print changes can be made and recorded by the responsible engineer after adequate training in disposition write-ups.

Nonconforming hardware outside the machine shop, including that in the machine shop final inspection area, will be reviewed by the responsible engineer. Hardware, with its documentation which is dispositioned "REWORK," will be released to production on receipt of a production order or certification log CPR sheet describing the work to be accomplished in accordance with the disposition. Instructions for rework, re-inspection and re-test shall be equivalent or better in detail than originally provided. Drawings, specifications and procedures, if used, shall be identified in the disposition.

The MITs of items dispositioned "SCRAP" will be marked with a SCRAP stamp. The documentation identified as HARDWARE WAS SCRAPPED, and the hardware will be sent to the receiving inspection area. The hardware identified as SCRAP will be physically defaced by marking it with red paint. The hardware and documentation will be forwarded to property control for appropriate disposal.

For disposition "RETURN TO SUPPLIER," a shipping order will be requested from the purchasing organization. On receipt of the signed shipping order, quality inspection will forward the hardware and appropriate documentation to shipping for return to supplier.

For disposition "SUBMIT TO MRB," the PAM will be responsible for convening and chairing the MRB, having the nonconformance dispositioned and obtaining the authorized signatures.

In testing of assemblies and subassemblies, the design engineer and/or test conductor has the authority to do minor, controlled troubleshooting not involving destructive operations such as unsoldering. All actions must be documented. After the troubleshooting has been completed, the hardware must be dispositioned and processed as previously described. Quality assurance involvement is mandatory on any specification nonconformance or any anomaly after the second power-on integration (QP 506).

6.4 MATERIAL REVIEW BOARD

The formal MRB membership will be compromised of the following:

- BASD quality representative (chairperson)
- BASD engineering representative
- BASD production engineering representative

The BASD quality representative will serve as MRB chairperson and will be responsible for convening the MRB. The MRB's responsibilities are as follows:

- Analyzing data and examining all nonconforming articles, materials, and/or conditions
- Determining the disposition of submitted articles or materials
- Ensuring timely corrective action as applicable (remedial and preventive), including changes to drawings, specifications, procedures, tooling, etc.
- Ensuring that accurate records of MRB actions are maintained

The following minor nonconformance dispositions may be made with unanimous MRB concurrence:

- Repair: Those items which can be repaired to function properly, but are physically different from the drawing.
- Use-as-is: Those items which do not adversely affect safety, reliability, performance, interchageability, weight or the basic objectives of the contract. The rationale for making a use-as-is disposition will be documented on the report form.

Nonconformances requiring dispositioning by the MRB will be processed by the PAM who will be responsible for the proper documentation of dispositions on the appropriate paperwork, obtaining the authorized MRB signatures and scheduling MRB meetings as priorities dictate.

MRB personnel shall have responsibility and authority to delay further processing of a disposition if effective corrective action has not resulted.

The MRB shall determine the need to inspect and disposition materials and hardware in-process, or those delivered which may exhibit similar nonconformances, actually or potentially, to those under consideration.

Supplier nonconformances requiring "repair" or "use-as-is" dispositions will be documented and processed, per the above, on an Material(s) Discrepancy Report (BR/4/067). The customer shall be notified in any MDR action affecting end-item specification or interfaces

7.0 QUALITY ASSURANCE PLAN FOR GROUND SUPPORT EQUIPMENT AND SPECIAL TEST EQUIPMENT

7.1 GENERAL

This section describes the method for conductance of the quality assurance program for the fabricated and procured functional ground support equipment (GSE) and special test equipment (STE) used in conjunction with the flight hardware.

7.2 DESIGN DOCUMENTATION

The PAM will review GSE/STE drawings to assure that the engineering drawings reflect the "as-built" configuration and are under configuration control. All changes during the fabrication cycle, must be incorporated into a released engineering prior to the GSE/STE use with the flight hardware. The PAM will review and approve the GSE/STE Test Procedures used to certify the GSE/STE to the Flight interface.

7.3 PROCUREMENT CONTROL

GSE/STE will be manufactured to commercial standards. Procurement documents will be processed using Standard Departmental procedure or as stated in the programs'quality work instructions (QWIs).

7.4 RECEIVING INSPECTION

Procured items will be logged into the RS2000 program database and delivered to the procuring department

7.5 INSPECTION

Quality assurance will audit inspect the GSE/STE subsequent to informal functional checkout and may monitor test to pre-approved procedures. Workmanship will be verified to be compatible with good commercial quality standards that are defined in BASD's Ball Support Procedure (PSP) 135000. Interface connection points with the flight hardware will be inspected to assure physical and functional compatibility. The GSE/STE interfaces must be certified to be per engineering drawing that has been released to configuration control prior to connecting to flight hardware. This certification will be done to an approved GSE/STE certification test procedure.

QA will conduct an inspection of each GSE item prior to its initial use with flight hardware and verify it has been certified for use. In-process inspections may be performed on those subassemblies which cannot be verified visually by final inspection of the final assembly inspection.

7.6 CALIBRATION AND TEST

Checkout procedures and supplier manuals will be utilized to assure GSE/STE is calibrated and functional to specification requirements prior to use with the flight hardware. A quality representative will witness and certify performance to these requirements. Subsequent to these operations, each unit will be controlled to preclude unauthorized/undocumented adjustments and modifications. Quality assurance will audit the functional and certification checkouts and ensure compliance with the GSE/STE performance and interface requirements. Any adjustable controls not required for operational control must be sealed to prevent unauthorized adjustment which would invalidate the calibration or certification of the GSE/STE. These tests will include interface signal tests and validation of software items. Software, once validated, will be subjected to configuration and integrity controls. All such tests will be accomplished to test procedures approved by the PAM and responsible engineer.

7.7 NONCONFORMANCE CONTROL

In-process nonconformances noted during fabrication and preliminary checkout phases will be dispositioned by responsible Project Engineer Production (PEP) or the Project Engineer Design (PED). "Use-as-is" and "repair" dispositions require PAM concurrence to ensure they are reflected in the "as-built" configuration.

7.8 FUNCTIONAL TEST NONCONFORMANCE

Hardware nonconformances noted during functional test and calibration will be dispositioned by the PED and the PAM. Any "use-as-is" dispositions for nonconformances which violate contract requirements or could detrimentally affect the flight hardware will be documented on an MDR and submitted to the MRB. A waiver will be submitted to the customer for approval. Software nonconformances will be documented and dispositioned the same as flight hardware. Corrections made to software test code and approved documentation used for testing will be made through the configuration control process.

8.0 SYSTEM SAFETY

8.1 SCOPE

This section of the Product Assurance Plan establishes the system safety program to be implemented for the program.

Implementation of the system safety program will ensure that hazards to personnel, equipment, and facilities are eliminated or controlled to acceptable levels of risk.

The system safety program encompasses the organizational responsibilities and authority, system safety tasks, and methods necessary for program implementation. The system safety program will remain in effect throughout the period of contract performance.

8.2 ORGANIZATIONAL RESPONSIBILITIES AND AUTHORITY

8.2.1 Program Manager

The BASD Program Manager (PM) is responsible for safety. The PM has delegated authority to the PAM and the System Safety Engineer (SSE) to develop and implement the system safety program.

8.2.2 System Safety Engineer

The BASD SSE will be responsible for the development and implementation of the safety program plan. The SSE will:

- • Be a point of contact for program personnel and the customer for safety-related matters.
- • Be cognizant of the design, development, test, and ground handling of the RS2000 Bus.
- • Direct, coordinate, and monitor all program safety activities.
- • Advise the PM of problems encountered in the implementation of this system safety program.
- • Draft and maintain all program safety documentation.
-

8.2.3 Industrial Safety

Industrial safety is the responsibility of a the Ball Aerospace & Technologies Corp. (BATC) safety department. The BATC industrial safety department is responsible for ensuring compliance with OSHA, EPA, and other federal, state, and local regulations with respect to facilities and operations. The industrial safety organization coordinates with the SSE regarding program specific requirements and operations.

8.3 SYSTEM SAFETY ENGINEERING

The SSE will use standard system safety methods and techniques. System safety activities will support design, production, test, and operations on the program.

8.3.1 System Safety Criteria and Requirements

The SSE will review the program and develop a safety checklist of the applicable requirements to program management and the cognizant design, test, and operations personnel. The requirements will be reviewed for incorporation into the appropriate design specifications and test and operations requirements documents by the PAM. Concern areas will be worked to an acceptable solution.

8.3.2 Mishap Reporting and Investigation

The SSE will participate in the investigation of all mishaps and safety-related failures involving the RS2000 Bus. Mishaps involving hardware will be investigated and reported according to established BASD policies and procedures. The results of such investigations will be incorporated into subsequent program activities, as required, to avoid recurrence.

8.3.3 Support of Safety-Critical Activities

The responsible engineer will monitor all safety-critical activities, as necessary. The responsible engineer will ensure, to the greatest extent possible, that all safety requirements specified in procedures are followed. The responsible engineer will have authority to shut down operations (i.e., either prevent an operation from starting, or stop an operation which is already underway) if:

- Safety criteria cannot be ensured or maintained.
- Safety criteria are being violated.
- Personnel and/or equipment are or will be unduly jeopardized.
- A dangerous situation exists.

8.3.5 Safety Analysis

The responsible engineer, using the Parts, Reliability and Safety Handbook (SP0031A-014), will perform analyses to identify subsystem hazards, assess risks associated with each hazard, determine appropriate hazard controls, and verify adequacy of hazard control measures. The safety analysis will use other analyses (e.g., FMECA), where possible, to avoid duplication of effort. Hazard identification and assessment will be performed in accordance with the methodology of MIL-STD-882C.

Safety analysis will consider normal and failure modes of system operation. Design features that could result in hazards will be identified and controls implemented. Particular attention will be given to design that could result in operator injury or operator error that could cause a subsequent hazard. Human factors design will be implemented to control these hazards.

Safety analysis will be qualitative, in nature. Analytical techniques will be selected to best identify and classify hazards so that appropriate controls can be implemented, effectively. Meeting imposed safety requirements will be one criterion used in assessing adequacy of hazard controls. Tracking of safety requirements and verification of implementation will be accomplished by completion of the safety requirements checklist.

A standard of precedence for hazard controls will be followed. The order of precedence is:

- • Design to eliminate or minimize hazards to acceptable risk levels.
- • Incorporate protective devices and measures in the design.
- • Design in cautions and warning systems to alert system operators to potentially hazardous conditions.
- • Invoke special safety procedures.
- • Use personal protective equipment where appropriate.

Results of the safety analyses will be communicated to design, test, and operating personnel. Internal communication will be by design reviews, drawing reviews, SERs, and informal coordination..

8.4 HAZARD CONTROL VERIFICATION AND HAZARD CLOSURE

The hazard reports resulting from safety analyses will include the appropriate control methods and will be updated periodically to show the status of verifications. Examples of verification methods performed by the responsible engineer are:

- • Review of design analysis to verify margins of safety
- • Conduct operational readiness reviews to ensure procedure compliance
- • Review of test results to verify conforming hardware

Hazards will be closed only on verification of the implementation of controls approved as adequate to achieve the desired level of risk.

8.5 SAFETY DOCUMENTATION

Safety documentation items developed and maintained by the responsible engineer include:

- Hazard Reports
- Mishap Reports

Additional documentation with safety significance to which the responsible engineer will provide inputs and/or review for safety compliance include the following:

- Hardware/Software Specifications
- System Integration/Test Procedures
- Transportation/Handling Procedures

8.6 REVIEWS

Safety will be an agenda item at design reviews, both formal and informal. The responsible engineer will submit the current safety data to support major reviews.

8.7 SAFETY DEVIATION/WAIVER

The responsible engineer or PAM will prepare and submit deviation or waiver requests for any system safety requirement that cannot be satisfied. Safety deviation/waiver requests will be submitted in compliance with the contract. These requests will provide explanation why the requirement cannot be satisfied, rationale for alternate approaches, and justification for the approach selected.

8.8 PROCEDURE APPROVAL

The responsible engineer or PAM will be cognizant of all procedures affecting the system and related Ground Support Equipment (GSE). Hazardous operations will be identified, and procedures to control them will be developed and implemented.

9.0 ACRONYM LIST

AIL	Action Item List
ASD	Advanced Spacecraft Design
BMS	Ball Material Specification
BPS	Ball Process Specification
CAL	Configured Article List
CCB	Change Control Board
CCE	Contamination Control Engineer
CDR	Critical Design Review
CPR	Commercial Production Record
CSC	Computer Software Component
CSCI	Computer Software Configuration Item
DPA	Destructive Physical Analysis
EEE	Electrical, Electronic & Electromechanical
EO	Engineering Order
EPA	Environmental Protection Agency
ESD	Electro-Static Discharge
FMECA	Failure Modes, Effects and Criticality Analysis
FPGA	Field Programmable Gate Array
GIDEP	Government Industry Data Exchange Program
GSE	Ground Support Equipment
HEPA	High Efficiency Particle
I & T	Integration & Test
M&P	Materials & Processes
MDR	Material Discrepancy Report

MIT	Material Identity Tag
MRB	Material Review Board
NVR	Non-Volatile Residue
OSHA	Occupational Safety and Health Administration
PA	Product Assurance
PAM	Product Assurance Manager
PCB	Parts Control Board
MDR	Mission Design Review
PED	Project Engineer Design
PEP	Project Engineer Production
PAM	Project Engineer Quality Assurance
PM	Project Manager
PO	Production Order
PROM	Programmable Read Only Memory
PSP	Production Support Procedure
PWB	Printed Wiring Board
QA	Quality Assurance
QAD	Quality Assurance Directive
QP	Quality Procedure
QWI	Quality Work Instructions
RP	Reliability Procedure
SCM	Software Configuration Management
SDF	Software Development Folders
SDP	Software Development Plan
SER	Systems Engineering Report
SID	Selected Item Drawing
SMS	Selected Material Specification
SPS	Selected Process Specification
SQE	Software Quality Engineer

SSE	System Safety Engineer
TML	Total Mass Loss
TQCM	Temperature Controlled Quartz Crystal Microbalance
VCM	Volatile Condensable Material
VID	Vendor Identification Drawing

QSPERF

PERFORMANCE SPECIFICATION

FOR

THE NASA QUICK SCATTEROMETER (QuikSCAT) MISSION

NOVEMBER 3, 1997

Rev. A: 11/18/97

**NASA/GODDARD SPACE FLIGHT CENTER
GREENBELT, MARYLAND 20771**

QuikSCAT

PERFORMANCE SPECIFICATION

Prepared by: Original Signed ________ 11/3/97
Kenneth O. Schwer — Date
QuikSCAT Observatory Manager

Approved by: Original Signed ________ 11/3/97
James E. Graf — Date
QuikSCAT Project Manager

Revision Letter	Reason	Date	Approval
A	Update for Delivery Order. Revise D.C. Power requirement (section 4.2.1 & Fig. 4-2)	11/18/97	K. O. Schwer

1. SCOPE

This document describes the highest level mission and system requirements governing the performance of the NASA Quick Scatterometer Mission (QuikSCAT).

2. APPLICABLE DOCUMENTS

The following documents support the specifications described in this document.

2.1 Government Documents

MIL-STD-1553B	Digital Time Division Command/Response Multiplex Data Bus, 21 September 1975.
MIL-STD-461C	Electromagnetic Interference Characteristics Requirements For Equipment
MCR-86-6013	Payload User's Guide, Titan II Launch Vehicle, August 1986.
CCSDS 101.0-B-3	Telemetry Channel Coding. Blue Book. Issue 3. May 1992.
CCSDS 102.0-B-4	Packet Telemetry. Blue Book. Issue 4. November 1995.
CCSDS 411.0-G-3	Radio Frequency and Modulation. Part 1:Earth Stations. Green Book. Issue 3. May 1997.
ASTM E-595	Standard Test Method for Contamination Outgassing Characteristics of Spacecraft Materials
JPL Dwg: 10155454	CDS Mechanical ICD
JPL Dwg: 10155455	SES Mechanical ICD
JPL Dwg: 10155456	SAS Mechanical ICD

3. QUIKSCAT SYSTEM PERFORMANCE CHARACTERISTICS

The following paragraphs are the minimum set of performance characteristics required for the QuikSCAT System.

3.1 Observatory (or Mission) Level Performance

3.1.1 Launch Vehicle Specifications

The Titan II launch vehicle will be used for the QuikSCAT mission. The Titan II specifications can be found within this document and the redlined version of the Titan II User's Guide provided separately.

3.1.1.1 Launch Vehicle Compatibility

The spacecraft, with the Scatterometer instrument integrated, shall be capable of being subjected to the loads of Titan II without damage and shall be capable of mechanically interfacing to the payload attach fitting (PAF) of the launch vehicle.

3.1.1.2 Injection Orbit

The observatory will be injected into a transfer ellipse with an inclination of 98.6°, an apogee at the altitude specified in 3.1.2, and the perigee at a nominal altitude of 220 km.

3.1.1.3 Injection Errors

The maximum errors at injection into the transfer ellipse will be ±11 km at perigee, ±15 km at apogee, and ±0.15° in inclination.

3.1.1.4 Payload Adapter

The non-separating payload adapter will be the 56-inch diameter (bolt-hole interface) adapter provided by the launch vehicle contractor. The spacecraft contractor may provide other adapters as appropriate.

3.1.1.5 Launch Vehicle Separation

The spacecraft shall provide for the separation from the launch vehicle adapter in response to a relay switch closure signal provided from the launch vehicle at the time of the final stage shut down. The spacecraft shall provide a time delay between the discrete command and the actual separation event. The magnitude of this delay, corresponds to the time after the disabling of the launch vehicle attitude control system.

3.1.2 Orbit Compatibility/Constraints

This mission shall be conducted in a sun-synchronous, 803 km circular orbit with a local equator crossing time at the ascending node of 6:00A.M.±30 minutes. The orbit eccentricity shall be less than 0.0008.

3.1.3 Orbit Maintenance

The orbit altitude shall be maintained with ±1km.

3.1.4 Cleanliness Levels

As a minimum, the spacecraft shall be designed and built such that the spacecraft has a total mass loss (TML) of 1.0 % and a maximum collected volatile materials (CVM) of 0.10% per ASTME-595.

3.1.5 Design Lifetime
The spacecraft shall be designed to support a 2-year minimum on-orbit mission lifetime, with sufficient consumables to support a 3-year mission lifetime.

3.2 QuikSCAT System Performance

3.2.1 Structural Characteristics

3.2.1.1 Spacecraft Mass
The combination of the spacecraft bus mass and the Scatterometer mass, as well as all attach fittings and expendables, shall not exceed 965 kg.

3.2.1.2 Structural Modes
The combined spacecraft and Scatterometer system in the launch configuration shall have a fundamental frequency $\geq$ 24Hz in the thrust axis and $\geq$ 10Hz in the lateral axis.

3.2.2 Electrical Scatterometer Power
The spacecraft shall supply power to the Scatterometer consistent with paragraph 4.2.

3.2.3 Propulsion Performance
The spacecraft shall provide the necessary delta-V capability to achieve and maintain the orbit specified in 3.1.2, given the initial injection performance specified in 3.1.1.2 and 3.1.1.3.

3.2.4 Attitude Control Performance

3.2.4.1 Pointing Accuracy
The spacecraft shall maintain pointing relative to the Scatterometer antenna coordinate axes as defined in Figure 4-1 to within $\pm 0.3°$, 3σ, for the pitch and roll axes and $\pm 0.5°$, 3σ, for the yaw axis.

3.2.4.2 Pointing Knowledge
The spacecraft shall provide pointing knowledge relative to the Scatterometer antenna coordinate axes as defined in Figure 4-1, with accuracy no worse than $\pm 0.05°$, 3σ, for all three axes.

3.2.4.3 Stability
The spacecraft pointing stability shall be included as a pointing knowledge and control error source.

3.2.4.4 Spacecraft Orientation
The spacecraft shall maintain the Scatterometer antenna's +Z axis (the nominal spin axis), pointed to the local geodetic nadir, and shall maintain a fixed yaw orientation.

3.2.4.5 Momentum Compensation
The spacecraft shall be capable of compensating for the angular momentum generated by the rotation of the Scatterometer antenna. This momentum will be constant, within $\pm 1\%$, in the nadir spin axis and shall not exceed 2 Newton-meter-seconds.

3.2.4.6 Scatterometer Dynamic Disturbance
The spacecraft shall accommodate a Scatterometer induced dynamic disturbance of 0.1 Newtons applied at 1.3 meters above the SAS mounting surface. This dynamic disturbance force will vary sinusoidally at the antenna spin frequency, of either 18.0 rpm or 19.8 rpm.

3.2.4.7 Initial Sun Acquisition
The ACS shall be capable, upon separation from the launch vehicle, of autonomously placing the spacecraft in a power and thermal safe attitude that also allows ground communication. Initial acquisition shall be capable of starting from any attitude with a maximum spacecraft body rate enveloped by the Titan II launch vehicle and shall not be affected by single event effects. The ACS shall be capable of maintaining this attitude indefinitely.

3.2.5 Command and Data Handling Performance

3.2.5.1 On Board Computational Capacity
The spacecraft shall have sufficient computational capacity to support all C&DH, ACS, and science requirements described elsewhere in this document.

3.2.5.2 Autonomous Spacecraft Safing
The spacecraft shall autonomously protect itself from the following conditions:

- processor upsets
- power system anomalies which threaten battery capacity or lifetime
- illegal maneuvers (i.e., maneuvers which violate ACS constraints)
- memory anomalies
- single event effects
- latch-up conditions
- significant external events

3.2.5.2.1 Scatterometer Anomalous Conditions
The spacecraft shall make provisions to monitor a minimum of six analog signals and to autonomously power off the appropriate Scatterometer subsystem and place the Scatterometer in standby mode when one of these analog signal readings exceeds its specified limits. The values of the limits thresholds will be negotiated.

3.2.5.2.2 Spacecraft Anomalous Conditions
For agreed upon spacecraft anomalous conditions, the spacecraft shall completely power off the Scatterometer and power on the Scatterometer survival heaters.

3.2.5.3 Science Data Collection
During normal operations, the Scatterometer will continuously collect science data at an average rate not to exceed 40 kbps. This data will be formatted as 3 CCSDS packets of length 796 bytes per the electrical ICD and sent to the spacecraft for storage and subsequent downlink.

3.2.5.4 Data Storage Capacity
The spacecraft shall provide sufficient data storage capacity to allow for three orbits worth of Scatterometer data.

3.2.5.5 Data Storage Bit Error Rate

The bit error rate of the stored data shall be considered a contribution to the downlink channel performance requirements.

3.2.5.6 Spacecraft Time Synchronization

The spacecraft shall provide the Scatterometer with a spacecraft time message, with format to be negotiated, at least every 8 seconds. The provided time data shall be calibrated (on the ground) to within 100ms of UTC. The resolution of the message shall be 31.25 ms or better.

3.2.5.7 Equator Crossing Indication

The spacecraft shall provide the Scatterometer with a real-time indication of each ascending node equator crossing within ±700ms of the actual crossing time.

3.2.6 Communications Performance

3.2.6.1 Downlink Capabilities

3.2.6.1.1 Downlink Format

The spacecraft downlink data, or Scatterometer data, shall consist of the Scatterometer science and housekeeping data, as well as the time coincident spacecraft attitude knowledge, orbit ephemeris, spacecraft housekeeping and time data. The Scatterometer data shall be formatted as CCSDS transfer frames. The transfer frames shall be time-tagged with the same time signal specified in 3.2.5.6.

3.2.6.1.2 Payload Downlink Period and Rate

The spacecraft shall be capable of downlinking Scatterometer data twice per orbit. The spacecraft shall support an operational downlink data rate sufficient to downlink 2 orbits of Scatterometer data during a single 5 minute tracking pass.

3.2.6.1.3 Downlink Channel Performance

All telemetry downlink rates and corresponding encoding scheme shall provide at least +3db link margin.

3.2.6.1.4 Downlink Bit Error Rate

The downlink bit error rate shall not exceed 10^{-7}.

3.2.6.1.5 Downlink Bandwidth

The bandwidth (99% power) of the downlink transmitter shall be within 5 Mhz.

3.2.6.1.6 Ground Station Compatibility

The spacecraft downlink shall be compatible with the NASA ground stations at Wallops Flight Facility; Poker Flat, Alaska; Svalbard (Longyearbyen), Norway; and McMurdo, Antarctica. The specifications for these ground stations can be found in CCSDS 411.0-G-3: Radio Frequency and Modulation—Part1: Earth Stations which is available for downloading at http://www.ccsds.org/ccsds/ccsds_green_books.html. The spacecraft shall be compatible for downlink at S-band, however, X-band options will be considered if they are compatible with these stations.

3.2.6.2 Uplink Capabilities

3.2.6.2.1 Uplink Command Rate
The spacecraft shall supply an uplink command rate sufficient to support the mission operations command load.

3.2.6.2.2 Uplink Channel Performance
The uplink bit error rate shall not exceed 10^{-6}. The uplink channel shall also provide at least +6dB link margin.

3.2.7 Thermal Control
The Scatterometer shall be mounted externally and shall be thermally isolated. The thermal control of the Scatterometer shall be provided by JPL.

3.3 Spacecraft Mechanical Alignment

3.3.1 Alignment Errors Included in Pointing
The on-orbit spacecraft mechanical alignment control errors and uncertainties shall be included in the pointing control and knowledge accuracies specified in 3.2.4. The mechanical alignment error budget shall include thermal distortions, gravity effects, launch effects, and measurement and installation repeatability errors.

3.3.2 Pre-Launch Alignment Measurement
The mechanical alignment of the Scatterometer alignment cube, specified in Figure 4-1, relative to the appropriate spacecraft attitude reference frame shall be measured with an accuracy better than ±0.008°, 3-sigma.

3.3.3 Scatterometer Alignment Cube
The Scatterometer will provide an alignment cube mounted to the instrument antenna which the contractor can assume relates directly to the Scatterometer antenna coordinate axes with no additional errors. The Government will be responsible for aligning this cube to the Scatterometer antenna coordinate axis and the Scatterometer RF beam.

3.4 System Verification

3.4.1 Full-Up Spacecraft Operational Test
The full-up system shall demonstrate operational capability when operated by the ground support equipment during ground tests. The contractor shall demonstrate, by test, the compatibility of the spacecraft command and telemetry systems with the ground station command and telemetry systems as detailed in the QuikSCAT SOW section 4.3.5.2.1.1. The contractor shall demonstrate, by test, the end-to-end compatibility of the command uplink process from JPL Scatterometer command request to Scatterometer action and the compatibility of the downlink process from Scatterometer data output to JPL receipt as detailed in the QuikSCAT SOW section 4.3.5.2.1.2. The contractor shall also verify, by test, the spacecraft fault protection.

3.4.2 Environmental Verification
The spacecraft contractor shall demonstrate by test, or analysis if justified, the compatibility of the full-up spacecraft system with the mission environments including: launch, structural and thermal; on-orbit thermal; space radiation; single event effects; atomic oxygen; and electromagnetic interference. The tests shall include thermal-vacuum, vibration, acoustics, pyro shock, and EMI/EMC. The actual

spacecraft/observatory configuration for these tests and the details/variations of these tests shall be negotiated/coordinated with the Government.

3.4.3 Spacecraft System Level Burn-In

All spacecraft electronics subsystems shall be operated for a minimum of 500 hours prior to delivery to the launch site. Of this 500 hours, at least 300 hours shall be at the observatory level, 120 hours shall be at an elevated temperature of 45°C or higher (or at the limits of the thermal test environment), and 18 hours shall be at a lowered temperature of -10°C (or at the limits of the thermal test environment). The reference temperature locations are to be negotiated. The last 100 hours of observatory level testing shall be error-free.

3.4.4 Launch Site Testing

The observatory shall be checked out at the launch site to assure satisfactory operation. These tests shall include interface tests with the launch vehicle as detailed in the QuikSCAT SOW section 4.3.5.1.

4. SCATTEROMETER INSTRUMENT ACCOMMODATIONS

4.1 Physical Requirements

The spacecraft shall be capable of supporting the Scatterometer with the characteristics shown in Figure 4-1 and detailed in this section and the mechanical ICDs.

4.1.1 Scatterometer Envelope

The spacecraft shall accommodate the Scatterometer volume as described in the Scatterometer mechanical ICDs.

4.1.2 Scatterometer Mass Properties and Frequencies

The spacecraft shall be capable of supporting a nominal Scatterometer mass of 220 kg with the mass allocation as follows:

Scatterometer Subsystem	Mass kg	C.G. ± 6mm mm			MOI ±10% about C.G. $Kg\text{-}m^2$			Lowest Response Frequency* Hz
		X	Y	Z	Ixx	Iyy	Izz	
CDS	35	164.3	212.2	219.7	0.9	0.7	0.5	104
SES	110	-386.6	452.6	155.1	7.8	5.9	11.5	120
SAS	70	26.2	210.7	443.8	8.5	8.8	3.7	84*
Cables and waveguide(s)	5	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Total	220							

* The boundary condition is fixed at the Scatterometer subsystem/spacecraft interface. The lowest response frequency for the SAS is 84 Hz with the Scatterometer antenna caged and 40 Hz with the Scatterometer antenna uncaged.

4.1.3 Scatterometer Center of Gravity and Moment of Inertia

The Scatterometer shall be mounted so as to ensure that the observatory center of gravity and moments of inertia are compatible with the Titan II and with the spacecraft attitude control system, without violating the thermal constraints specified elsewhere in this document. The Scatterometer system center of gravity location is obtained by translating the coördinate axes shown in Figure 4-1 to the indicated mechanical reference point and applying the CG dimensions from section 4.1.2.

4.1.4 Scatterometer Mechanical Constraints

4.1.4.1 Mechanical Interface

4.1.4.1.1 Standard Mounting Option

The mechanical interface between the spacecraft and the Scatterometer shall conform to the following mechanical ICDs or as coordinated with the Government:

Scatterometer Subsystem	JPL ICD Drawing Number
CDS	10155454
SES	10155455
SAS	10155456

4.1.4.2 Interconnecting Cabling and Waveguide

The spacecraft configuration shall accommodate the routing of waveguide and cabling between the Scatterometer subsystems, with provisions for Scatterometer provided support brackets and tie-downs, as necessary. The thermal blankets for the platform waveguide shall be provided by the contractor.

4.1.5 Scatterometer Thermal Interface

The Scatterometer shall be thermally isolated at the spacecraft mounting surface with heat transfer levels to be negotiated.

4.1.6 Field Of View Constraints

The Scatterometer shall have an unobstructed view at ±51° from the Scatterometer nadir axis, with the point of origin shown in Figure 4-1.

4.1.7 Scatterometer Orientation Constraints

The primary thermal radiators/louvers, as oriented in Figure 4-1, shall be oriented so as to minimize (as agreed to by the Government) sun exposure.

4.2 Electrical Power and Signals/Data Interface

The spacecraft shall provide the electrical interfaces as outlined in Figure 4-2 and detailed in this section and the electrical ICDs.

4.2.1 D.C. Power

The spacecraft shall supply a switched D.C. power service to the Scatterometer with a voltage range of +32V to +52V to the Scatterometer electronics and a voltage range of +28 +6/-4V to the Scatterometer survival heaters. Whenever the +32V to +52V power is not applied to the Scatterometer, the spacecraft shall autonomously power the survival heaters at +28V +6/-4V. This autonomous function shall be able to be enabled/disabled via command to support ground testing and launch. All power services shall be single fault tolerant to ensure that power is provided to the Scatterometer electronics or survival heaters at all times. The nominal Scatterometer power consumption is described in paragraph 4.2.2. The spacecraft shall provide commands to switch power to the survival heaters within 115 minutes from liftoff.

4.2.2 Power Availability

The spacecraft shall be capable of supporting the Scatterometer power consumption on a continuous basis. The nominal Scatterometer power consumption is shown in the table below. When the Scatterometer is operational (normally the Scatterometer is continuously powered), the power shown below is a continuous power draw. When the Scatterometer is not operational, the Scatterometer survival heaters will draw 165W at the nominal orbital average of the bus voltage for the heaters.

Scatterometer Subsystem	Nominal Power
CDS	32 W
SES	160 W
SAS	28 W
TOTAL	**220 W**

4.2.3 In-Rush Capability

For all switched Scatterometer power services, the spacecraft shall not sustain any damage from Scatterometer generated transients with a power-on peak current of 15A and a duration of 150μs.

4.2.4 Scatterometer Chassis Grounding

The spacecraft shall provide a ground lug accommodating ground straps from each of the 3 Scatterometer subsystems, and the spacecraft shall provide a low impedance path from that point to the spacecraft single point ground with a dc resistance of < 25 mΩ.

4.2.5 Scatterometer Pyro Interface

The spacecraft shall provide ordnance level pyro actuation signals to the Scatterometer for uncaging the Scatterometer antenna bearings. The pyro actuation signal shall be compatible with the specifications in the electrical ICD.

4.2.6 Scatterometer Command Interface

The spacecraft shall provide a Mil-Std 1553B interface to the Scatterometer for commanding.

4.2.7 Scatterometer Data Interface

4.2.7.1 Housekeeping Telemetry Data

The spacecraft shall provide a Mil-Std 1553B interface to the Scatterometer for housekeeping telemetry collection as specified in the electrical ICD. In addition, the spacecraft shall have provisions for the discrete analog housekeeping interfaces as defined in the electrical ICD.

4.2.7.2 Science Data Interface

The spacecraft shall provide a Mil-Std-1553B interface to the Scatterometer for science data collection. The Scatterometer will packetize this data and transfer it to the spacecraft with a format as specified in the electrical ICD. The spacecraft shall poll the Scatterometer for readiness to transfer a data packet, on a time interval to be negotiated. The contractor may alternatively propose the use of an RS-422 interface with the protocol specified in the electrical ICD, instead of a Mil-Std-1553B interface, for the science data only.

4.2.8 Scatterometer Control Interface

The spacecraft shall provide up to 24 discrete command interface lines to the Scatterometer for commanding Scatterometer relays . This interface is specified in the electrical ICD.

4.2.9 Spacecraft Interface Cables

The spacecraft shall provide the interface cabling to mate to the connectors shown in Figure 4-2.

4.3 Observatory Environmental Requirements

4.3.1 Thermal Environment

Scatterometer Subsystem	Operating Range (°C)	Non-Operating Range (°C)	Qual-Temperature Range (°C)
CDS	+5 to +40	0 to +45	-20 to +65
SAS Antenna	-80 to +80	-80 to +130	-110 to +130
SAS Electronics	-5 to +45	-10 to +50	-20 to +70
SES	0 to +40	-10 to +45	-20 to +65

4.3.2 EMI/EMC Environment

The spacecraft EMC design shall comply with the applicable specifications from MIL-STD 461, the Titan II requirements and the Scatterometer specific emissions and sensitivities. An electromagnetic environment effects analysis shall detail how compatibility will be achieved, and verified as applicable.

4.3.2.1 Spacecraft Radiated Susceptibility

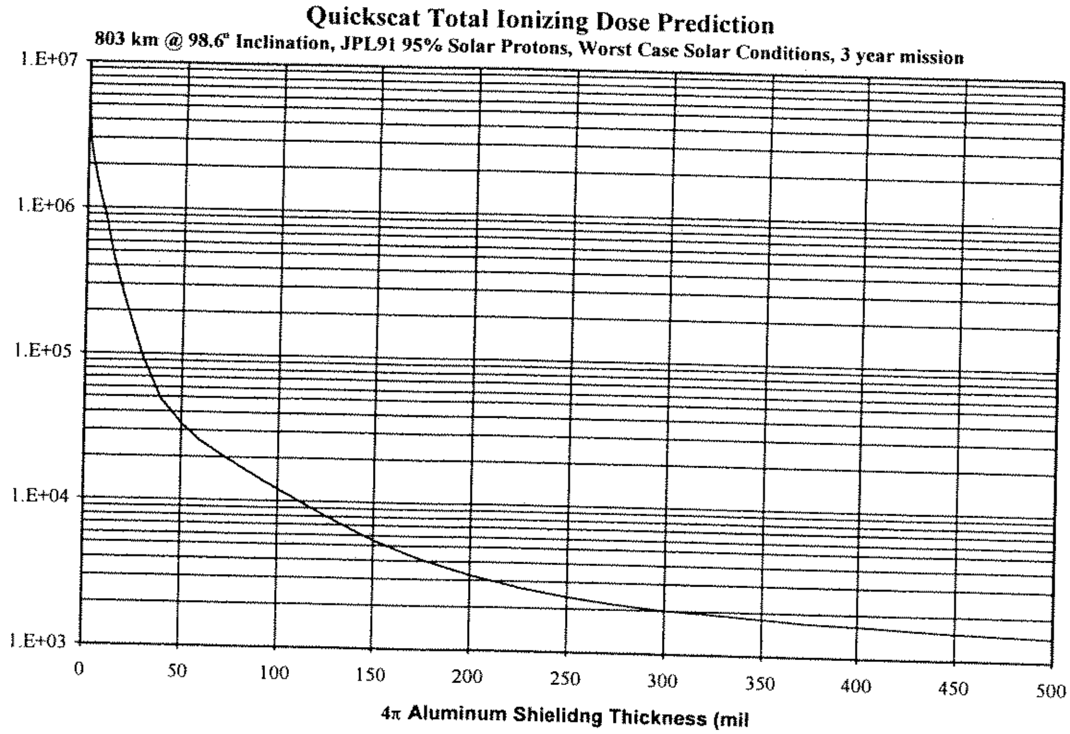
The spacecraft shall not be susceptible to radiated emissions with a field strength of 20 V/m over the frequency range of 13.402 GHz ± 770 kHz. This level applies at the mounting surface of the Scatterometer antenna subsystem. Objects closer to the antenna radiating elements will experience higher levels.

4.3.2.2 Spacecraft Radiated Emissions

The spacecraft radiated emissions, at a distance of 1m from the spacecraft, shall not exceed +10 dBμV/m over the frequency range of 13.402 GHz ± 1 MHz, or +25 dBμV/m over the frequency range of 11.852 GHz ± 1 MHz.

4.3.3 Radiation Tolerance

4.3.3.1 Total Dose
The spacecraft shall be designed to meet the total ionizing dose environment illustrated below.



4.3.3.2 Heavy Ions
All flight parts shall be latch-up immune at an LET of 100MeV/mg/cm^2 at a fluence of 107 ions/cm^2.

4.3.3.3 Single Event Effect (SEE) Tolerance
The observatory shall be tolerant of SEE. Since SEEs are highly implementation dependent, the acceptable SEE rates for various spacecraft functional slices will be negotiated.

4.4 Operational Factors

4.4.1 Science Data Distribution
The science data will be distributed to the ground data processing center at NOAA Suitland, MD, within 150 minutes of acquisition and to JPL with no backlog for each downlink station pass.

4.4.2 Scatterometer Command Types
The spacecraft shall provide the capability to transmit commands to the Scatterometer in real-time or to store commands and issue them at a designated time. The stored commands shall have a resolution of 1 second or better.

4.4.3 Scatterometer Command Storage
The spacecraft shall provide the capacity to store up to 2 kbytes of Scatterometer commands.

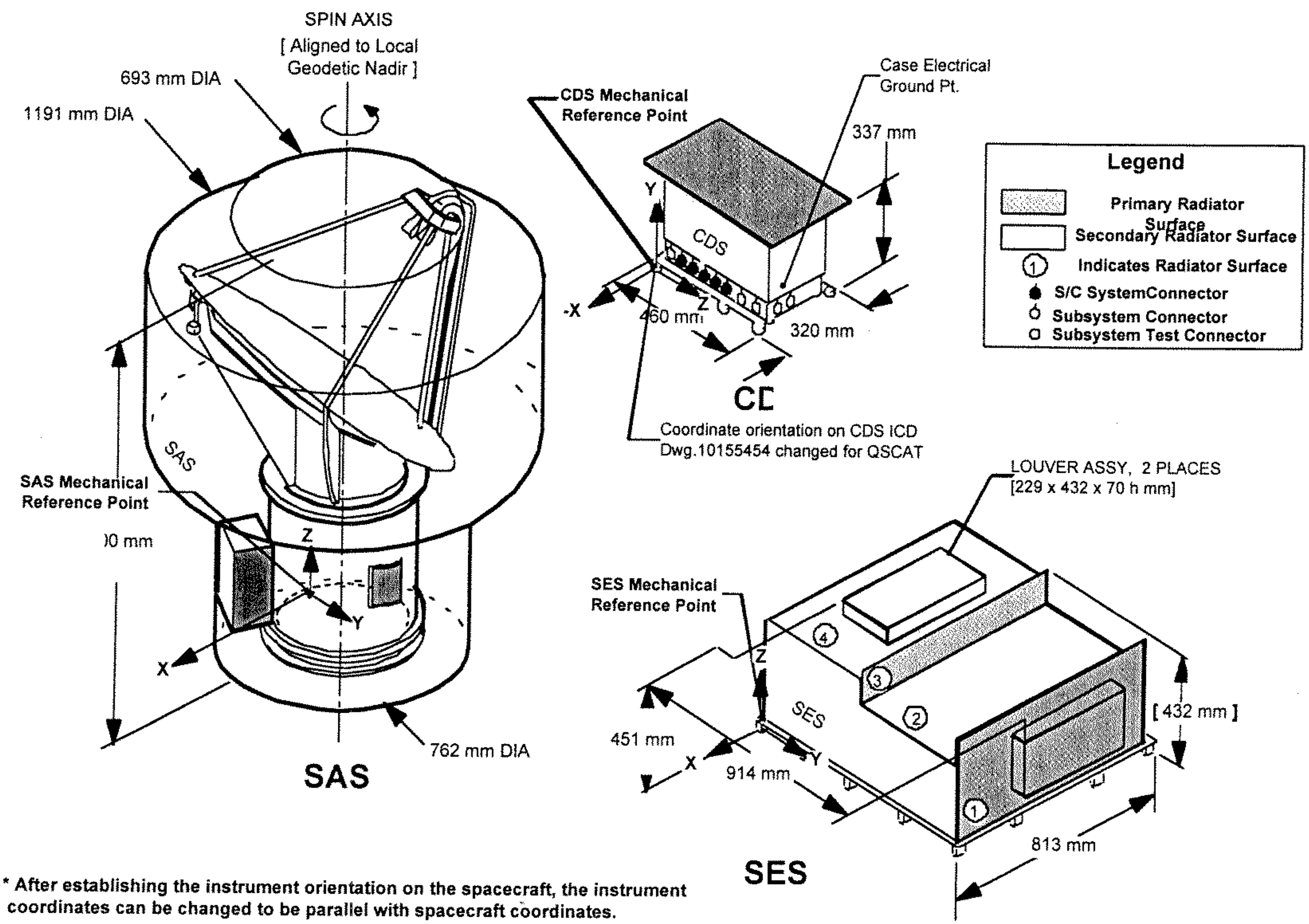
4.4.4 Ephemeris Predicts

The spacecraft contractor shall prepare tracking station predicts for the NASA Ground Stations three times per week. The ephemeris shall be predicted 3 days in advance within ±1 km, each axis, and determined 3 days after data acquisition within ±200m, each axis.

4.4.5 Command Planning Timeline

The spacecraft contractor shall accept Scatterometer commands for stored programming activation on a routine planning timeline up to one week prior to the first day of the execution period. Scatterometer commands for real-time execution shall be accepted up to 24 hours prior to the nominal commanding opportunity.

Figure 4-1, Sheet 1 QuikSCAT Instrument Configuration*



* After establishing the instrument orientation on the spacecraft, the instrument coordinates can be changed to be parallel with spacecraft coordinates.

Figure 4-1, Sheet 2 QuikSCAT Instrument View

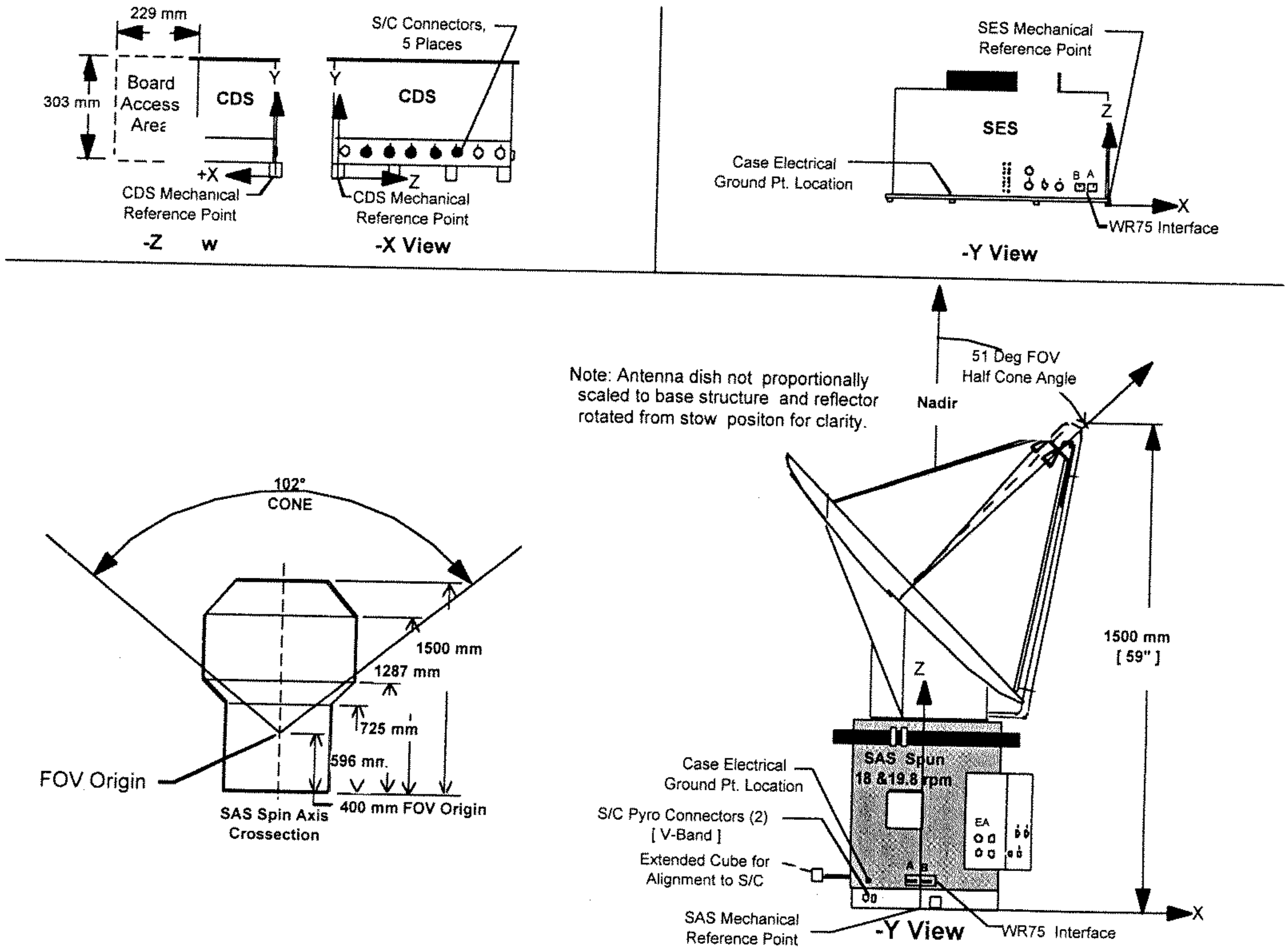
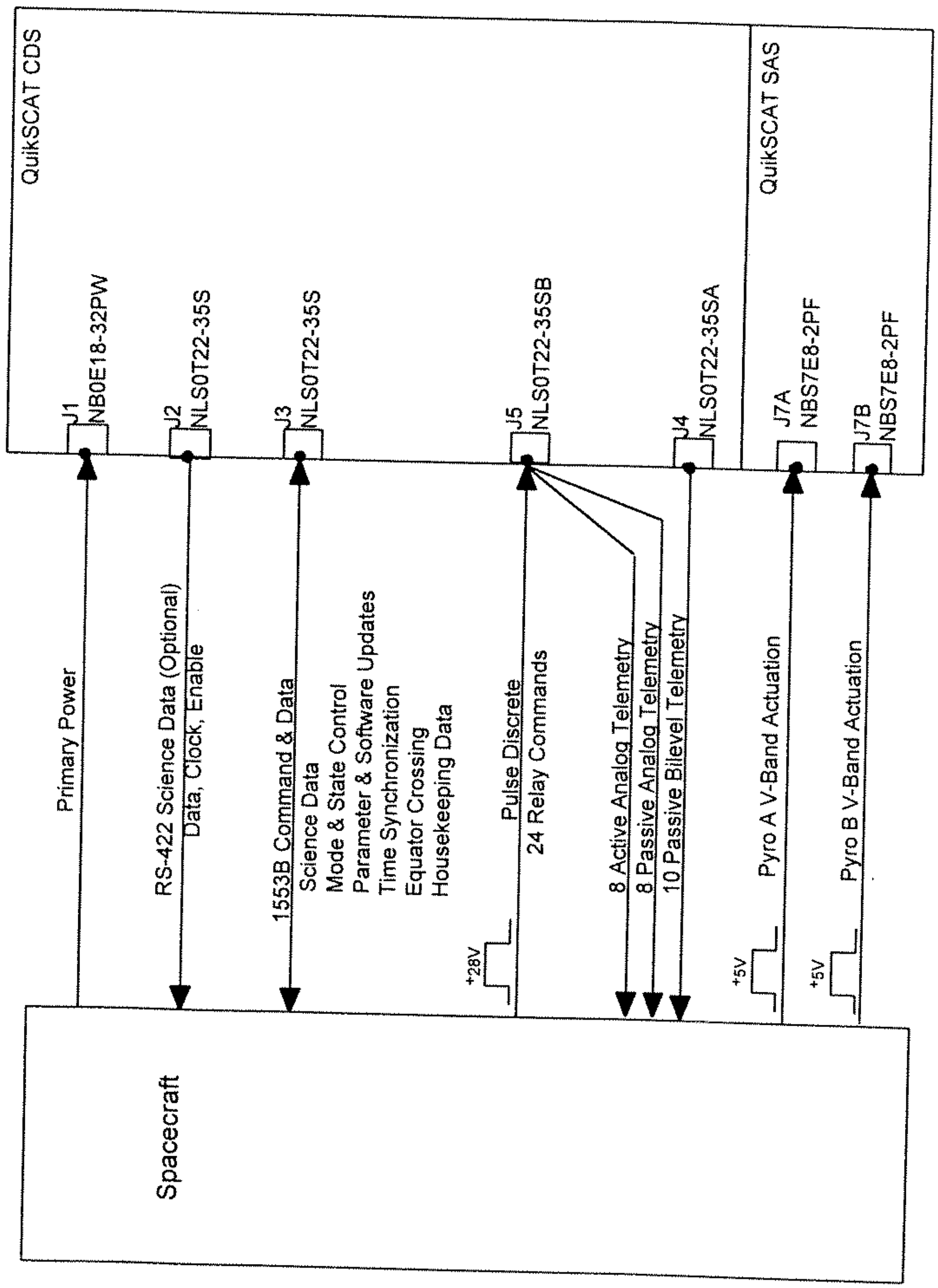


Figure 4-2 QuikSCAT/Spacecraft Interface Block Diagram



All three QuikSCAT subsystems (CDS, SAS, & SES) are fully block redundant.
The CDS connectors listed above contain the signals for both the A and B strings.

Note: The voltage range to the Scatterometer electronics is +32V to +52V and the voltage range to the Scatterometer survival heaters is +28V +6/-4V.

QuikSCAT

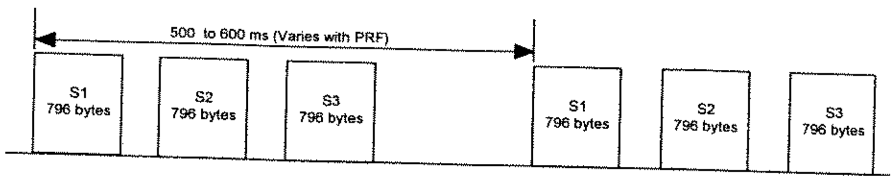
Electrical ICDs

1553B Interface Specification Sheet

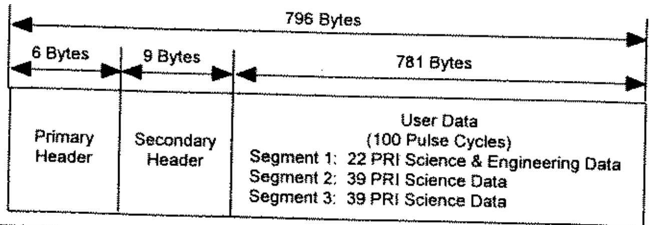
Mean Data Rate:	< 40kbps
Packet Format:	CCSDS
Packet Length:	2388 bytes; Three 796 byte segments
Stub Length:	20 Ft. (Max)
Z_0 of Main Bus Cable:	70-85 Ω

Commanding, housekeeping telemetry, and science data available on primary and redundant buses.
Details of the redundancy connection between QSCAT CDS-A & CDS-B and the spacecraft are to be negotiated.
All hardware is to meet the requirements of MIL-STD-1553B.

Telemetry Packet Timing Diagram



Segmented Packet Format



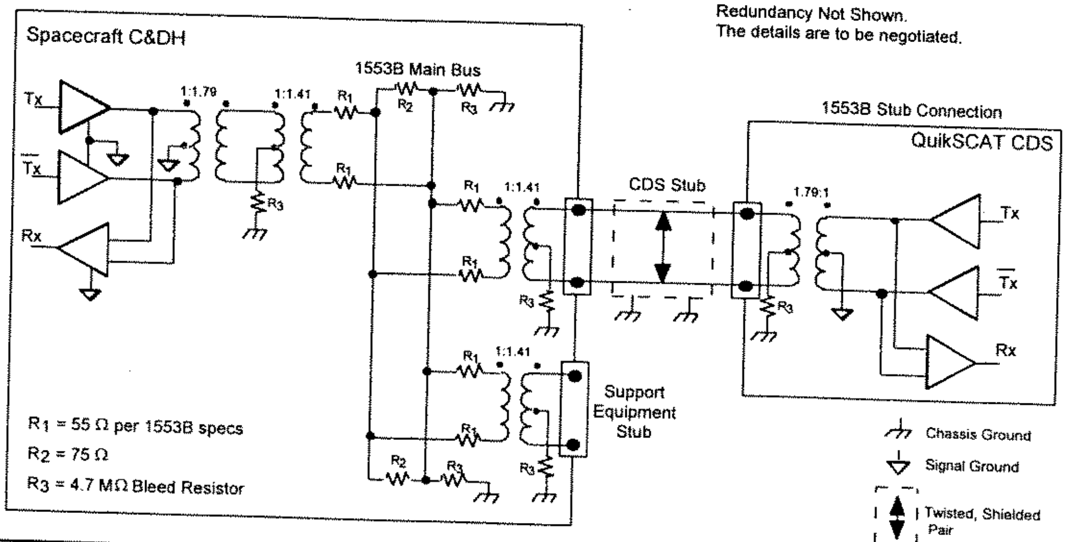
Command Format

Word Rate:	32 words/sec (Max)
Max Time Between Words in a Command:	1 sec

Command Type 1 Byte	Command ID 1 Byte	Data Word	•••	Data Word	Checksum 1 Word
Identifier Word		N Data Words			

Signal Timing Diagram

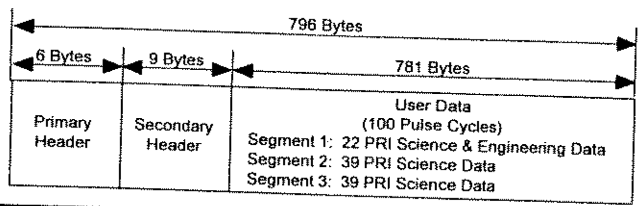
Redundancy Not Shown.
The details are to be negotiated.



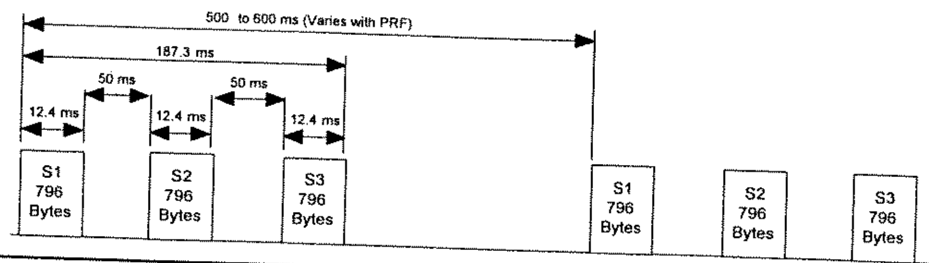
Optional RS-422 Mission Data Interface Specification Sheet

Signals from QSCAT:	Enable, Clock, Data	Data Code:	NRZ-L
First Bit:	MSB (Bit 0)	Mean Data Rate:	< 40kbps
Clock Rate:	512 kHz	Packet Format:	CCSDS
Clock Stability:	(+/- 512 kHz x 10^{-4})/year	Packet Length:	2388 bytes; Three 796 byte segments
Clock Duty Cycle:	50% +/- 10%		

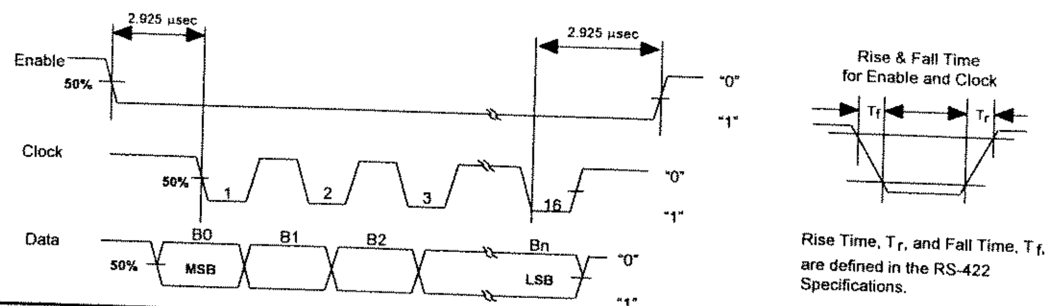
Packet Diagram

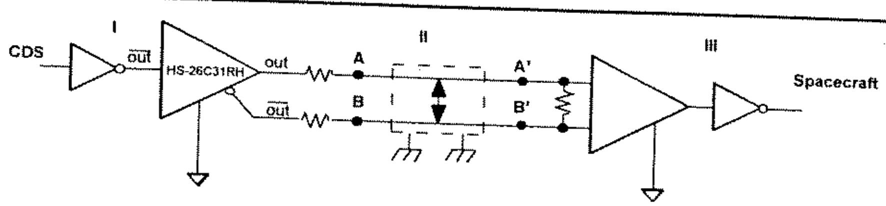


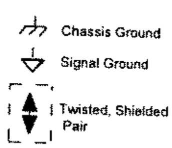
Packet Timing Diagram



Signal Timing Diagram







I Logic Input before Inverse	II V_A-V_B	III Logic Output After Inverse
"1"	< -1V	"1"
"0"	> 1V	"0"
OFF	Undefined	"0"

Discrete Telemetry Specification Sheet

Active Analog

Spacecraft Receiver Type:	Differential
Isolation at Spacecraft:	1 MΩ (Min)
Input Impedance (to CDS):	1 MΩ (Min)
Sampled Range :	0.0 to 5.1 Volts
Source Impedance:	10 kΩ (Max)
A/D Converter	
Accuracy:	+/- 1% (for full scale)
Quantization:	8 bits (Min)

Passive Analog

Input Impedance (to Spacecraft):	1 MΩ (Min)
Driving Current:	Spacecraft Specified
Sampled Range (Volts):	Spacecraft Specified
Output Impedance:	
Range:	0-3.78 k Ω
Maximum:	800 pF
A/D Converter	
Accuracy:	+/- 1% (for full scale)
Quantization:	8 bits (Min)
Minimum Temp Range	-30 °C to +80 °C

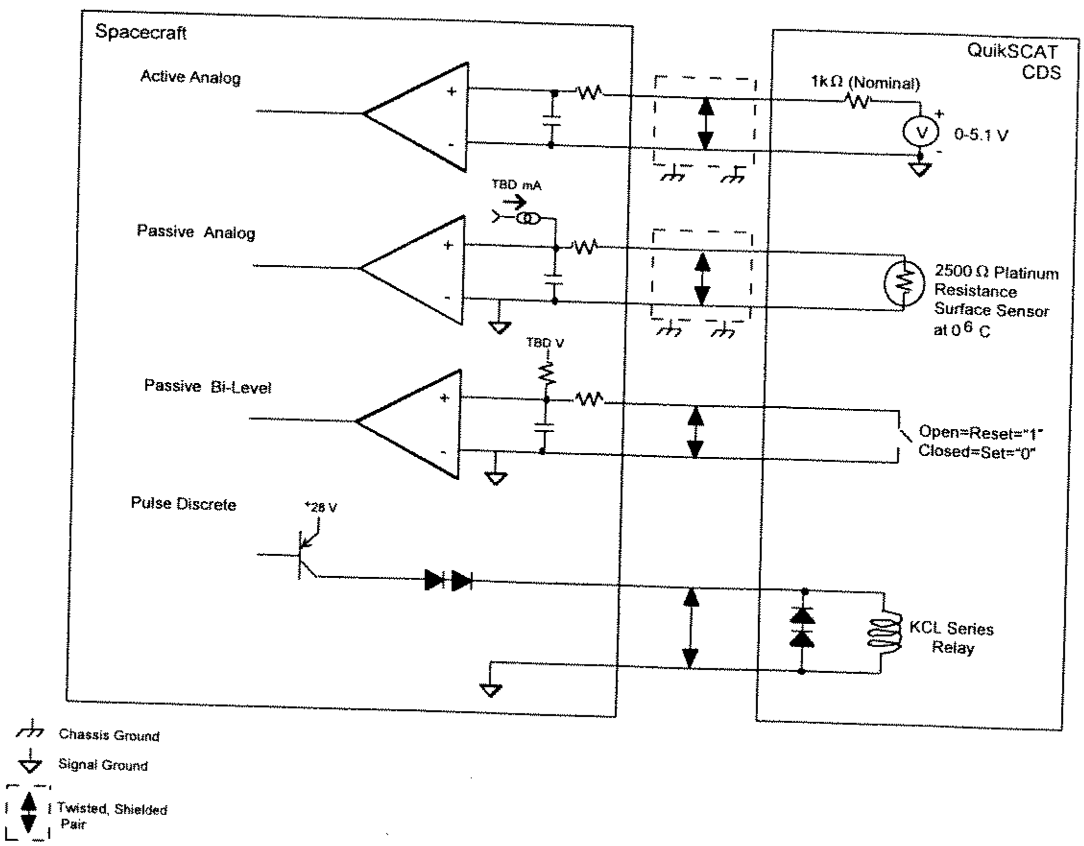
Passive Bi-Level

Input Impedance:	> 1 MΩ
Signal Source Output:	
Logic One:	Open Circuit
Logic Zero:	Closed Circuit
Impressed Voltage to Signal Source:	Spacecraft Specified
Output Impedance from Spacecraft:	2.5 k Ω (Min)

Pulse Discrete

Pulse Width:	> 30 ms
Output Voltage:	
Nominal:	26 V
Maximum:	29 V
Coil Resistance:	450 Ω +/- 10%

Sample Interface Circuits

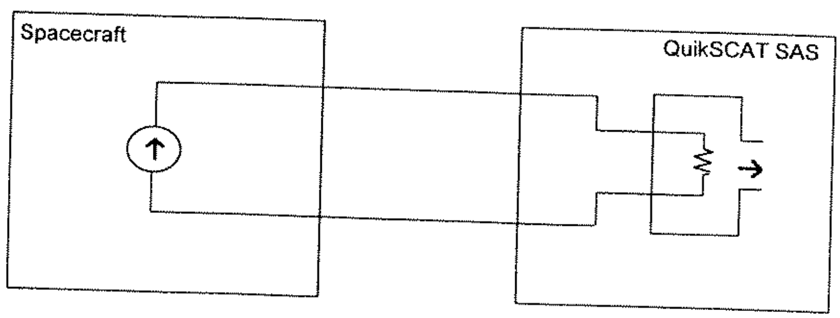


Pyrotechnic Device Specification Sheet

Number of Squibs:	2
Ground Strap Resistance:	< 2.5 mΩ dc
Input Current:	5.0 A per squib (Min) 10.0 A per squib (Max)
Pulse Width:	22 msec (Min)
Voltage After Firing:	16-24 Vdc
Firing Timing:	Simultaneously, within 10 ms of each other

The design of the pyrotechnic device must be compatible with NSI, NASA Standard Initiator.
The design must also meet Mill Spec 1576.

Sample Interface Circuit



List of Acronyms

ACS	Attitude Control System
C&DH	Command and Data Handling
C.G.	Center of Gravity
CCSDS	Consultative Committee for Space Data Systems
CDS	Command And Data Subsystem
CMV	Collected Volatile Materials
D.C.	Direct Current
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference
FOV	Field of View
GSE	Ground Support Equipment
I&T	Integration and Test
ICD	Interface Control Document
JPL	Jet Propulsion Laboratory
MOI	Moments of Inertia
PAF	Payload Attach Fitting
QuikSCAT	Quick Scatterometer
RF	Radio Frequency
SAS	Scatterometer Antenna Subsystem
SEE	Single Event Effects
SES	Scatterometer Electronics Subsystem
TID	Total Ionizing Dose
TML	Total Mass Loss
UTC	Universal Time Code

Payment Events and Completion Criteria

1. **Major Subcontract Placement Complete:** Placement of Solar Array, Launch vehicle separation system, Launch vehicle adapter, and RF components complete.
2. **Mission Design Review**: As defined in the basic contract, B.4, Performance-Based Payments Events and Completion Criteria.
3. **Bus Structure Build Complete**: Core structure build completed, including cornerposts, shear panels, and nadir deck, excluding zenith deck / propulsion module and mid deck assembly.
4. **Structure and Power Integration Complete:** Harness & Power components integrated onto the flight structure (PCU, Test battery if needed, SEP portions relating to Bus functions, PDA's relating to Bus functions). Integration consists of functional check of unit on spacecraft and verification of interfaces.
5. **Bus Integration Complete:** Bus subsystem integration complete with the exception of the propulsion subsystem and RF components. Integration consists of functional check of unit on spacecraft and verification of interfaces.
6. **Bus System Test Complete:** All bus subsystem functional tests complete, with the exception of the RF and propulsion subsystems. System tests are the performance verification of the subsystems per the I&T plan.
7. **Pre Environmental Review:** As defined in the basic contract, B.4, Performance-Based Payments Events and Completion Criteria.
8. **Pre-Ship Operational Readiness Review:** As defined in the basic contract, B.4, Performance-Based Payments Events and Completion Criteria.
9. **Flight Readiness Review:** Shipment of spacecraft to launch site and completion of all launch site activities. All open items, affecting flight readiness, must be dispositioned prior to launch.
10. **On-Orbit Acceptance:** As defined in the basic contract, B.5, Acceptance and Final Payment for Spacecraft. In addition, spacecraft shall exhibit mission compliant performance or in event of a launch failure this milestone will be met. Subsystem checkout includes:

- Verification of initial acquisition mode and preliminary status check
- Calibration of thruster force and CG measurements through the process of orbit adjustment (as required)
- On orbit alignment of yaw, pitch, and roll and verification of system pointing accuracy
- Mechanism verification including (solar array panel motion)

- GPS performance (comparison of GPS data to the predict based upon the reconstructed orbit)
- Calibration of magnetometers, sun sensors, and star trackers (attitude solution)
- Verification of the magnetics and momentum control units
- Verification of thermal and power subsystem
- Scatterometer testing to the defined requirements
- Functional test to determine spacecraft ability to perform the following functions:
  - Equatorial crossing synchronization
  - Establish nadir pointing to defined requirements
  - Command instrument subsystem and collect data
  - Downlink instrument data through the Wideband link

11. **Quarterly Mission Operations:** submittal of a Quarterly Operations Report, which will consist of mission performance, anomaly status, anomaly resolution, and planned mission objectives for the following quarter. In addition, operations must meet the mission operations requirements as specified in the statement of work and performance specification of this delivery order.

PERFORMANCE BASED PAYMENT SCHEDULE

Attachment F

Payment Event No.	Performance Based Milestones	Cum %	Month	Performance %	$ Performance Based Payments Amount	$ Per Cum M/S
1	Major Subcontract Placement Complete (Int)	(b) (4)				$ 3,677,876
2	Mission Design Review (Maj)					$ 9,194,691
3	Bus Structure Build Complete (Int)					$ 13,792,036
4	Structure & Pwr Integ Complete (Int)					$ 18,389,381
5	Bus Integration Complete (Int)					$ 22,067,257
6	Bus System Test Complete (Int)					$ 23,170,620
7	Pre Enviromental Review (Maj)					$ 28,687,434
8	Pre Ship/Operationa Readiness Review (Maj)	(b) (4)				$ 32,686,533
9	Flight Readiness Review (Int)					$ 33,422,108
10	On-Orbit Acceptance (Clause B.5/D.O. Att. E)					$ 37,099,984
11	**Mission Operations**	(b)				$ 272,[illegible]
12	**Mission Operations**	(4)				$ 544,754
13	**Mission Operations**					$ 817,131
14	**Mission Operations**					$ 1,089,508
15	**Mission Operations**					$ 1,361,885
16	**Mission Operations**					$ 1,634,262
17	**Mission Operations**					$ 1,906,639
18	**Mission Operations**					$ 2,179,016
	Total Basic + 2yr of ops					