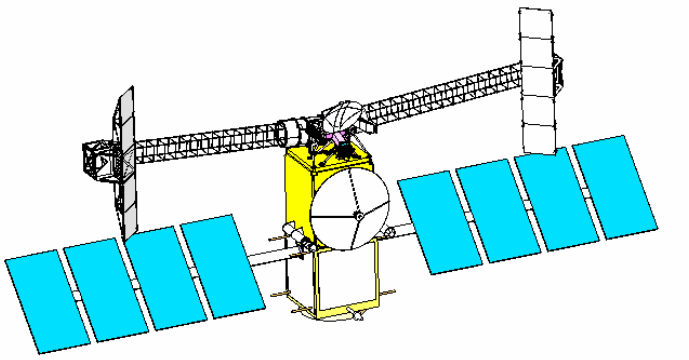
Ocean Surface Topography Mission (OSTM)

Advanced Microwave Radiometer (AMR) Instrument
Reflector Structure Assembly
Requirements Specification



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NATIONAL AERONAUTICS and
SPACE ADMINISTRATION

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AMR-RSA Requirements Specification

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Reflector Structure Assembly Requirements Specification

1 INTRODUCTION

1.1 SCOPE

This specification establishes the requirements for the design, fabrication, verification, and performance of Reflector StructureAssembly (RSA) of the Advanced Microwave Radiometer (AMR) instrument. AMR will is part of the Ocean Surface Topography Mission (OSTM).

The AMR is a three-frequency radiometer (18.7, 23.8, and 34.0 GHz) that provides water vapor correction to the nadir altimeter through a co-located radiometric brightness measurement. The 23.8 GHz channel is the primary water vapor channel, while the 18.7 and 34.0 GHz channels are used to estimate the ocean surface component and liquid cloud component brightness temperatures respectively.

1.2 PURPOSE

The AMR-RSA provides the reflector and primary structure for the AMR instrument and allows mounting of the instrument to the PROTEUS Jason-2 spacecraft Payload Instrument Module (PIM).

1.3 DESCRIPTION

The AMR-RSA consists of a Reflector, hardware that interfaces to the AMR Electronic Structure Subassembly (ESS) and hardware that interfaces to the PIM as well as required support structure.

2 APPLICABLE DOCUMENTS

The following applicable documents, of the exact issue and revision level shown, form a part of this requirements specification. Where an exact issue or revision date is not specified, the applicable issue/revision shall be as required in the Statement of Work (SOW). In case of conflict between provisions of this document and other applicable documents, the Contract Technical Manager will be consulted for resolution. Engineering data should be taken from the engineering drawings referenced herein and not from figures within the body of this document. These documents shall be used in their totality unless specified otherwise herein.

2.1 JPL DOCUMENTS

ES 501492	Safety Requirements for Mechanical Support Equipment for JPL Critical Items Equipment, Rev. G, July 27, 2000.

JPL D-25614/ OSTM-31-5006	OSTM Structural Requirements & Verification Plan (SVP) February 12, 2003
JPL D-21959	OSTM Materials & Processes Control Plan, January 29, 2003
JPL D-19837	Surface Treatments For CloudSAT Reflectors, Revision B December 12, 2000
JPL 10229971	AMR RSA Interface Control Drawing, Rev. A
JPL 10229988	Equivalator Support Structure
OSTM-37-5002	Jason 2 Payload Design And Interface Specification, Draft 11/09/02

2.2 OTHER DOCUMENTS

MIL-HDBK-V	Metallic Materials And Elements For Aerospace Vehicle Structures

3 AMR RSA MECHANICAL SUBSYSTEM REQUIREMENTS

3.1 AMR INSTRUMENT HARDWARE DESCRIPTION

The AMR instrument is comprised of two subsystems, namely the Electronic Support Structure (ESS) and the Reflector Structure Assembly (RSA). The RSA includes the Reflector, its supporting structure as well as interfaces to the ESS and Proteus Spacecraft Payload Interface Module (PIM). The OSTM Spacecraft configuration is shown in Figure 1. The AMR Instrument, including the ESS and a conceptual design for the RSA, is shown in Figure 2.

3.1.1 Reflector Structure Assembly (RSA)

The RSA consists of the Reflector, interfaces to the ESS and PIM, as well as the interconnecting structure.

3.1.2 Electronic Support Structure (ESS)

The primary components of the ESS are two electronics boxes, waveguide runs, a radiator and the microwave feed horn. All ESS hardware is fabricated by JPL.

3.1.3 Radiometer Calibration Target (RCT)

The RCT is used for functional testing of the AMR instrument, and is shown in Figure 3. It is mounted directly to the ESS. It is used for testing on Earth when the AMR is both on and off the Spacecraft. The RCT is fabricated by JPL. It will not be mounted during any AMR structural testing.

Figure 1 OSTM Spacecraft

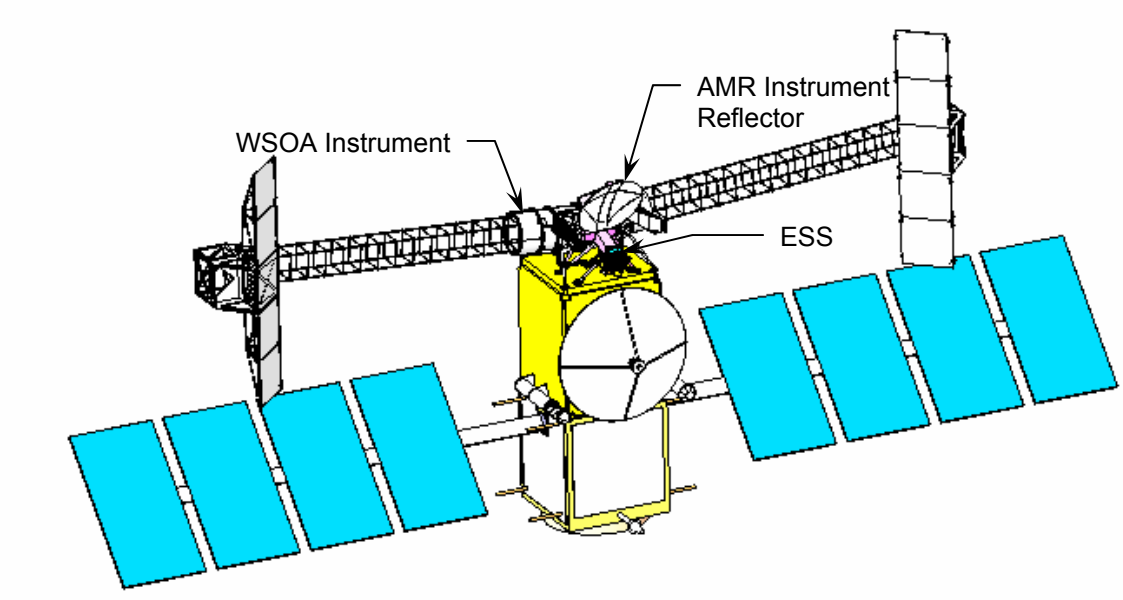
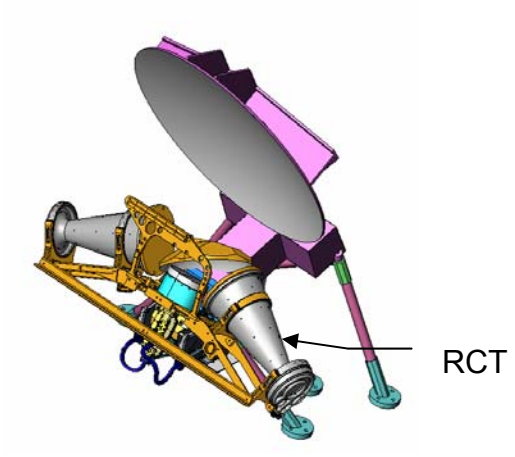


Figure 2 RSA with and without ESS

Figure 3 AMR with RCT



3.1.4 Interface Definitions

3.1.4.1 Mechanical Flight Interfaces

The AMR-RSA shall interface with the Spacecraft PIM at Contractor defined locations on the +X surface of the PIM within the area defined in JPL MICD 10229917. The AMR-RSA shall mount to the PIM in a statically determinate arrangement.

The AMR-RSA shall not require assembly or disassembly to perform mounting on or dismounting from the spacecraft. The AMR-RSA design shall permit easy access to mounting bolts and to test points and components that may require adjustment

The Contractor shall specify and supply the required metric spacecraft mounting fastening hardware. The ESS mounts to the RSA as described in JPL drawing 10229971. Mounting hardware will be provided by JPL.

The mechanical interfaces between the AMR-RSA and the JPL-provided ESS hardware are be defined by JPL Drawing 10229971, AMR-RSA Mechanical Interface Control Drawing (MICD). Included in this MICD are the allowable RSA dynamic volume, ESS CG location, the ESS and RCT volumes as well as defined areas for mounting the RSA to the PIM.

The mechanical interfaces between the AMR-RSA and the CNES provided Jason-2 spacecraft Payload Instrument Module (PIM) shall be described by an MICD generated by the Contractor. Included in this MICD shall be the location of the AMR instrument relative to AMR Coordinate System Origin, Ground Support Equipment (GSE) attach points, the structural attachment types and footprints, specific fastener requirements and the AMR instrument dynamic envelope.

3.1.4.1.1 PIM Characteristics

The PIM panel surface to which the AMR-RSA mounts will have a planarity of better than 0.25 mm in 300 mm and than 1 mm/m

The PIM panel will have a surface roughness of 3.2 micro m rms.

3.1.4.1.2 Interface Fasteners

For attachment to the PIM the AMR-RSA shall be designed to use metric M5 fasteners with a minimum spacing 100 mm between fasteners and / or M4 fasteners with a minimum spacing of 25 mm between fasteners. Loads applied to the fasteners shall not exceed the values stated in Table 1.

Fastener	Pull Out (N)	Shear (N)	Tension (N)
M4	1080	820	4100
M5	2000	2000	10000

Table 1 PIM Interface Fastener Allowed Loads

The RSA will interface to the ESS with titanium M6 fasteners which will be installed with the torque required to generate at least 11843 N of preload for each fastener.

3.1.4.2 Adjustment

The RSA to PIM interface shall provide a means of adjustment, shimming or other technique to ensure alignment of the AMR instrument (given the above spacecraft distortions and AMR RSA PIM interface tolerances) during spacecraft integration. The range of adjustment at the PIM interface shall be at least ± 2 mm normal to the PIM and ± 3.0 mrad about the AMR X, Y and Z axes.

The RSA to ESS interface shall provide means of adjustment, shimming or other technique to ensure alignment of the ESS to the RSA. The range of adjustment at the ESS interface shall be at least ± 2 mm normal to the interface plane and ± 0.5 mm within the interface plane.

3.1.4.3 Ground Support Equipment Interfaces

The AMR-RSA shall have distinct, non-Flight interfaces for the Mechanical Ground Support (MGSE) Equipment for lifting of the AMR. These interfaces shall have JPL concurrence and shall be documented in the Contractor generated MICD.

All permanently attached flight hardware interfaces with mechanical GSE (such as inserts), that will be loaded as a result of hoisting, lifting, or supporting structure, shall be qualified by proof testing. Proof testing for mechanical GSE loading is not required if it could be demonstrated that the planned proto-flight static testing for flight limit loads (1.20 x FLL) exceeds the required GSE proof test load.

3.1.4.4 Alignment Devices or Features

The contractor shall provide at least five M5 threaded inserted around the perimeter of the RSA Reflector dish for the temporary installation of JPL supplied alignment targets. The location of these inserts will be agreed upon by the Contractor and JPL.

The contractor shall provide two ∅3 mm reference holes at the RSA to ESS interface as shown in JPL DWG 10229971

3.2 CHARACTERISTICS

3.2.1 Physical Requirements

3.2.1.1 Envelope

The AMR-RSA shall exist within the envelope defined in MICD drawing 10229971. This envelope shall include all dynamic motions of the RSA assuming a rigid PIM interface. NOTE: The envelope defined in drawing 10229971 contains negotiable zones. Iterations between JPL and the Contactor shall be required in these areas due to the presence of struts from the WSOA instrument and thermal requirements of the ESS radiator.

3.2.1.2 Reflector Requirements

3.2.1.2.1 Reflector Definition

The Reflector surface is defined by the intersection of a ∅625 mm cylinder (centerline vector of 0,0,1 located at 312.5,0,0) with a paraboloid as indicated in Figure 4 (units are mm). Locations and orientation of the Reflector surface relative to the AMR-RSA coordinate system and the Spacecraft interface is given in MICD drawing 10229971.

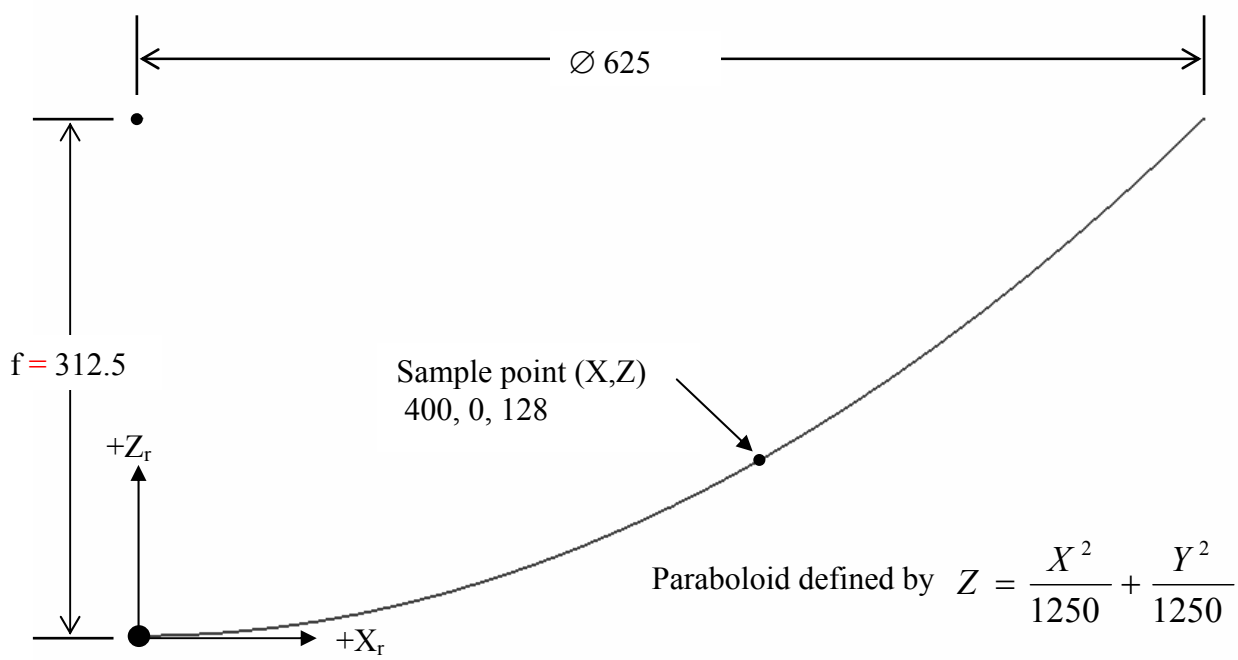


Figure 4 Reflector Definition

3.2.1.2.2 Reflector Surface Accuracy

The RSA Reflector shall have an on-orbit RMS error of less than 0.125 mm (.005 in) with respect to the ideal surface with a correlation area of 3.0 cm by 3.0 cm. The reflector inspection points shall be on a grid with a maximum spacing of 0.25 cm. The maximum deviation of any point with respect to the ideal surface shall be +/- 0.25 mm. Error allocations shall be given to thermal distortions, hygrothermal effects, 1 g sag and as-manufactured effects.

3.2.1.2.3 Pointing

The as-built best-fit focal axis of the surface shall not deviate from the theoretical focal axis defined in Section 3.2.1.2.1 by more than 0.05° about the X_r and Y_r axes and 0.10° about the Z_r axis.

On-orbit deviations shall not be more than 0.07° about the X_r and Y_r axes and 0.15° about the Z_r axis. On orbit error allocations shall be given to thermal distortions, hygrothermal effects and 1 g sag effects.

3.2.1.3 Mass Properties

3.2.1.3.1 Mass

Total mass of the AMR-RSA including reflector, support structure, attachment hardware and any required thermal blanketing shall not exceed 8.000 kg

3.2.1.3.2 Center of Gravity

The center of gravity of the RSA shall be located, identified and measured to within +/- 5 mm. The CG location shall be specified on the Contractor generated MICD.

3.2.1.4 Materials and Processes

Materials, parts and processes used for the design and manufacture of the AMR-RSA shall conform to the OSTM M & P Plan, JPL D-21959 Sections 3.5 through 3.8. All non-metallic materials must meet outgassing requirements of <1% TML and <0.1% collected volatile condensable mass (CVCM). All metallic materials shall be rated as A or B for stress corrosion cracking (SCC) per MSFC-HDBK-527.

3.2.1.5 Coatings

The aperture side of the reflector shall be coated per JPL D-19837 utilizing the procedures specified therein for the CloudSAT Primary Reflector. Thermo-optical properties for the coated AMR-RSA reflector aperture side, beginning and end of life, shall be as follows:

Solar absorbance (α_S):	< 0.60 (Hemispherical, 0.2μ-1.6μ at 300K)
Absorbance/emittance ratio (α/ε):	1.0 - 2.0
Specular Reflectance (ρ visible):	< 10% (BRDF, 10° angle of cone)

3.2.1.6 Utilities

3.2.1.6.1 Cabling

JPL will route the required electrical cables between the ESS and the PIM on the outside of the RSA. The mounting location and attachment method for the cables shall be determined jointly by the Contractor and JPL. The linear density of the cables will not exceed 5.1 g/cm.

3.2.1.6.2 Connector Bulkhead

JPL will mount a connector bulkhead to the RSA near the RSA / PIM interface at a location that shall be jointly determined by the Contractor and JPL. Estimated mass of the bulkhead with connectors (AMR and Spacecraft sides) is .225 kg.

3.2.2 Thermal Requirements

3.2.2.1 Thermal Design/Analysis

Contractor shall perform sufficient design and analysis to ensure a) the alignment requirements are satisfied and b) temperatures are maintained within the capabilities of the structural materials. Maximum and minimum RSA temperature estimates, based on preliminary JPL analysis, are stated in 3.3.4 for reference only.

The contractor shall provide JPL with a thermal model of the RSA for integration with JPL's OSTM Payload thermal model. JPL will provide the Contractor with temperature mapping of the RSA for worst case orbital conditions (operational and non-operational). The contractor shall determine the need for and specify passive thermal control measures per 3.2.2.4

3.2.2.2 Thermal Isolation from Spacecraft

The thermal control of AMR-RSA shall be designed assuming a complete decoupling from the satellite structure. Global coupling with the satellite structure shall be minimized to less than 0.1 W/°C, assuming a satellite structure temperature between -15°C and +50°C.

3.2.2.3 Thermal Isolation from ESS

The RSA interface to the ESS shall have a thermal conductance of less than 1.7 W/°C. For reference, JPL's preliminary design incorporated standoffs between the RSA and the ESS.

3.2.2.4 Passive Thermal Control Coatings / MLI

Passive thermal control coatings and Multi-Layer Insulation (MLI) shall be applied to AMR-RSA components as required to meet the alignment requirements and maintain temperatures within the capabilities of the structural materials/design. JPL will fabricate and install MLI on the delivered RSA based upon contractor requirements.

3.2.2.5 Active Thermal Control

Active thermal control measures, such as heaters, shall not be employed on the RSA.

3.2.3 Structural Performance

3.2.3.1 Stiffness / Strength

3.2.3.1.1 Stiffness

The fundamental natural frequency of the AMR instrument mounted at the S/C interfaces, assuming a rigid foundation, shall be greater than 55 Hz.

3.2.3.1.2 Deflection

Structural members shall have sufficient rigidity to withstand its design loads without deformation or deflections that would cause the RSA to exceed its envelope as defined in JPL drawing 10229971, AMR RSA ICD. All critical conditions shall be considered, including applied loads, thermal loads and manufacturing tolerances.

3.2.3.1.3 Strength

The AMR-RSA shall withstand the launch environments described in Section 3.3 of this specification, with all components having positive strength margins.

3.2.3.2 Material Properties and Allowables

Material properties used shall be in accordance with the OSTM Materials and Process Plan, JPL D-21959, Sections 3.6. The documentation of the source and the design allowables for all material used shall be submitted to JPL for approval.

3.2.3.3 Structural Factors of Safety

The structural factors of safety (FS) that shall be used for the design are described in detail in the OSTM Structural Requirements & Verification Plan, Section 3.1.2, as are shown below in Table 2.

Table 2. Structural Factors of Safety

No.	Structure/Component	Design Factor of Safety		Test Factors
		Yield FS_y	Ultimate FS_{ult}	Proto-Flight [3]
1	Metallic Structures Qualified by Testing	1.25	1.56	1.20
2	Metallic Structures Qualified by Analysis only	1.60	2.00	-
3	Composite Structures	-	1.56	1.20
4	Composite Structural joints/Discontinuities	-	2.00	1.20
5	Bonded Joints	-	2.00	1.20
6	Bolted Joint Separation and Slippage	-	1.00 [2]	1.20
7	Ground Support Equipment (GSE) [1]	1.875	2.50	-

Table 2 Notes:

1. For GSE a dynamic factor of 2.0 must be applied to the limit load. The values given here are for handling frames and spreader bars. Higher factors are required for other lifting equipment per JPL ES501492.
2. For alignment sensitive hardware use a Factor of Safety of 1.20.
3. If the Structure to be tested is not proto-flight see the JPL Structures specialist.

3.2.3.4 Structural Analysis

Evaluation of primary structure shall be accomplished through a combination of analysis and testing. All structural and finite element analyses shall be completed in accordance with the OSTM Structural Requirements & Verification Plan, JPL D-25614, Section 5.0. The requirements for the stress analyses are stated in SRVP Section 5.1, and margins of safety calculation in SRVP Section 5.1.1. Finite Element Models (FEM) delivered to JPL shall meet the requirements stated in SRVP Section 5.2.

3.2.3.5 Structural Qualification Testing

The static testing required in order to demonstrate structural qualification of flight hardware and mechanical GSE hardware shall be in accordance OSTM SRVP Section 5.3. The AMR RSA shall be thermal cycled a minimum of 5 times to the maximum & minimum predicted temperatures on orbit prior to structural test. Structural testing shall consist of a quasi-static proof load to 1.2 limit load and an environmental test program including sine survey, sine, and random to the environments specified in Section 3.3. Sine survey parameters shall be as follows: 5-2000 Hz @.25g 0 to peak, 1Oct/min.

3.2.3.6 Fasteners & Preloaded Joints

Installation of pre-loaded hardware elements shall provide for sufficient pre-load such that no physical separation or slippage shall occur at limit load times the appropriate yield factor of safety. All bolted assemblies of the OSTM Payload shall include a positive locking device, to prevent fasteners from losing pre-load

and backing out. All structural fasteners may use a mechanical locking device, or the application of adhesive to the bolt threads and/or staking heads. Inserts, key locking type, shall be used in all parent materials with an A basis Fsy (per MIL-HDBK-5) of less than 60 ksi.

3.2.4 Useful Life

The AMR-RSA shall meet all requirements during the 5 year AMR mission lifetime.

3.3 ENVIRONMENTS

3.3.1 General

The RSA shall be capable of meeting the requirements of this specification after having been subjected to the following ground, launch and on-orbit environmental conditions.

3.3.2 Launch Environments

The RSA shall be designed to withstand launch loads as defined in this Section without experiencing yielding or failure.

All secondary structures, black-boxes and non-structural components shall be designed to survive the entire frequency range of the vibro/acoustic/shock environments.

3.3.2.1 Mass Acceleration Curve (MAC) Loads

The RSA shall be capable of surviving the loads defined by the JPL developed Mass Acceleration Curve (MAC) shown in Figure 5. MAC loads are applicable to structures and components weighing or supporting more than 1 kg and with first resonance frequencies less than 80 Hz.

This particular data is based on the dynamic characteristics for the Delta II Launch Vehicle. The g levels shown on the MAC curve should be treated as design limit loads and applied at the c.g. of the component or assembly being analyzed acting in the worst direction.

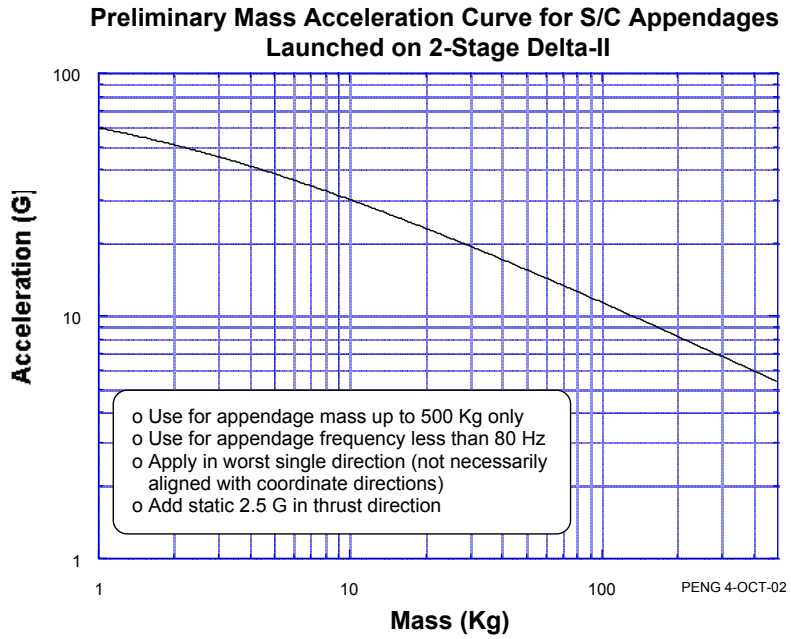


Figure 5 Mass Acceleration Curve

3.3.2.2 Ambient Pressure

The AMR-RSA shall be able to accommodate a decrease in ambient pressure during launch. The AMR-RSA design shall provide venting of all enclosed volumes to allow pressure equalization during launch ascent. Adequate venting is ensured when

$\frac{V}{A} < 5080$, where V=volume vented in cm^3 & A=vent area in cm^2.

If honeycomb core is used, it shall be perforated and vent paths shall provided from the core.

3.3.2.3 Acoustic Environment

The AMR-RSA shall withstand the maximum acoustic levels specified in Table 3.

Table 3. OSTM Protoflight Acoustic Environment

1/3 Octave Band Center Frequency	Protoflight Sound Pressure Level	Test Tolerances
(Hz)	(dB ref. 20 microPa)	
31.5	122.5	-2, +2
40	125.5	-2, +2
50	129.5	-2, +2
63	131.0	-1, +2
80	131.5	-1, +2
100	132.5	-1, +2
125	133.0	-1, +2
160	133.0	-1, +2
200	133.5	-1, +2
250	134.5	-1, +2
315	135.5	-1, +2
400	134.5	-1, +2
500	131.0	-1, +2
630	128.0	-1, +2
800	125.0	-1, +2
1000	123.0	-1, +2
1250	121.0	-1, +2
1600	120.0	-1, +2
2000	119.5	-1, +2
2500	119.0	-1, +2
3150	118.0	± 3
4000	116.5	± 3
5000	114.0	± 4
6300	110.0	± 4
8000	106.0	± 4
10000	103.0	± 4
Overall	143.8	-1, +3
Duration:	1 min.	

3.3.2.4 Sinusoidal Vibration

The AMR-RSA shall be capable of surviving and operating after exposure to the protoflight sinusoidal vibration environment stated in Table 4. sinusoidal vibration test input can be notched per the OSTM SRVP Section 5.3.2

Table 4. Sinusoidal Vibration Launch Environment

Axis (Spacecraft CS)	Frequency Range (Hz)	Protoflight Level
X	5-16.5 Hz	22 mm (D.A.)*
	16.5-140 Hz	12 g
Y	5 → 16.5	22 mm (D.A.)
	16.5 → 20	12 g
	20 → 140	5 g
Z	5 → 13.4	22 mm (D.A.)
	13.4 → 20	8 g
	20 → 140	6 g
All	Sweep rate	4 oct/min

*D.A. = Double Amplitude

3.3.2.5 Random Vibration

The AMR-RSA shall be capable of surviving and operating after exposure to the protoflight random vibration environment stated in Table 5. Random vibration test input can be notched per the OSTM SRVP Section 5.3.2.

Table 5. Random Vibration Launch Environment

Frequency Range (Hz)	Protoflight
20 - 150	+3 dB/octave
150 - 400	0.06 g2/Hz
400-2000	-5 dB/octave
Overall	6.6 g rms

3.3.2.6 Pyrotechnic Shock

The AMR-RSA shall be designed to withstand the spacecraft induced pyrotechnic shock environment as shown in Table 6. The shock shall be applied at the subsystem mounting points in each of three orthogonal axes. The synthesized shock waveform shall meet the following criteria: a) The time history shall be oscillatory in nature; b) The pulse shall decay to less than 10% of its peak value within 20 milliseconds.

Table 6 External Pyroshock Requirements

Frequency, Hz	PF SRS Level
100	10.0 g
100 - 2000	+10 dB/octave
2000 - 10,000	1500 g

Note: SRS (Q=10)

3.3.3 On-Orbit Environments

3.3.3.1 Interface distortions

The AMR Instrument shall meet the on-orbit pointing and stability requirements with the following PIM interface distortion listed in Table 7.

Table 7. PIM On-Orbit Interface Mechanical Distortions

Type	**Value**
In Plane ($YZ_{S/C}$)	0.0016 m/m

3.3.3.2 Charged Particle Radiation Environment

All OSTM assemblies shall be designed to operate within performance specification during and after the exposure to the naturally occurring space radiation environments with a radiation design factor (RDF) of 2.

3.3.3.3 Mission Fluence

The total mission fluences contributed from the Earth's trapped and the Solar Particle Events (SPE) charged particles are given in Table 9 for protons and Table 10 for electrons.

3.3.3.4 Total Ionization Dose (TID)

The total ionizing dose (TID) exposure of OSTM hardware will come from Earth trapped protons and electrons, solar protons, and galactic cosmic rays (0.02 Rad-Si /day, which is negligible for this mission). The relative magnitude of the TID contribution from each of these sources is both position and shielding dependent.

The total ionizing dose exposure for the duration of the mission, is shown in Table 11. A radiation design factor (RDF) of 2 times the TID level present at the location of the device shall be used.

Devices that require spot shielding shall be evaluated at a radiation design factor (RDF) of 3 times the TID level present at the location of the device.

3.3.3.5 Atomic Oxygen Environment

The OSTM atomic oxygen fluence will be less than 5E+19 cm^-2 yr^-1.

3.3.3.6 Maximum On-Orbit Accelerations

The AMR-RSA shall be designed to the on-orbit quasi-static accelerations shown in Table 8, applied separately in each axis, and ensure structural integrity.

Table 8. Maximum On-orbit Accelerations

Acceleration Direction (S/C coordinates)	Acceleration
a_x	0.004 g
a_y	0.004 g
a_z	0.004 g
α_x	0.3 mrad/s^2
α_y	0.3 mrad/s^2
α_z	0.3 mrad/s^2

Table 9. Integral Proton Fluences for OSTM

Proton Energy (MeV)	Solar Proton Fluence (/cm^2) 5 year		**Proton** Energy (MeV)	Solar Proton Fluence (/cm^2) 5 years
0.10	1.14E+13		1.00E-01	1.75E+11
0.50	1.70E+12		5.00E-01	1.24E+11
1.00	7.48E+11		1.00E+00	8.97E+10
2.00	4.55E+11		2.00E+00	5.62E+10
3.00	3.75E+11		3.00E+00	3.97E+10
4.00	3.30E+11		4.00E+00	3.02E+10
5.00	3.02E+11		5.00E+00	2.42E+10
6.00	2.82E+11		6.00E+00	2.02E+10
8.00	2.52E+11		8.00E+00	1.47E+10
10.00	2.32E+11		1.00E+01	1.14E+10
12.00	2.17E+11		1.20E+01	9.48E+09
15.00	1.98E+11		1.50E+01	7.65E+09
17.00	1.90E+11		1.70E+01	6.77E+09
20.00	1.78E+11		2.00E+01	5.72E+09
25.00	1.67E+11		2.50E+01	4.42E+09
30.00	1.56E+11		3.00E+01	3.57E+09
35.00	1.48E+11		3.50E+01	2.98E+09
40.00	1.41E+11		4.00E+01	2.57E+09
45.00	1.34E+11		4.50E+01	2.23E+09
50.00	1.28E+11		5.00E+01	1.97E+09
60.00	1.16E+11		6.00E+01	1.55E+09
70.00	1.05E+11		7.00E+01	1.24E+09
80.00	9.53E+10		8.00E+01	1.00E+09
90.00	8.62E+10		9.00E+01	8.22E+08
100.00	7.80E+10		1.00E+02	6.82E+08
125.00	6.05E+10		1.20E+02	4.78E+08
150.00	4.72E+10		1.40E+02	3.45E+08
175.00	3.67E+10		1.60E+02	2.53E+08
200.00	2.87E+10		1.80E+02	1.88E+08
300.00	1.10E+10		2.00E+02	1.41E+08

Table 10 Integral Electron Fluences for OSTM

Electron	AE8MAX
Energy	Fluence (/cm^2)
(MeV)	5 year
0.04	6.65E+14
0.10	4.58E+14
0.20	2.12E+14
0.30	9.20E+13
0.40	3.82E+13
0.50	1.73E+13
0.60	1.14E+13
0.70	7.77E+12
0.80	5.72E+12
1.00	3.53E+12
1.25	2.25E+12
1.50	1.44E+12
1.75	9.43E+11
2.00	6.20E+11
2.25	4.13E+11
2.50	2.78E+11
2.75	1.58E+11
3.00	9.25E+10
3.25	5.25E+10
3.50	3.13E+10
3.75	1.78E+10
4.00	1.03E+10
4.25	5.57E+09
4.50	3.05E+09
4.75	1.61E+09
5.00	8.67E+08
5.50	2.00E+08
6.00	3.72E+07

Table 11 Ionizing Dose for OSTM 3 Year Mission

(Spherical shell Aluminum shield)

OSTM Mission (66 degree / 1336Km), 5 year mission								
	(Spherical Shell)							
	Shielding Thickness		(rads, Si)	(rads, Si)	(rads, Si)	(rads, Si)	(rads, Si)	
g/sqcm	mm	mils	trapped proton	solar proton	electron	bremsstrahlung	Total	RDF=2
1.00E-02	3.70E-02	1.46E+00	5.48E+05	9.45E+04	2.07E+07	1.06E+03	2.13E+07	4.27E+07
1.59E-02	5.89E-02	2.32E+00	3.48E+05	6.50E+04	1.44E+07	1.35E+03	1.48E+07	2.95E+07
2.00E-02	7.41E-02	2.92E+00	2.92E+05	5.40E+04	1.17E+07	1.48E+03	1.20E+07	2.40E+07
2.51E-02	9.30E-02	3.66E+00	2.45E+05	4.42E+04	9.22E+06	1.56E+03	9.50E+06	1.90E+07
3.98E-02	1.47E-01	5.80E+00	1.72E+05	2.83E+04	5.08E+06	1.63E+03	5.28E+06	1.06E+07
5.01E-02	1.86E-01	7.31E+00	1.44E+05	2.22E+04	3.47E+06	1.60E+03	3.63E+06	7.27E+06
6.86E-02	2.54E-01	1.00E+01	1.19E+05	1.68E+04	1.83E+06	1.47E+03	1.97E+06	3.93E+06
1.00E-01	3.70E-01	1.46E+01	9.23E+04	1.11E+04	7.50E+05	1.23E+03	8.55E+05	1.72E+06
1.37E-01	5.07E-01	2.00E+01	7.57E+04	7.95E+03	3.57E+05	9.98E+02	4.42E+05	8.83E+05
2.06E-01	7.63E-01	3.00E+01	5.97E+04	5.10E+03	1.59E+05	7.40E+02	2.25E+05	4.50E+05
2.74E-01	1.02E+00	4.00E+01	5.02E+04	3.85E+03	9.30E+04	5.90E+02	1.48E+05	2.95E+05
3.43E-01	1.27E+00	5.00E+01	4.23E+04	3.08E+03	6.17E+04	4.95E+02	1.08E+05	2.15E+05
4.12E-01	1.53E+00	6.01E+01	3.90E+04	2.67E+03	4.33E+04	4.28E+02	8.55E+04	1.72E+05
4.80E-01	1.78E+00	7.00E+01	3.57E+04	2.30E+03	3.17E+04	3.80E+02	7.00E+04	1.40E+05
5.49E-01	2.03E+00	8.01E+01	3.18E+04	2.05E+03	2.32E+04	3.40E+02	5.73E+04	1.15E+05
6.17E-01	2.29E+00	9.00E+01	3.02E+04	1.82E+03	1.72E+04	3.10E+02	4.95E+04	9.90E+04
6.86E-01	2.54E+00	1.00E+02	2.87E+04	1.62E+03	1.29E+04	2.85E+02	4.35E+04	8.68E+04
8.23E-01	3.05E+00	1.20E+02	2.72E+04	1.34E+03	7.23E+03	2.45E+02	3.60E+04	7.20E+04
9.60E-01	3.56E+00	1.40E+02	2.55E+04	1.16E+03	4.13E+03	2.17E+02	3.10E+04	6.20E+04
1.00E+00	3.70E+00	1.46E+02	2.47E+04	1.07E+03	3.47E+03	2.08E+02	2.93E+04	5.88E+04
1.10E+00	4.07E+00	1.60E+02	2.33E+04	9.67E+02	2.27E+03	1.97E+02	2.68E+04	5.35E+04
1.23E+00	4.56E+00	1.79E+02	2.23E+04	8.68E+02	1.26E+03	1.82E+02	2.47E+04	4.93E+04
1.37E+00	5.07E+00	2.00E+02	2.15E+04	7.78E+02	6.57E+02	1.70E+02	2.32E+04	4.62E+04
1.51E+00	5.59E+00	2.20E+02	2.10E+04	6.98E+02	3.42E+02	1.60E+02	2.22E+04	4.43E+04
1.65E+00	6.11E+00	2.41E+02	2.02E+04	6.40E+02	1.75E+02	1.51E+02	2.12E+04	4.23E+04
1.78E+00	6.59E+00	2.60E+02	1.95E+04	5.90E+02	9.62E+01	1.43E+02	2.03E+04	4.07E+04
1.92E+00	7.11E+00	2.80E+02	1.90E+04	5.48E+02	4.93E+01	1.37E+02	1.97E+04	3.95E+04
2.06E+00	7.63E+00	3.00E+02	1.83E+04	5.03E+02	2.57E+01	1.28E+02	1.90E+04	3.80E+04
2.74E+00	1.02E+01	4.00E+02	1.66E+04	3.93E+02	7.57E-01	1.00E+02	1.72E+04	3.42E+04
3.43E+00	1.27E+01	5.00E+02	1.50E+04	3.15E+02	1.67E-03	8.30E+01	1.54E+04	3.08E+04
3.98E+00	1.47E+01	5.80E+02	1.44E+04	2.72E+02		7.53E+01	1.47E+04	2.95E+04
5.01E+00	1.86E+01	7.31E+02	1.27E+04	2.10E+02		6.57E+01	1.30E+04	2.60E+04
6.31E+00	2.34E+01	9.20E+02	1.13E+04	1.62E+02		5.72E+01	1.15E+04	2.30E+04
7.94E+00	2.94E+01	1.16E+03	9.90E+03	1.25E+02		4.18E+01	1.01E+04	2.02E+04
1.00E+01	3.70E+01	1.46E+03	8.33E+03	8.83E+01		3.13E+01	8.45E+03	1.68E+04

3.3.4 Temperature Environments

3.3.4.1 Thermally induced structural degradation

Degradation in materials or joint capability resulting from multiple thermal cycles from AMR RSA maximum protoflight temperatures to RSA minimum protoflight temperatures shall be considered in structural analysis.

3.3.4.2 Temperature Ranges

Thermal stresses, thermal distortion and material property degradation shall be considered in the analysis of structures. Thermal conditions, such as temperature change and thermal gradient extremes, which could affect structural alignment, shall be analyzed or tested.

Thermally induced structural loads shall be based on thermal analyses, where applicable. All potentially critical thermal conditions shall be checked including temperature and thermal gradient extremes. Thermal stresses with a F.S. of 1.0 shall be combined with all other simultaneously occurring stresses with appropriate F.S.

The RSA Temperature predictions will be determined by JPL utilizing Contractor and JPL thermal models as described in the AMR-RSA Statement of Work. The RSA temperature limit estimates are shown in Table 12 for information purposes. The Contractor shall establish temperature limits based on JPL predictions. The Allowable Flight Temperature (AFT) is the maximum (worst case) temperature range expected during the mission, and includes thermal design control uncertainty. The Protoflight Temperature is the worst case temperature range expected during testing. Protoflight test temperatures shall be at least 20 C greater than the AFT maximum and 15 C less than the AFT minimum. The AMR-RSA shall be designed to survive all temperature ranges and to maintain pointing / alignment within the AFT.

The basic OSTM orbital parameters are given in Table 13 for reference purposes. Detailed orbital parameters are found in Sections 1.5 and 1.6 of the Jason 2 Payload Design And Interface Specification

Table 12. Temperature Limits (Reference Only)

Protoflight		Allowable Flight	
Minimum	Maximum	Minimum	Maximum
-90C	+80C	-70C	+60C

Table 13 Spacecraft Orbital Parameters (Reference Only)

semi major axis:	7714.43 km
eccentricity:	0.000095
nodal period:	6745.75 s
drift of the orbital plane:	-2.077186 °/ day
inclination:	66.038°
argument of periapis:	90°
cycle duration:	9.91564 days
number of revs per cycle:	127 orbits

3.3.5 Ground Environments

3.3.5.1 Ground Handling Loads

For the AMR-RSA, handling loads and dynamic factors shall be separately determined for use in the analysis of all hardware. Ground handling equipment design loads shall be the static weight supported by the ground handling structure times the dynamic factor. The ground handling equipment dynamic factor in the vertical direction shall be equal to 5.0 unless there is reason to believe that a higher dynamic factor is required. The ground handling equipment dynamic factor in the lateral direction shall be equal to 0.5 unless there is reason to believe that a higher dynamic factor is required.

3.3.5.2 Ground Handling & Storage Environment

RSA flight hardware shall always be protected from exposure to natural or induced environments that could cause degradation. AMR flight hardware storage shall be maintained in areas that afford protection from theft, temperature extremes, fire, water, humidity, contamination, electrostatic discharge, and earthquake, that is:

a) AMR-RSA flight hardware shall be kept in areas with controlled access
b) The temperature shall be kept to within temperature limits in Section 3.3.4
c) Storage areas shall be located within a facility that is resistant to fire
d) Equipment shall be protected from sources of water, such as fire sprinklers and air conditioner condensation (Relative humidity shall be kept to within 20 to 60%).

AMR flight hardware shall be protected form seismic induced damage. Seismic protection considerations shall include:

a) Tethers or containment to prevent falling;
b) Ensuring that loose articles cannot fall on the flight hardware; and

c) Ensuring that tipping cabinets or fixtures cannot spill out or tip over on flight hardware.

3.3.5.3 Contamination Control

Contamination controls shall include:

a) Maintaining a Clean Work Area (an area maintained to a high degree of shop cleanliness) in all assembly and test facilities
b) Bagging instrument elements; storage in dust proof cabinets
c) Once coated per Section 3.2.1.5, the AMR-RSA shall be stored in a hermetically sealed container which shall be pressurized with dry GN2 to a pressure above the ambient pressure.
d) Storing the completed RSA in its transportation carrying case
e) The completed RSA shall not be exposed to the outdoors
f) Maintaining a log for the completed RSA recording all instances and durations that the RSA is outside of its dry nitrogen flushed, hermetically sealed container

3.3.5.4 Shipping Environment

Flight hardware being shipped from one facility to another shall be protected from damage that could be caused by: temperature extremes, shock and vibration, humidity, contamination, and ESD.

During shipment, the temperature of the flight hardware shall be kept to within temperature limits in Section 3.3.4. Flight hardware shall be protected from excess shock and vibration. The packaging shall be designed so that the hardware will be protected from shock and sinusoidal vibration. The shipping vibration environment for the unit, as packaged for shipping, shall not exceed the launch random vibration environment in Section 3.3.2.5.

Care shall be exercised so that the container is not over pressurized due to decreases in cabin pressure during air transport. Also, the selection of insulating materials and shock absorbing materials in containers shall ensure that contamination and electrostatic charging are controlled.

4 QUALITY ASSURANCE PROVISIONS

4.1 QUALITY CONFORMANCE

4.1.1 Verification Methods

The verification methods specified below establish how each requirement will be met. The verification matrix shown in paragraph 4.1.2.4 assigns the methods to each applicable paragraph of Section 3 of this specification.

4.1.1.1 Inspection

Inspection is an observation or examination of an article to confirm compliance with requirements.

4.1.1.2 Analysis

Analysis is used to support testing or may replace testing where testing is impractical, or may be used as direct proof of compliance.

4.1.1.3 Demonstration

Demonstration is an exhibition of the operability of an item under intended use conditions. Data derived from demonstrations is intended to be qualitative in nature but may be used to confirm compliance to less critical requirements.

4.1.1.4 Test

Tests subject the test article to controlled environments and controlled conditions to demonstrate specified qualities of the test article. Data derived from tests may be used to support analyses or as direct proof of compliance.

4.1.1.5 Similarity

Similarity is the comparison of the article under consideration to existing items of similar design with the intention of using any existing verification of compliance of the similar design with its requirements as proof of compliance of the article under consideration to its requirements. The primary purpose for using similarity is to reduce compliance verification costs.

4.1.2 Verification of Performance by Test

4.1.2.1 General

Physical inspections shall be conducted on the AMR-RSA prior to, during, and after major environmental exposures to the extent practicable, to thoroughly characterize the test article and determine if there are any deviations from baseline performance as a result of testing.

4.1.2.2 Qualification Tests

Qualification tests, if determined necessary by the contractor, shall be carried out on engineering qualification model hardware. Qualification test requirements shall be in accordance with approved qualification test plan. Qualification testing may be carried out using test coupons.

4.1.2.3 Protoflight Tests

The AMR-RSA shall be subjected to protoflight testing. Protoflight testing shall be carried out to verify compliance with each requirement of this specification, and shall verify the suitability of all parts and materials used.

4.1.2.4 Test Tolerances / Requirements

4.1.2.4.1 Thermal Tests

The thermal/vacuum and temperature/atmosphere test tolerances shall be as follows:

a) Pressure: +1 percent full scale from atmospheric to 1 bar. +2 percent full scale below 1 bar. At vacuum conditions, tolerances shall be such that a pressure of 1.33 x 10-6 kPa (1x10-5 Torr) or less is assured.
b) Time: +5%
c) Temperature: +3°C

Additionally, The rate of temperature change from one plateau to another shall be </= 5C/min and test article temperatures shall be monitored to assure that the temperatures are within the allowable range

4.1.2.4.2 Dynamics Test Tolerances

The dynamics test tolerances shall be as follows

a) Time: + 1%
b) Frequency: + 5% or + 1 Hz. Whichever if greater.
c) Acoustic Spectral Shape: As noted in Table 3.
d) Acoustic Overall Level: within + 10% (true RMS) of the specified level.
e) Random Vibration Spectral Shape: The Power Spectral Density (PSD) shall be within + 1.5 dB from 20 Hz to 300 Hz and + 3 dB from 300 Hz to 2000 Hz when measured in frequency bands no wider than 25 Hz.
f) Random Vibration Level: within + 10% (true RMS) of the specified level.
g) Sinusoidal Vibration Level: Measured sine amplitude shall be within + 10 % of the specified value.
h) Static Acceleration: + 5%, -0% of the specified value

4.1.3 Component Inspection

Prior to assembly, all piece parts and subassemblies shall be inspected and accepted in accordance with their respective specification and/or drawings.

4.1.4 Verification Matrix

The AMR-RSA shall be verified by Design, Analysis, Inspection and / or Test according to the verification matrix shown in Table 14. Specific test and inspection verification methods shall be defined and documented in test plans to be approved by JPL.

Table 14 Verification Matrix

Specification Paragraph #	Description	Verification Method			
		D	I	A	T
3.1.4.1	Easy of installation / no disassembly required	X			
	mounting bolts will be ISO-metric fine thread steel bolts	X			
	Interface per JPL 10229917		X		
	generate MICD	X			
3.1.4.1.2	Mounting fastener size / spacing	X			
	Interface insert load capability (Pull out/shear/tension)	X		X	X
3.1.4.2	adjustment features	X			
3.1.4.3	GSE interfaces to be proof tested				X
	Separate MGSE interface	X			
3.1.4.4	alignment features	X			
3.2.1.1	exist within envelope of 10229971		X	X	X
3.2.1.2.1	paraboloid definition	X			
3.2.1.2.2	surface accuracy		X	X	
3.2.1.2.3	pointing		X	X	X
3.2.1.3.1	Not to exceed mass		X		
3.2.1.3.2	mass properties to be identified		X		
3.2.1.4	materials per M&P plan	X			
3.2.1.5	reflector coated per spec	X			
3.2.1.6	accommodate cabling and bulkhead	X			
3.2.2.1	Contractor shall perform thermal analysis	X		X	
3.2.2.2	Thermal isolation from S/C			X	
3.2.2.3	Thermal isolation from ESS			X	
3.2.2.4	Thermal coatings	X			
3.2.2.5	No active thermal control	X			
3.2.3.1.1	Antenna stiffness > 55 Hz				X
3.2.3.1.2	Deflections must not cause contact or joint separation			X	X
3.2.3.1.3	No yielding or failure			X	X
	Withstand all loads with positive margin			X	X
3.2.3.2	Material propoerties per M&P plan	X			
3.2.3.3	Factors of safety as specified	X			
3.2.3.4	Stress analyses shall be performed			X	
	Structural analysis per SVP			X	
3.2.3.5	Sine survey parameters				X
	Proof testing required for composites				X
	Thermal cycle before structural test				X
3.2.3.6	All fastners shall use locking features	X			
	no physical separation or slippage shall occur at bolted joints			X	X
3.2.4	Minimum lifetime	X		X	
3.3.2.1	MAC shall be used for frequencies less than 80 Hz			X	X
3.3.2.2	Venting	X		X	
3.3.2.3	Accoustic levels				X
3.3.2.4	Sine vibration levels				X
3.3.2.5	Random vibe levels				X
3.3.2.6	pyro shock			X	
3.3.3.1	Accommodate PIM distortions			X	
3.3.3.2	Radiation Design Factor of 2			X	
3.3.3.3	Proton and Electron Fluence			X	
3.3.3.4	Total Ionizing Dose			X	
3.3.3.5	Atomic oxygen			X	
3.3.3.6	On-orbit accelerations			X	
3.3.4.1	Material allowable degradation due to thermal environments			X	X
3.3.4.2	Temp limits and thermal analysis			X	X
3.3.5.1	Ground handling loads			X	
3.3.5.2	Ground environment			X	
3.3.5.3	Contamination Control		X		
3.3.5.4	Shipping environments			X	
4.1.2.3	RSA shall be protoflight tested				X
4.1.2.4.1	Thermal test constraints				X
	thermal test tolerances				X
4.1.2.4.2	dynamic test tolerances				X

A. ACRONYMNS

CDR	Critical Design Review
CM	Configuration Management
CNES	Centre National d'Etudes Spatiales
CTM	Contract Technical Manager
CVCM	Collected Volatile Condensable Mass
DWG	Drawing
ERD	Environmental Requirements Document
FS	Factor of Safety
GSE	Ground Support Equipment
I&T	Integration and Test
ICD	Interface Control Document
JPL	Jet Propulsion Laboratory
L/V	Launch Vehicle
M & P	Materials & Processes
MAC	Mass Acceleration Curve
MAP	Mission Assurance Plan
MICD	Mechanical Interface Control Document
MLI	Multi-Layer Insulation
MMR	Monthly Management Review
MRB	Materials Review Board
MS	Margin of Safety
NASA	National Aeronautics and Space Administration
OSTM	Ocean Surface Topography Mission
P/FR	Problem / Failure Report
P/L	Payload
PDR	Preliminary Design Review
PIM	Payload Instrument Module
PMTS	Payload Mechanical Thermal Subsystem
QA	Quality Assurance
RCT	Radiometer Calibration Target
RF	Radio Frequency
RFA	Request For Action
RSA	Reflector Structure Assembly
RMS	Root Mean Squared
S/C	Spacecraft
SCC	Stress Corrosion Cracking
SFRD	System Function Requirements Document
SOW	Statement of Work
TBD	To Be Determined
TBR	To Be Resolved
TML	Total Mass Loss
WSOA	Wide Swath Ocean Altimeter