JSC-10633
REVISION A

REQUIREMENTS/DEFINITION

DOCUMENT

REMOTE MANIPULATOR SYSTEM

National Aeronautics and Space Administration

LYNDON B. JOHNSON SPACE CENTER

Houston, Texas

DECEMBER 15, 1975

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ILLUSTRATIONS

1. SCOPE

This document establishes the performance, design, development and verification acceptance and delivery requirements for the Remote Manipulator Subsystem, referred to herein as RMS, and its unique Ground Support Equipment (GSE). It also establishes the interface requirements of the RMS by reference to the appropriate ICD's.

2. APPLICABLE DOCUMENTS

The following documents form a part of this specification to the extent specified herein. In the event of conflict between the documents called out and the content of this specification, the order of precedence shall be as follows:

1. Space Shuttle Flight and Ground System specification
2. Interface control documents
3. This document
4. Other applicable specifications and standards of the most recent revision.

Documents identified with "(Reference)" next to document number are applicable for information only and are not imposed as requirements by this specification. These reference documents are called out herein as a source of background data for interpretation of requirements.

SPECIFICATIONS

Military

MIL-I-6870B 25 February 1965	Inspection Requirements - NDT Testing for Aircraft Materials and Parts
MIL-I-26860B(1) 26 October 1972	Indicator, Humidity, Plug, Color Change
MIL-S-7742B(1) 15 March 1973	Screw Threads, Standard, Optimum Selected Series: General Specification For
MIL-S-8879A(1) 15 March 1973	Screw Threads, Controlled Radius Root With Increased Minor Diameter; General Specification For

National Aeronautics and Space Administration/Johnson Space Center (NASA/JSC)

JSCM 8080 October 1972	Manned Spacecraft Criteria and Standards
JSC 08800A November 1974	JSC Supplement to NHB 5300.4(3A) Requirement for Soldered Electrical Connections
JSC 07700, Vol X 20 March 1973	Space Shuttle Flight and Ground System Specification
JSC 07700, Vol XIV	Space Shuttle System Payload Accommodations
JSC 07700, Vol XVIII	Computer Systems and Software
JSC 07700-10 MVP-01, Rev A 26 July 1974	Shuttle System Master Verification Plan, General Approach and Guidelines, Vol I
JSC 09709 (Reference) 9 June 1975	Concept design of the Payload Handling Manipulator System
SC-D-0001 (Reference) 16 February 1971	Metal Foil Decals, Manned Spacecraft and Related Flight Crew Equipment
SC-L-0002 (Reference) 25 July 1972	Lighting, Manned Spacecraft and Related Flight Crew Equipment, Functional Design Requirements for
SC-M-0003 (Reference) 18 November 1971	Markings, Labeling, and Color, Manned Spacecraft and Related Flight Crew Equipment, Functional Design Requirements for - Basic
SC-C-0005 (Reference) 30 June 1972	Controls, Manned Spacecraft and Related Flight Crew Equipment, Functional Design Requirements for - Basic
SC-D-0007 (Reference) 1 October 1974	Displays, Manned Spacecraft and Related Flight Crew Equipment, Functional Design Requirements for - Basic
SC-E-0006	Manned Spacecraft Extravehicular/Intravehicular Activity Support Equipment, Functional Design Requirements for
SN-C-0005 March 1974	Specification, Contamination Control Requirements for the Space Shuttle Program

SE-R-0006A 2 April 1973	NASA-JSC Requirements for Materials and Processes
SL-E-0002 4 June 1973	Specification, Electromagnetic Interference Characteristics, Requirements for Equipment for the Space Shuttle Program
SP-T-0023B September 1975	Specification - Environmental Acceptance Testing

Rockwell International/Space Division

MF0004-002B 28 June 1974 Amendment C-01	Electrical Design Requirements for Electrical Equipment Utilized on the Space Shuttle Vehicle
MF0004-019A 22 March 1975	General Nomenclature Standardization Requirements Orbiter
MF0004-014B (Reference) 4 August 1975 Amendment C-01	Environmental Requirements and Test Criteria for the Orbiter Vehicle
MF0004-100 18 October 1973 Amendment A-01 19 February 1974 Amendment A-02 April 1974 Amendment A-03 5 December 1974	Mechanical - Orbiter Project Parts List
MF0004-400 6 December 1973 Amendment A-01 1 July 1974	Electrical, Electronic, and Electromechanical - Orbiter Project Parts List
MF0004-032 10 June 1974	Vibration Testing for the Shuttle Program, Procedural Requirements for
MC621-0043C 16 April 1975	Space Shuttle Flight Control Subsystem

STANDARDS

Federal

FED-STD-101B(2) 8 October 1971	Preservation, Packaging, and Packing Materials, Test Procedure

Military

MIL-STD-129F 30 March 1973	Marking for Shipment and Storage
MIL-STD-143B 12 November 1969	Standards and Specifications, Order of Precedence for the Selection of
MIL-STD-280A 7 July 1969	Definitions of Item Levels, Item Exchangeability, Models, and Related Terms
MIL-STD-794D(1) 25 May 1973	Parts and Equipment, Procedures for Packaging and Packing of
MIL-STD-810B(4) 21 September 1970	Environmental Test Methods
MIL-STD-1247B 20 December 1968	Markings and Functions and Hazard Designations of Hose, Pipe, and Tube Lines for Aircraft, Missile, and Space Systems
MS33540C 9 February 1973	Safety Wiring and Cotter Pinning, General Practices for
MIL-STD-1472B 31 December 1974	Human Engineering Design Criteria for Military Systems, Equipment, and Facilities

Industry

AS1212 December 1971	Electric Power, Aircraft, Characteristics and Utilization of

Interface Control Documents

ICD-3-0014-01	Aft Station/RMS C&D
ICD-3-0018-01	Manipulator/Orbiter Physical Interface
ICD-3-0018-02	Manipulator/Orbiter Electrical Interface
ICD-3-0018-03	Manipulator D&C/Orbiter Interface
ICD-3-0018-04	Manipulator Controller Interface Unit/ Orbiter Interface
ICD-3-0018-05	Manipulator/Orbiter Lighting Requirements

ICD-3-0018-06	Manipulator/Orbiter Thermal Interface
ICD-3-0018-07	Manipulator/Orbiter/GSE Interface
ICD-3-0018-08	Manipulator/Orbiter Software Interface
ICD-3-0018-09	Standard End Effector/Orbiter Interface, Stowage
ICD-3-0050-01	Shuttle Orbiter Closed Circuit Television System
ICD-2-85001	RMS Standard End Effector/Payload
ICD-2-85002	RMS Manipulator Arm/End Effector

OTHER PUBLICATIONS

Handbooks

DOD H 4-1 Latest Issue	Federal Supply Code of Manufacturers Name to Code
NHB6000.1(1B) June 1973	Requirements for Packaging, Handling and Transportation for Aeronautical and Space Systems Equipment and Associated Components
NHB5300.4(1D-1) August 1974	Safety, Reliability, Maintainability and Quality Provision for the Space Shuttle Program
NHB5300.4(3A) May 1968	Requirements for Soldered Electrical Connections
MIL-HDBK-5B(4) 1 September 1971	Strength of Metal Aircraft Elements
MIL-HDBK-17A 1 January 1971	Plastics for Flight Vehicles
MIL-HDBK-23A 30 December 1968	Structural Sandwich Composites

United States Air Force

AD916682L January 1973	USAF Advanced Composite Design Guide
AFSC DH2-2	Crew Stations and Passenger Accommodations

3. REQUIREMENTS

3.1 Subsystem Definition. The RMS is a part of the overall Space Shuttle inflight payload handling system. It is primarily used to deploy payloads from the Orbiter payload bay for release into orbit and to retrieve payloads from orbit and stow them in the payload bay for servicing or return to earth.

The basic RMS consists of two arms (3.1.1.a) plus supporting equipment. The port arm will be available to be flown on all missions and the starboard arm will be installed on the Orbiter for selected missions. The end effectors (3.1.1.c) will be a separable part of the RMS and will be standard for all payloads identified herein. The RMS must be capable of meeting operational requirements with handling aids and payload retention mechanism installed on the Orbiter.

3.1.1 RMS Components. The RMS shall consist of the following major components.

a. Arm assemblies

b. TV cameras, TV lighting, and EVA handholds installed on the arm assembly

c. End effector

d. Displays and Controls [includes hand controller(s)]

e. Manipulator Controller Interface Unit

f. Control software

g. Associated GSE

h. Crew restraints

3.1.2 Interfacing Subsystems. Interfacing subsystems of the RMS which are part of the payload handling system but not necessarily part of nor fully described in this document are as follows:

a. Manipulator Position Mechanism (deploys the manipulator arm and the retention system from stowed position to allow payload access into payload bay)

b. Manipulator Retention System (holds arm in stowed position in Orbiter)

c. Payload Retention Mechanism (latches to hold payload in payload bay)

d. Orbiter Lighting System (on board lighting system)

e. Closed Circuit Television System (onboard CCTV system)

f. Handling Aids

g. Orbiter Data Processing System

h. End Effector Stowage Mechanism

3.1.3 Manipulator Arm Configuration. The manipulator arm assembly shall be a six degree-of-freedom system of joints and rigid structural links with an overall length of fifty feet from the first joint to the tip when completely straightened. The arrangement and nomenclature of the joints and structural links are shown in Figure 1 and Figure 4. The joint arrangement shall result in a gimbal order of shoulder yaw, shoulder pitch, elbow pitch, wrist pitch, wrist yaw and wrist roll. An end effector is attached to the wrist for purposes of applying desired loads and/or motions. The end effector has an additional degree-of-freedom for attaching to and releasing from payloads.

3.1.4 Item Diagram. Figure 2 is the schematic for the RMS.

3.1.5 Interface Definition.

3.1.5.1 Functional Interface. The functional interfaces between the RMS and other program elements are as shown schematically in Figure 2. The interfacing requirements between these elements are as specified in the Interface Control Document (ICD) in accordance with 3.1.5.1.1. The areas of responsibility for design, qualification and procurement of production interfacing hardware are as defined in Table I.

3.1.5.1.1 Interface Control Documents (ICD). The ICD's specified in this document control the interfacing requirements of the RMS. A subsystem block diagram defining working interfaces is included in ICD-3-0018-04.

3.1.5.2 Mechanical Interface. All mechanical ICD interfaces shall be nonfunctional (static) in the performance of the RMS mission except the end effector-grapple fixture interface and the arm-end effector interface.

The manipulator arm must meet the Orbiter interface provided in ICD-3-0018-01. The second RMS arm shall meet the same interface requirements on the starboard longeron.

3.1.6 Major Component Identification. The identification of the major components of the RMS shall be as follows:

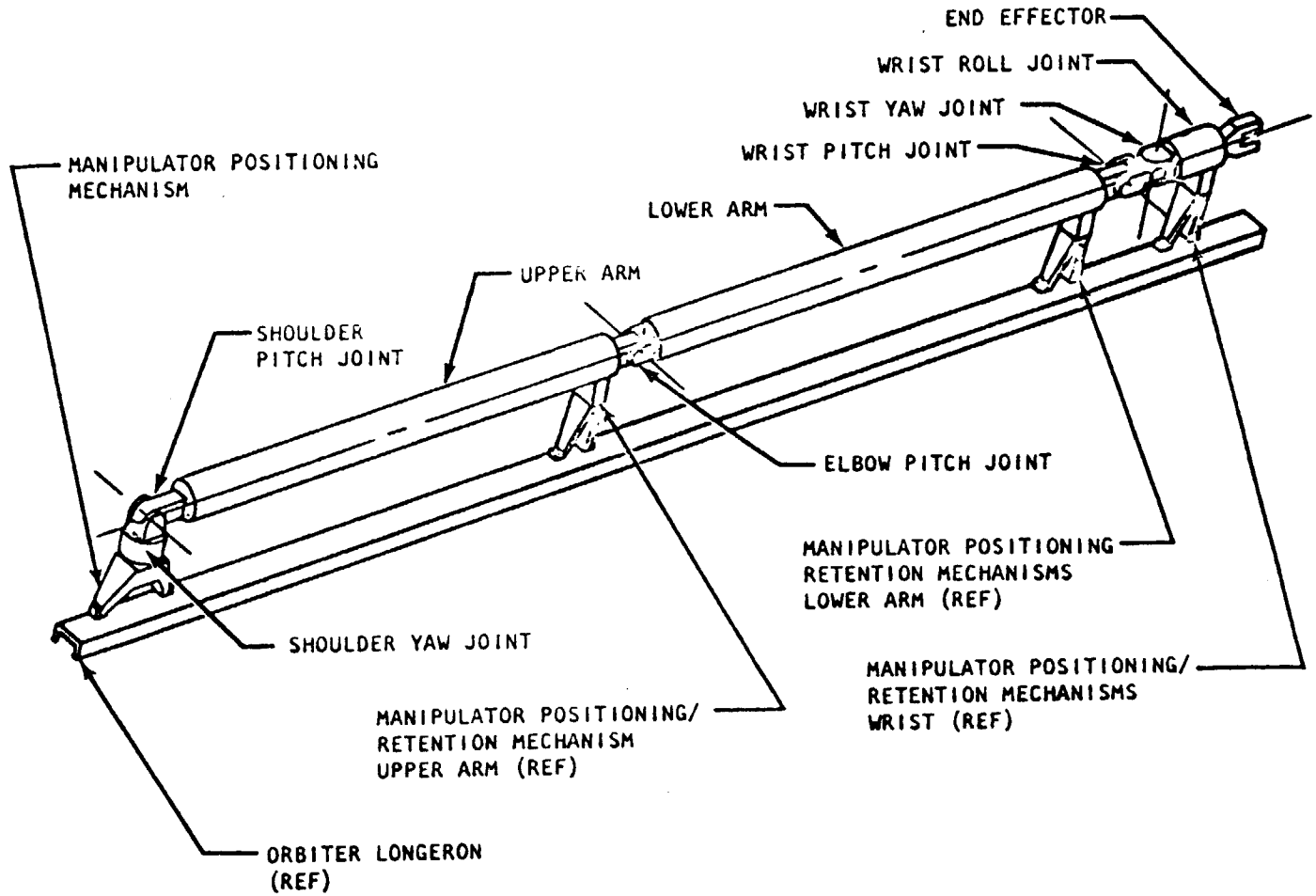


FIGURE 1. MANIPULATOR ARM ASSEMBLY NOMENCLATURE

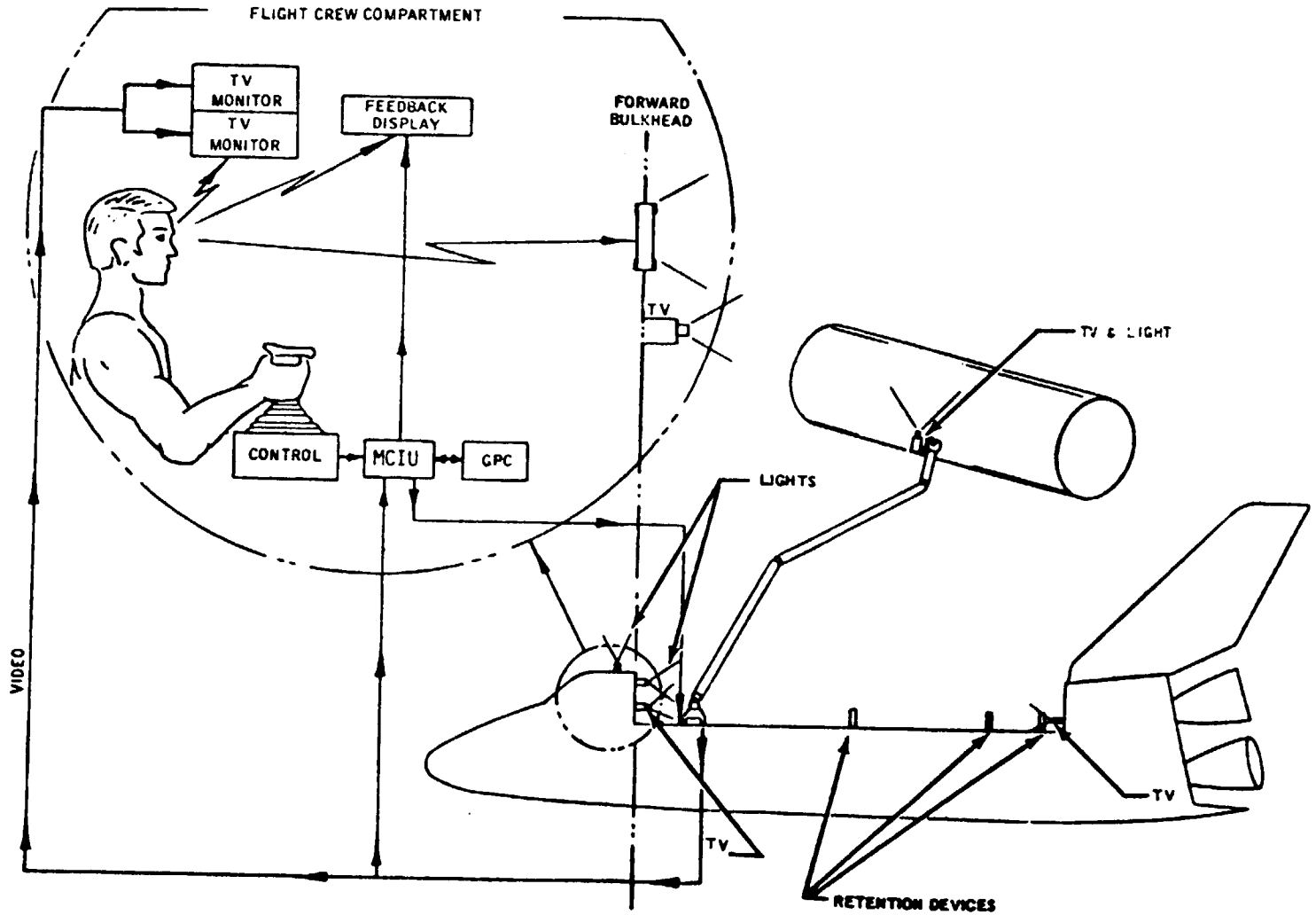


FIGURE 2. RMS SCHEMATIC

Table I. RMS and Interfacing Subsystems

Component	Responsible Organization			
	Design/Fabrication	Qualification	Procurement	Installation
RMS System				
Arm Assembly	NRCC	NRCC	NASA (1)	Orbiter Contractor
Displays and Controls	↓	↓	↓	↓
Hand Controllers	NRCC	NRCC	NASA	Orbiter Contractor
Manipulator Controller	NASA	NASA	NASA	NASA
Interface Unit	Orbiter Contractor	Orbiter Contractor	Orbiter Contractor	Orbiter Contractor
Standard End Effector				
RMS Associated GSE				
Control Software				
Crew Restraints				
CCTV and Lighting				
RMS				
Television Camera	NASA Contractor	NASA Contractor	NASA (1)	NRCC
Lighting	NASA Contractor	NASA Contractor	NASA (1)	NRCC
Displays & Controls	Orbiter Contractor	Orbiter Contractor	Orbiter Contractor	Orbiter Contractor
Pan/Tilt Mechanism	NASA Contractor	NASA Contractor	NASA (1)	NRCC
Orbiter				
Television	NASA Contractor	NASA Contractor	NASA	Orbiter Contractor
Lighting	Orbiter Contractor	Orbiter Contractor	Orbiter Contractor	Orbiter Contractor
Displays & Controls	Orbiter Contractor	Orbiter Contractor	Orbiter Contractor	Orbiter Contractor
Payload Retention				
Mechanical/Structural	Orbiter Contractor	Orbiter Contractor	Orbiter Contractor	Orbiter Contractor
Displays & Controls	Orbiter Contractor	Orbiter Contractor	Orbiter Contractor	Orbiter Contractor
Manipulator Positioning and Retention				
Mechanical/Structural	Orbiter Contractor	Orbiter Contractor	Orbiter Contractor	Orbiter Contractor
Jettison System	Orbiter Contractor	Orbiter Contractor	Orbiter Contractor	Orbiter Contractor
Displays & Controls	Orbiter Contractor	Orbiter Contractor	Orbiter Contractor	Orbiter Contractor

(1) Except for first flight article to be provided by NRCC.

Nomenclature	Mfg. Code Ident No.	National Stock No. (NSN)	Seller Part No.	Traceability Classification	Maintenance Level
TBS	(TBD)	TBD	(TBS)	TBD	(LRU/SRU)

3.1.7 Government Furnished Equipment. The following items will be supplied by the Government and shall be incorporated into the RMS.

Nomenclature	NSN	Traceability Classification
TBD	TBD	TBD

3.2 Performance and Design Characteristics.

3.2.1 Performance Requirements.

3.2.1.1 System Performance Requirements. The RMS shall be capable of performing the following operations in a zero-g environment.

a. Deploy or retrieve payloads exemplified by those shown in Figure 3 to/from a location clear of the Orbiter.

b. Deploy or retrieve single of multiple ($\leq$5) payload elements on orbit during a single mission.

c. Removing or deploying any payload (with handling aids as required) with a maximum dimensional envelope up to 15 feet diameter by 60 feet long, 65,000 pound from/to the payload bay without exceeding a clearance envelope of plus or minus 3.0 inches longitudinally and laterally. The force required to engage/disengage the payload retention latches and other restraints will not exceed fifteen (15) pounds.

d. Serve as a translational aid to assist in removal of a crewman in a pressure garment, or personnel rescue enclosure from the area of the side access door or the airlock door of a disabled orbiter vehicle and assist in the transfer of the crewman or personnel rescue enclosure to the area of the airlock of the rescue orbiter vehicle.

e. Remote interchange of end effectors.

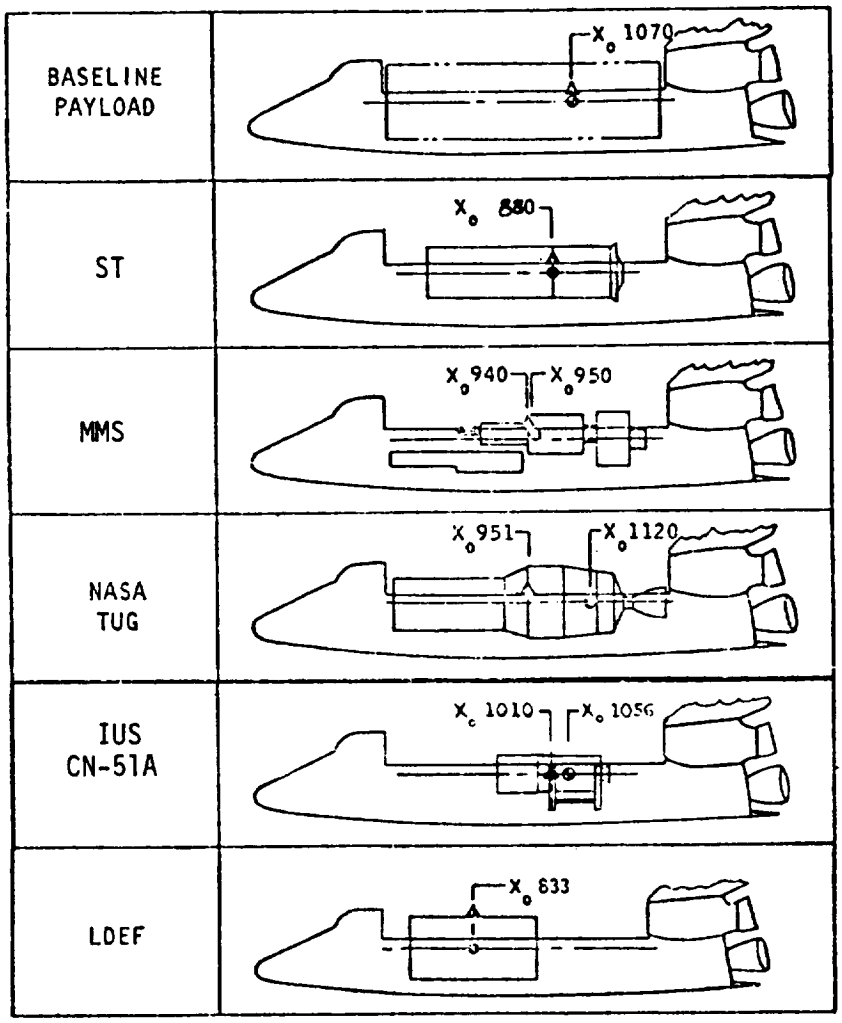
f. Without payload attached the maximum speed of the end effector shall not exceed 2.0 ft/sec. The maximum angular rates for the individual joints unloaded shall be 10 times the maximum angular rates required for handling of the 32,000 lb payload (Design Case).

g. Perform other tasks (such as payload specific servicing) that are incidental to the performance of the above functions.

h. With a 32,000 lb payload (Design Case) attached (with a maximum dimensional envelope of 15 ft in diameter by 60 ft long), the maximum driven speed of the end effector shall not exceed .2 ft/sec. At this speed the RMS shall be capable of stopping the payload within two feet. The end effector payload interface is the reference point for this requirement. For an interface located at the mid-length of the payload the individual joint parameters and stop distance are shown in Table II.

3.2.1.1.1 Time Critical Payload Handling Requirements.

3.2.1.1.1.1 Payload Deployment and Stowage. The RMS shall be capable of deploying a 32,000 pound, 15 foot diameter by 60 foot long payload envelope in 7.0 minutes from release of payload tiedown to releaseof the payload



⊕ CENTER OF GRAVITY

△ GRAPPLE POINT

Figure 3. Typical Payload Configurations

Table II. Manipulator Joint Performance Parameters

	32,000 lb Payload (Design Case)					
	SHOULDER YAW	SHOULDER PITCH	ELBOW PITCH	WRIST PITCH	WRIST YAW	WRIST ROLL
JOINT RATE, RAD/SEC (DEG/SEC)	.004 (.229)	.004 (.229)	.0057 (.327)	.0083 (.476)	.0096 (.550)	.011 (.630)
TIP SPEED FT/SEC	.20	.20	.159	.049	.042	.63 DEG/SEC
STOP DISTANCE OF TIP FT	2.0	2.0	1.528	.464	354	5.47 DEG
STOP DISTANCE OF PAYLOAD EXTREMITY, FT	2.864	2.864	2.864	2.864	2.864	2.864
ACCELERATION TIME TO FULL SPEED, SEC	19.64	19.64	18.70	18.61	18.63	15.71

to a stabilized condition external to the orbiter payload bay. The RMS shall be capable of retrieving a stabilized payload weighing up to 25,000 pounds with a payload envelope 15 foot diameter by 60 foot long, from the retrieval zone defined by TBD and stowing the payload in the payload bay in 7.0 minutes from initial grapple to payload tiedown.

3.2.1.1.2 Payload Contact Velocity. The closing rate of the payload at contact with the payload retention mechanism or handling aid(s) shall not exceed 0.10 FPS (rate limiter control switch).

3.2.1.1.3 Payload/Target Vehicle Retrieval. During payload retrieval the orbiter and the payload shall be stabilized with respect to one and the same coordinate reference (either inertial or local vertical). The RMS shall be capable of retrieval of an orbiting passive or cooperative payload/target vehicle under either of the following conditions:

(a) Maximum limit cycle amplitude = ±1 deg about all axes
Maximum limit cycle rates = ±0.1 deg/sec about all axes
Allowable attach point motion = ±3 in (±762 mm)

(b) Maximum attach point amplitude = ±15 in (381 mm)
Maximum attach point velocity = ±.05 in/s (1.27 mm/s)

3.2.1.1.4 Payload Release. Errors resulting from the release of a payload from the manipulator shall be equal to or less than the following maximum figures referenced to an orthogonal axis system originating at the manipulator shoulder joint and parallel to the orbiter vehicle axis system.

Attitude error	15° (assuming orbiter in drift mode (0.01°/sec) during damping period) ±1° (active orbiter stabilization)
Linear tip-off motion	0.2 ft/sec
Angular tip-off motion	

(a) LDEF: 0.03°/sec maximum with a TBD minute maximum damping period

(b) Time Critical Payloads: 0.75°/sec maximum within the time constraints of paragraph 3.2.1.1.1.

(c) All Other Payloads: 0.10°/sec maximum within TBD time

3.2.1.1.5 Orbiter/Payload Attitudes.

3.2.1.1.5.1 RCS Active. The RMS shall meet performance requirements specified in this document with the following orbiter dynamic inputs:

a. Relative station-keeping position and velocity between orbiter and payload in preparation for payload operations shall be maintained as follows:

(1) Range: TBD
(2) Relative velocity: 0 plus or minus 0.1 FPS
(3) Translation drift: Plus or minus 5 ft
(4) Attitude rate: plus or minus 0.01 deg/sec
(5) Attitude hold: plus or minus 0.1 degree

b. During payload handling operations with a payload attached to the manipulator arm, the orbiter limit cycle shall be no greater than:

Roll - TBD	Roll rate - TBD
Pitch - TBD	Pitch rate - TBD
Yaw - TBD	Yaw rate - TBD

c. Peak orbiter accelerations shall be no greater than those given in Table III. It should be noted that if a special jet selection logic is required for attached payloads, a revision to Table III would be required.

3.2.1.1.5.2 RCS Inactive. (TBD)

3.2.1.2 Component Performance Requirements.

3.2.1.2.1 Manipulator Arm Assembly.

3.2.1.2.1.1 Pivot Joint Actuator Angular Travel. Joint angular travels shall be in accordance with Figure 4 which also shows the 15° inclination of the shoulder yaw and pitch axes with the orbiter axes due to deployment from the stowed to the operational position. The angular values specified are minimum unless otherwise stated and are established in accordance with the following:

3.2.1.2.1.1.1 Shoulder Yaw. Angular travel for the shoulder yaw joint shall be 360 degrees to provide the maximum usable angle and to allow the manipulator to be relocatable to the plus "Y" longeron without a special purpose shoulder assembly.

3.2.1.2.1.1.2 Shoulder Pitch. Shoulder pitch angular travel shall be zero to minus 145 degrees maximum.

3.2.1.2.1.1.3 Elbow Pitch. Pitch angular travel for the elbow shall be zero to plus 160 degrees.

3.2.1.2.1.1.4 Wrist Pitch and Yaw. Wrist pitch and yaw angular travel shall be plus or minus 120 degrees.

Table III. Orbiter RCS Maximum Acceleration Levels

DIRECTION	TRANSLATION ACCELERATION FT/SEC^2 (m/sec^2)					ROTATIONAL ACCELERATION DEG/SEC^2			
RCS System	+X	-X	$\pm$Y	+Z	-Z	$\pm\ddot{\phi}$	$+\ddot{\theta}$	$-\ddot{\theta}$	$\pm\ \ddot{\psi}$
Primary Thrusters	0.658 (0.201)	0.504 (0.153)	0.826 (0.252)	1.486 (0.453)	1.205 (0.367)	1.251	1.351	1.517	0.776
Vernier Thrusters	0 0	0 0	0.0083 (0.0025)	0 0	0.0095 (0.0029)	0.040	0.025	0.017	0.020

Based on mass properties from Shuttle Operational Data Book, Volume II, Revision A, for Orbiter alone.

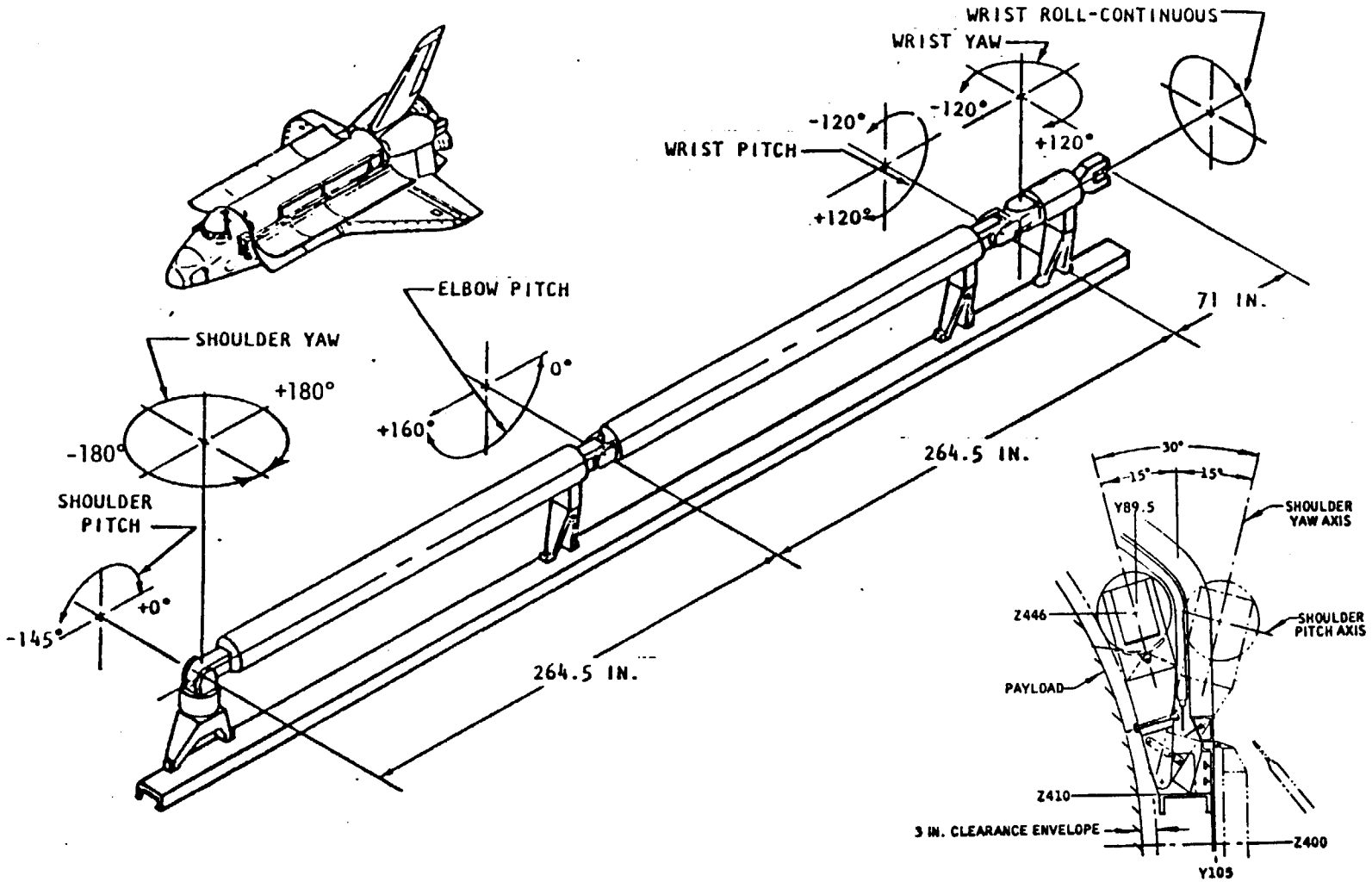


FIGURE 4. MANIPULATOR ARM LENGTH, JOINT ANGULAR TRAVEL AND AXIS ORIENTATION

3.2.1.2.1.1.5 Wrist Roll. A continuous angular travel shall be provided for wrist roll.

3.2.1.2.1.1.6 Joint Brakes. A brake or other suitable device shall be provided at each joint to secure the joint when desired.

3.2.1.2.1.2 End Effectors. The end effector of the manipulator system shall interface with the payload grapple fixture described in ICD-2-85001 and provide a rigid link between the two. It shall accommodate an initial relative angular misalignment of plus or minus 15 degrees in roll, pitch, and/or yaw and plus or minus 4 inches in Y, and/or Z axis as defined in Figure 5. The end effector shall be capable of in-flight changeout from a baseline grappling end effector to a special purpose end effector provided by a payload requiring unique manipulator functions. The changeout shall be remotely accomplished by the RMS operator. The end effector mechanical and electrical interfaces will be controlled by ICD-2-85002. After rigidizing the end effector/grapple fixture interface, the angle between the end effector reference axes and the payload reference axes shall be known or assured within $\pm 0.15°$ in pitch, roll, or yaw and within ± 0.1 inches in X, Y and Z. During maximum acceleration of a 32,000 pound homogeneous payload by the RMS the deflection of the end effector/grapple fixture interface shall not exceed ± 0.15 degrees in pitch, roll, or yaw and ± 0.10 inches in X, Y or Z.

3.2.1.2.1.2.1 Initial Contact. At initial contact of the end effector to the grapple fixture the actuation of the end effector may be initiated manually or automatically with provisions for manual override. Should the initial relative position of the end effector and grapple fixture not be within the limits described in 3.2.1.2.1.2 or if for other reasons the end effector should fail to acquire the grapple fixture the failure shall not result in any alternate mating (hang-up).

3.2.1.2.1.2.2 Grapple Force. The end effector grapple force shall be TBD pounds and the grappling torque TBD ft lbs.

3.2.1.2.1.2.3 Standard End Effector Stowage. The standard end effector stowage requirements in the orbiter shall be in accordance with ICD-3-0018-09 or the standard end effector may be stowed on the payload pallet. In both cases the stowage device shall be rigidly attached to the structure and positioned such that the changeout interface is within the direct line of sight of the RMS operator.

3.2.1.2.1.2.4 End Effector Preload. The end effector will be designed to relieve any preload energy prior to release of the grapple fixture. This is to preclude any inadvertent movement of the end effector into the payload or orbiter after end effector release.

3.2.1.2.2 RMS Control System. The RMS control system shall be capable of smoothly operating the manipulator arm with a payload attached weighing up to 65,000 pounds and with a maximum dimensional envelope of 15 feet

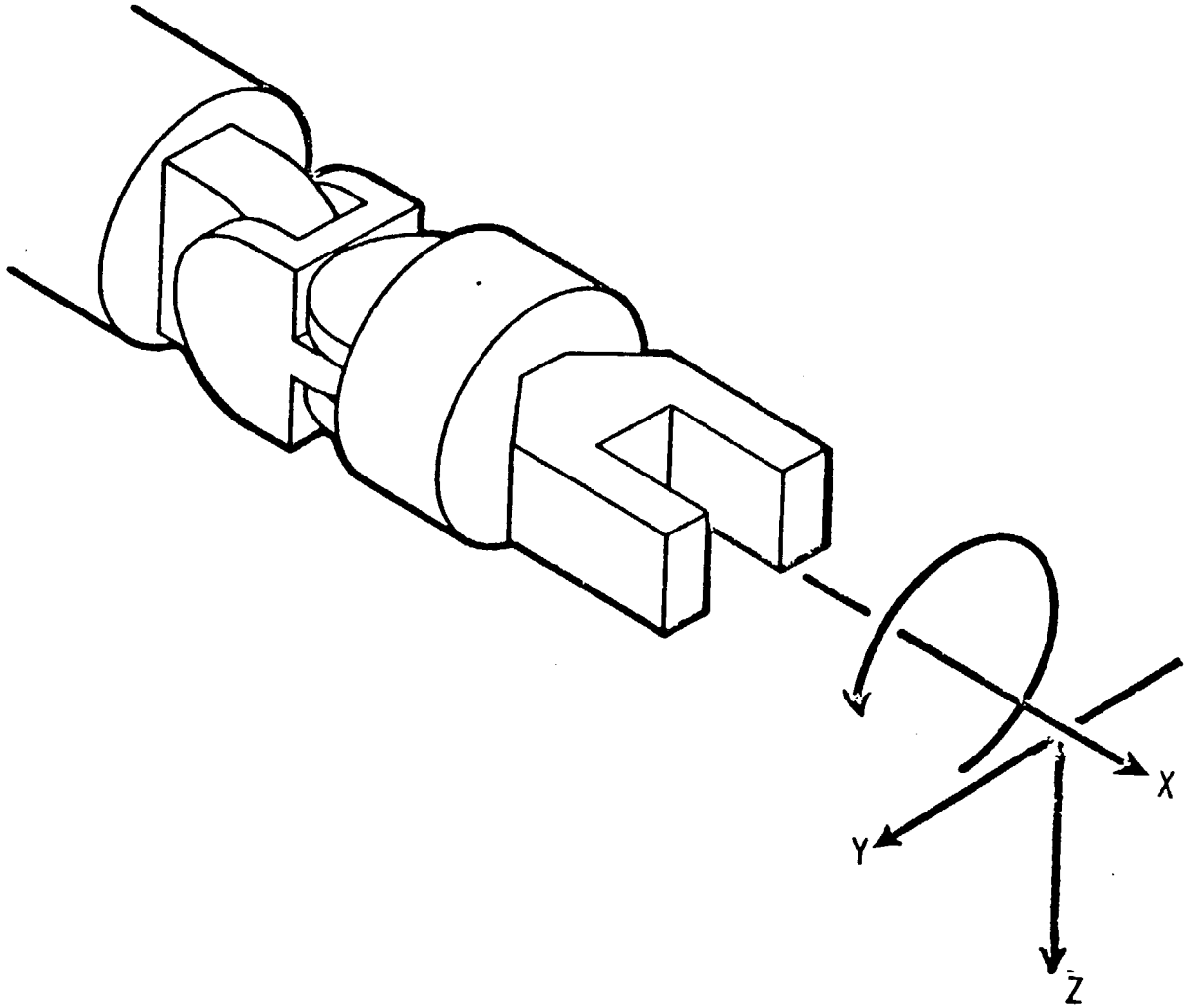


FIGURE 5. END EFFECTOR AXES

diameter by 60 feet long. The control system shall also be capable of controlling two manipulator arms. When two manipulator arms are installed the arms shall be operated in series only (not to exceed 15 seconds time delay between operation of one arm and the other). Different configurations of end effectors will be accommodated within the software.

3.2.1.2.2.1 Operating Mode. The RMS control system shall be capable of controlling the manipulator arm in the following three basic modes:

a. Automatic Mode
b. Manual Augmented Mode
c. Manual Direct Drive Mode

3.2.1.2.2.1.1 Automatic Mode. The manipulator shall be capable of being controlled automatically. Different end effectors and their lengths will be accommodated with software. Two possible types of movements in this mode are as follows:

a. A predetermined trajectory or path to get the end effector or payload from a prespecified initial position and orientation to the prespecified final position and orientation would be stored in the GPC. The operator would "call up" the trajectory which would be automatically input to the RMS control system.

b. The second type of movement possible would be similar to that above except the desired position and orientation are not known prior to launch. In this instance the operator would input the required position and orientation of the end effector or payload and a trajectory will be generated referenced to the orbiter coordinate system.

3.2.1.2.2.1.1.1 Tasks. The RMS shall be capable of performing the following tasks in automatic mode, meeting timeline requirements of paragraph 3.2.1.1.1.

a. Maneuver unloaded arm to any specified position within the operating range.

b. Maneuver arm to position poised for stowing.

c. Maneuver a payload to any specified position after manual payload grappling with capability for specifying the trajectory (provided the starting point is prespecified).

d. Maneuver a payload to the vicinity of handling aid(s).

3.2.1.2.2.1.1.2 Collision Avoidance. The RMS shall be designed with sufficient instrumentation, control and programming to provide collision avoidance of the orbiter and orbiter attached payloads and structures with or without the payload attached to the arm. The allowable operating envelope, bounded by orbiter structure, is defined on ICD-3-0018-01.

3.2.1.2.2.1.1.3 Singularity Avoidance. The RMS shall be designed with sufficient instrumentation, control, and programming to take care of all singularities.

3.2.1.2.2.1.2 Manual Augmented Control. Manual augmented control of the RMS shall be through multiple degree-of-freedom hand controllers using the resolved rate method (ref 6.1.32). Two three degree-of-freedom controllers shall be used unless it can be demonstrated that one-six degree-of-freedom controller can accomplish the task without impacting operator proficiency training time requirements.

3.2.1.2.2.1.2.1 Tasks. The RMS shall be capable of performing the following tasks in the manual augmented mode of operation:

a. Maneuver the unloaded arm using resolved rate
b. Grapple a payload
c. Maneuver the loaded arm using resolved rate
d. Maneuver of the payload into the payload bay retention fitting
e. Place arm in stowage position
f. Remotely exchange end effectors

3.2.1.2.2.1.2.2 Collision Avoidance. Collision avoidance capability as specified in 3.2.1.2.2.1.1.2 shall also be required for the Manual Augmented Control operating mode.

3.2.1.2.2.1.3 Manual Direct Drive. The manual direct drive mode shall allow movement of the Remote Manipulator Arm on a joint-by-joint basis using hard wired switches located on the control panel to command the joints. The computer would be bypassed completely. This mode will be used primarily in the event of a computer failure wherein the arm has been automatically slowed to a stop after the computer failure. The manual direct drive will then be selected for use. High accuracy joint position displays are required for effective use of this mode. The RMS will be capable of performing the following typical tasks in this mode.

a. Position the RMS arm to any safe operational position within the single joint accuracy of TBS.

b. Release of a payload.

3.2.1.2.3 RMS Displays and Control Subsystem (D&C). The D&C shall enable the RMS operator to control, monitor, relevant aspects of RMS operation and performance

The subsystem consists of a dedicated RMS display and control panel; manual controllers; time shared and orbiter supplied CRT displays, keyboards, and associated electronics; encoding, decoding, and conversion electronics associated with instruments and manual controllers; integral panel lighting; and the RMS caution and warning (C&W) subsystem.

The display and control of a function shall be required for RMS operation if the information or control action input provided by such function is essential and in sufficient depth to allow an RMS operator decision or action needed to successfully complete RMS/payload operations under normal conditions, or to return the RMS to a safe configuration under emergency conditions. The display and control functions provided by the D&C equipment shall give the RMS operator sufficient depth of information and command access to the spacecraft systems to enable the crewman to successfully accomplish the following minimum operations in controlling either one or the other manipulator arm during the mission.

a. Effect RMS operation as required under normal mission conditions or contingency operations.

b. Safe shutdown of the RMS with a single control input.

c. Monitor of the RMS as required for normal mission or contingency operations.

d. Recognize malfunctions or incipient hazards to crew, vehicle or mission in operating the RMS, and effect adjustment or selection of alternate subsystem elements as provided; or effect mission changes if normal subsystem operation cannot be restored by any of the above actions and effect monitoring of RMS subsystem condition for normal or contingency operations.

3.2.1.2.3.1 Subsystem Requirements. It is required that the D&C equipment present information to, and accommodate control action inputs from, the RMS operator for the following purposes:

a. Initiation, monitor and control of RMS maneuvers and maneuver sequences.

b. Operation of RMS subsystems and management of subsystem conditions.

c. Alarm for hazardous conditions and RMS subsystem malfunctions affecting the mission operations.

Critical information regarding subsystem operation, performance, or malfunction shall be displayed at the RMS station. Indicators at the RMS station may be time-shared between like parameters, provided that the crew's ability to assess subsystem condition is not thereby degraded. Orbiter supplied computer-driven multifunction CRT displays, installed at the Mission Station (primary) and forward stations (secondary) shall be used to backup, via alphanumeric text or graphic display, RMS station indicators for subsystem display and to present combined critical and noncritical data.

3.2.1.2.3.1.1 Display and Control Design Requirements. Display and control panel and equipment design, and crew interface characteristics of instruments

and controls, shall conform to MF0004-19A and the following specifications listed as design and standardization guides: SC-D-0001, SC-L-0002, SC-M-0003, SC-C-0005, SC-D-0007, MIL-STD-1472, AFSC DH2-2, and MIL-STD-143.

a. Subsystem Equipment Location. The specific space allotted for RMS D&C shall be in accordance with ICD-3-0018-03.

b. Subsystem Components. The displays and controls equipment shall consist of GFE (TBD) and CFE sub-assemblies and other items together with provisions for installation and operation of these items. The displays and controls equipment shall provide displays and controls for RMS operation, RMS subsystem management and general crew usage.

c. Modular Installation. RMS D&C panel will be capable of easy removal and replacement for missions not requiring the RMS.

d. Thermal Constraints. The touch temperature of the front panel surface and all exposed control or indicator surfaces shall not exceed 113°F at an ambient temperature of 70°F. Orbiter provides no active or convection cooling to this panel.

3.2.1.2.3.1.1.1 Arm Control. D&C shall be provided to select and indicate any one of the following control modes:

a. Automatic Control
b. Manual Augmented Control
c. Manual Direct Drive

The controls associated with each control mode shall be enabled only when that particular mode has been selected.

The automatic and manual augmented control modes shall be capable of operating in any one of the four typical coordinate systems as determined by crew selection: end effector referenced, orbiter referenced, payload referenced, and payload/orbiter referenced as shown in Figure 6.

a. Automatic Control. D&C shall be provided to individually select, start, and stop manipulator routines. Indication of the routine selected, that the program is running, and that the routine has stopped shall be provided.

b. Manual (Augmented) Control. Manual control of the manipulator arm has been baselined as a two-handed operation that shall direct the terminal end of the arm without conscious effort to control the individual joints. Different end effectors and their lengths will be accommodated with software. The input devices shall be two 3-degree of freedom (DOF) displacement type hand controllers, which shall be capable of commanding resolved rates (ref. 6.1.32) for the six DOF of the arm. A rotational controller shall allow

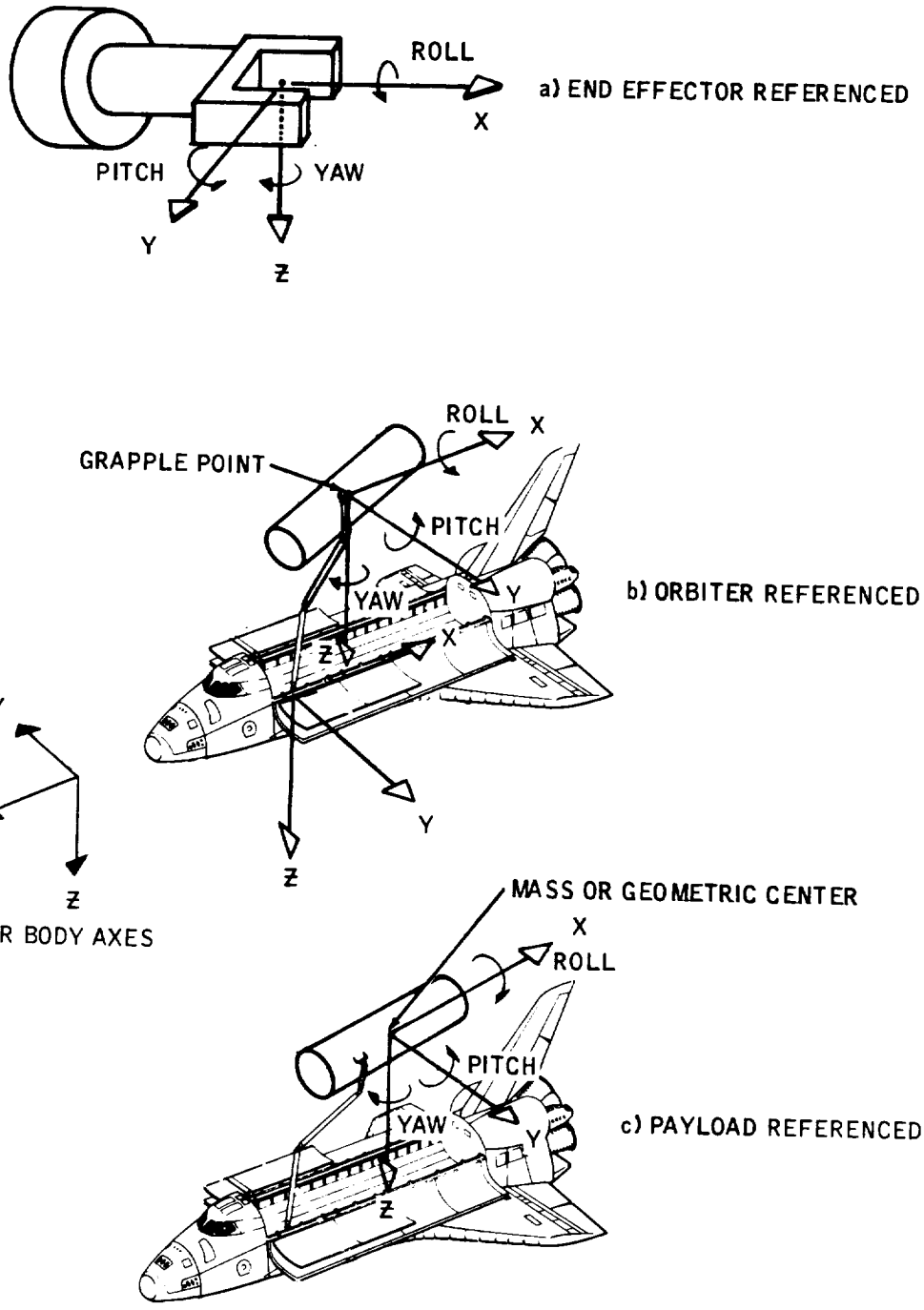


FIGURE 6. - TYPICAL CONTROL COORDINATE REFERENCE SYSTEMS

resolved roll, pitch, and yaw control. A translation controller shall provide resolved up/down, left/right, in/out translation.

The RMS controllers shall provide outputs proportional to grip deflection. The rotational controller shall be designed and mounted for right hand operations and the translation controller for left hand operation. The placement of the controllers shall allow viewing out the window and of the CCTV monitors, and shall correspond to the relative pilot axes so that the required input motions are obvious and not subject to the operator ability to perform coordinate transformations. It shall be possible to make inputs into each axis separately or into multiple axes simultaneously. However, each controller axis shall be independent so that the input motions, force feel, and electrical outputs are distinct and have minimal effect on another axis. A single 6-degree of freedom controller may be used if it can adequately accomplish this task.

c. Manual Direct Drive Control. Control shall be provided for each joint motion to allow for the operation of the arm in a direct drive control mode, which shall be independent of any computer functions.

3.2.1.2.3.1.1.2 Two Each, 3-Degree Hand Controllers. If this configuration of hand controllers is utilized, the requirements listed below shall apply using one rotational hand control and one translational hand control.

3.2.1.2.3.1.1.2.1 Rotational Hand Control (RHC). The RHC shall provide the crew capability for introducing rotational commands into the RMS. The commands will be utilized by the GPC computer allowing the manipulator end effector to move about the manipulator wrist.

a. Functional Requirements. Each RHC shall provide the following functions:

(1) Three axis manipulator arm rotation commands via manual grip displacement with simultaneous but isolated capability.

(2) Communication control via manually operated switches.

b. Configuration. The RHC shall be a crew-operated manual control configured for right-hand operation. RMS pitch commands are introduced via appropriate control rotation about the grip palm pivot point; roll and yaw commands are introduced via appropriate control rotations about a pivot in the control base.

c. The design of the RMS RHC shall conform to the requirements as contained in ICD-3-0018-03.

3.2.1.2.3.1.1.2.2 Translation Hand Control (THC). The THC shall provide the capability for introducing translational commands into the RMS. The commands will be utilized by the GPC allowing the arm to move about the orbiter.

a. Functional Requirements. Each THC shall provide three-axis end effector translational commands via manual grip displacement with simultaneous, but isolated, capability.

(1) Configuration. The THC shall be a crew-operated manual control configured for left or right hand operation. Manual translation commands are introduced into the system by displacement of the grip in the direction of the desired RMS movement.

b. The design of the RMS THC shall conform to the requirements as contained in ICD-3-0018-03.

3.2.1.2.3.1.1.3 Computer Data Entry and Display. RMS manual controls and dedicated displays that provide commands to and display data from the orbiter provided RMS computer(s) shall interface with the computer(s) as automatically selected. In addition, multipurpose keyboards and CRT graphic/alphanumeric indicators shall be provided by the orbiter per 3.2.1.2.3.1 for entry and display of RMS computer-related data.

a. Data selection and format callup for the CRT's will be by means of the keyboards.

b. Keyboards will be configured for display selection and manual data entry. A keyboard will be composed of numeric keys, decimal point, signs, (+ or -) and special function keys. Keys will be integrally lighted. Data entered via a keyboard will be displayed for verification prior to acceptance.

c. All data CRT's will be of identical configuration and all keyboards will be of identical configuration.

d. CRT's shall be configurable and shall have the format capabilities to present data solutions and supervisory messages related to:

1. RMS Guidance and Control (G&C) programs
2. RMS performance monitoring function (PMF) routines
3. Payload handling/monitoring programs
4. Other RMS dedicated/related data available in orbiter computer mass storage

e. Operationally, it will be possible to command transfer of a format from any orbiter CRT to any other orbiter CRT.

f. It will be possible to operate all CRT's simultaneously with a different format on each one and to call up any format on any CRT.

g. Data entered from any keyboard will be available to all orbiter computers designated for RMS support

h. The computer data entry and display configuration shall permit concurrent use of all keyboards.

3.2.1.2.4 Manipulator Controller Interface Unit (MCIU). All control electronics, signal processing, and switching, not installed on the manipulator arm, shall be contained in the Manipulator Controller Interface Unit. This unit shall be capable of transmitting signals to, and accepting commands from either the RMS Displays and Controls Panel or the Orbiter computer. This controls the manipulator arm and monitors its positions. This unit shall also be capable of controlling a second manipulator arm, in series.

3.2.1.2.4.1 Electrical Power Characteristics (at Load Interface). Electrical power supplied at the load interface will meet the following requirements:

3.2.1.2.4.1.1 Main DC Power. 28 vdc nominal, two wire, structure grounded system.

3.2.1.2.4.1.1.1 Steady-State Limits. 24 to 32v: continuous duty equipment
23 to 32v: intermittent duty equipment

3.2.1.2.4.1.1.2 Transient Voltage.

a. Surge. Transient surge voltages, when converted to their equivalent step functions as defined in AS1212 shall be within the limits of Figures 7, 8 and 9 herein for normal, abnormal, and emergency conditions respecitvely.

b. Spike. Transient spikes shall not exist at the power input terminals of equipment greater than twice the line voltage or 100 V, whichever is less, in accordance with SL-E-0002, paragraph 6.9.

c. Ripple. The maximum individual ripple component shall not exceed 0.9 volts peak-to-peak. The total broadband ripple content shall not exceed a maximum of 1.6 volts peak-to-peak. The frequency characteristics of the ripple voltage are shown in Figure 10.

3.2.1.2.4.2 Electrical Interface. All electrical interfaces with the manipulator arm, Displays and Control Panel, Instrumentation, and Orbiter computer shall be in accordance with ICD-3-0018-02, ICD-3-0018-03 and ICD-3-0018-04.

3.2.1.2.4.3 Physical Interface. The size, installation, and thermal environment requirements for the MCIU shall be in accordance with ICD-3-0018-04.

3.2.1.2.4.4 Memory Devices. Memory devices contained within the MCIU shall be nonvolatile such that reloading by the orbiter computer of the MCIU memory devices after a power interruption will not be required.

3.2.1.2.5 Closed Circuit Television Subsystem (CCTV). The baseline orbiter CCTV system is referenced in ICD-3-0050-01. The manipulator arm mounted TV camera shall be in accordance with the following requirements:

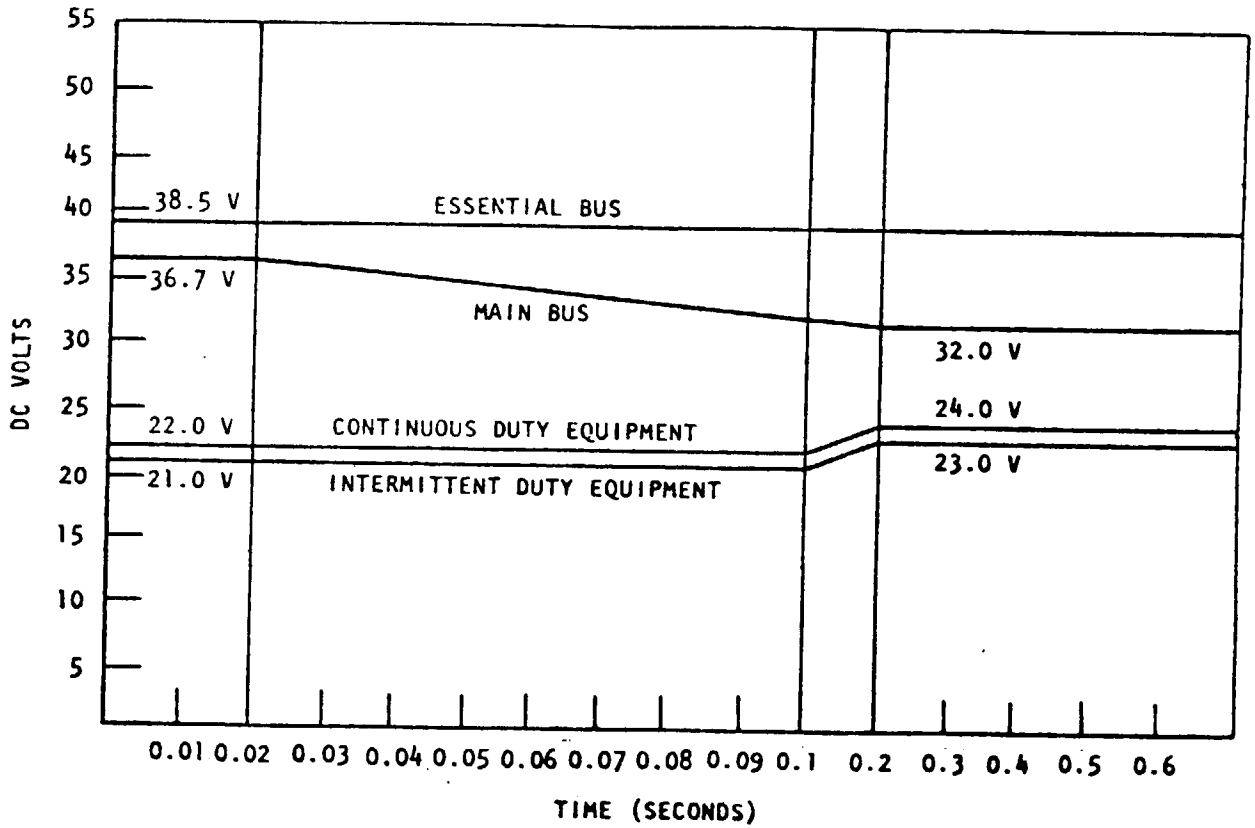
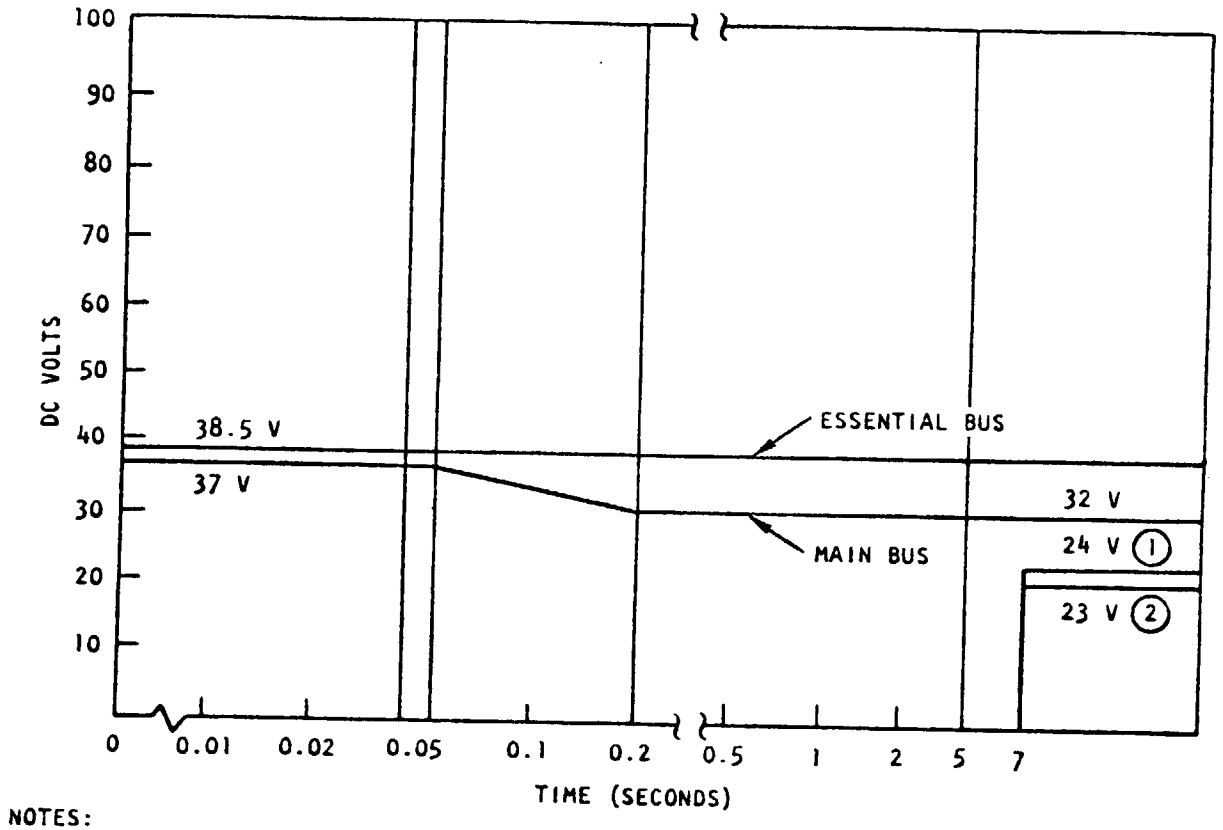


FIGURE 7. TRANSIENT SURGE OF DC-VOLTAGE STEP FUNCTION LOCI LIMITS DURING NORMAL EQUIPMENT SWITCHING CONDITIONS

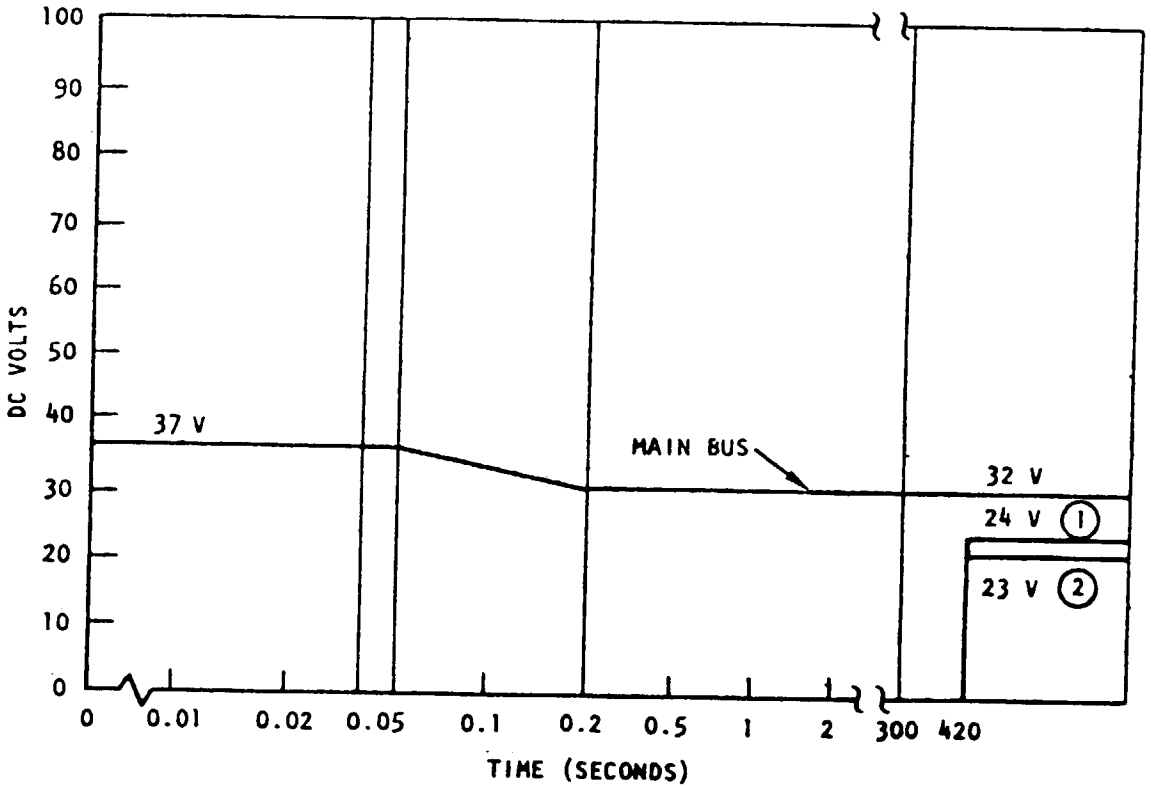


NOTES:

(1) CONTINUOUS DUTY

(2) INTERMITTENT DUTY

FIGURE 8. TRANSIENT SURGE OF DC VOLTAGE STEP FUNCTION LOCI LIMITS DURING ABNORMAL SWITCHING CONDITIONS



NOTES:

(1) MAIN BUS CONTINUOUS DUTY

(2) MAIN BUS INTERMITTENT DUTY

FIGURE 9. TRANSIENT SURGE OF DC VOLTAGE STEP FUNCTION LOCI LIMITS DURING EMERGENCY SWITCHING CONDITIONS

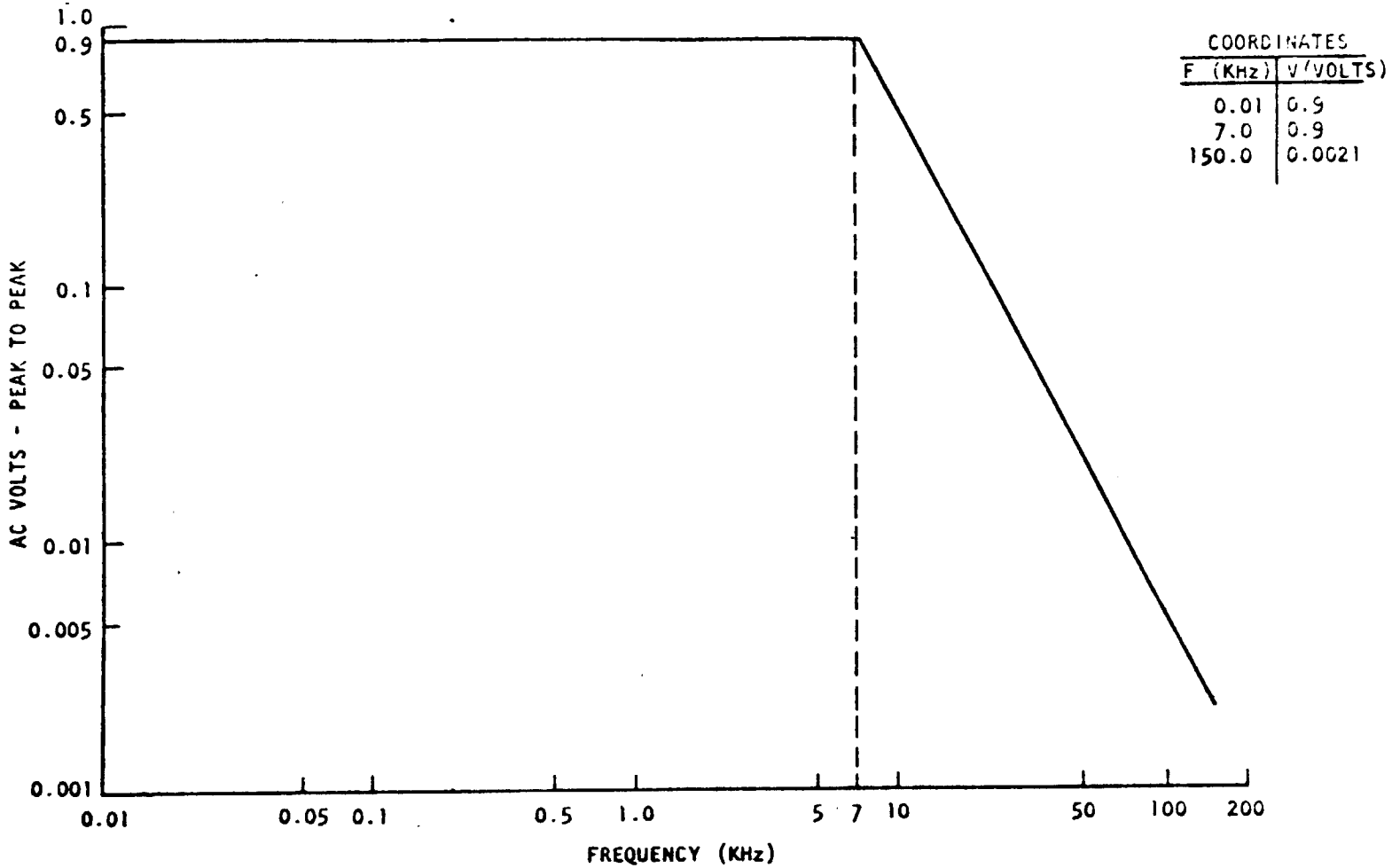


FIGURE 10. FREQUENCY CHARACTERISTICS OF RIPPLE VOLTAGE IN 28-VOLT DC ELECTRICAL SYSTEM

3.2.1.2.5.1 DC Power. The DC power shall have the characteristics specified in paragraph 3.2.1.2.4.1 with the following exceptions:

a. The 28 volt return shall be isolated from the camera assembly case and from signal returns by at least 10 megohms at 50 vdc. The power on-off for the B&W TV camera shall be on separate wiring.

The maximum loop resistance for power distribution wiring between the electrical TV Control Panel and the B&W TV camera in the orbiter shall be 2.5 ohms at 257 degrees F.

3.2.1.2.5.2 Composite Video Signal.

3.2.1.2.5.2.1 Impedance. The normal input and output impedance of the cameras shall be 75 ohms.

3.2.1.2.5.2.2 Video Frequency Response. The camera equipment shall provide a video output signal with a flat amplitude response with 3 dB from 25 to 200 TV lines.

3.2.1.2.5.3 Electrical. The electrical interconnection between the camera equipment and the manipulator arm interface shall be in accordance with ICD-3-0018-02, "Manipulator/Orbiter Electrical Interface".

3.2.1.2.5.4 Control. The baseline orbiter CCTV central panel shall be used to control the camera mounted on the manipulator arm.

3.2.1.2.5.5 Pan/Tilt Camera Mechanism. The manipulator arm mounted camera pan/tilt mechanism shall incorporate a fail safe design.

3.2.1.2.6 RMS Lighting System. Artificial lighting shall be provided to enable the performance of visual tasks either by direct vision or by TV during operations when the sun is blocked by the earth or spacecraft.

3.2.1.2.6.1 Orbiter Supplied Lighting. Orbiter equipment includes individual payload lights, a payload/manipulator light located on the payload bay forward bulkhead to provide full illumination into the payload bay and to provide illumination in the transition area between the payload bay and the overhead (-Z) operation and a payload/docking light located on the top (-Z axis) of the orbiter between and forward of the two overhead windows to provide illumination for payload manipulation, retrieval, and docking. The baseline orbiter lighting is as defined in ICD-3-0018-05.

3.2.1.2.6.2 Manipulator Arm TV Viewing Light. A light shall be located on the manipulator arm to provide illumination for the television system.

a. Lamp. The lamps shall be a narrow cone diffused floodlight.

b. Chromaticity. The color of the light output shall be white with a color temperature not less than 3200° Kelvin.

c. Radiation. The cone of radiation shall be a minimum of 5 degrees greater than the maximum field of view of the TV camera. The intensity across the cone, when measured in 5° increments, shall not vary more than 3 lumens from one adjacent cone to another.

d. Intensity. The intensity of the light shall be sufficient to provide a minimum of 5 foot candles illumination on a payload when the payload is at a distance of 60 feet from the light.

e. Controls. There shall be an on-off switch located on the CCTV lighting panel for independent control of this lamp.

f. Fixture. The fixture may be any design that will meet the manipulator requirements.

3.2.1.2.7 RMS Software. The RMS to orbiter software interface requirements are in accordance with ICD-3-0018-08.

3.2.1.2.8 GSE Handling Requirements. The RMS arm shall have the capability of being installed or removed from a horizontal or vertical orbiter. The RMS arm shall be capable of being handled as a complete unit without damage or degradation.

The RMS arm shipping container must accommodate the removal and re-installation of the RMS arm with the use of a handling sling. GSE interface requirements are defined in ICD-3-0018-07.

3.2.1.2.9 Life Requirements. The RMS shall be designed to provide the most cost effective life capability, considering minimum maintenance and refurbishment as well as state-of-the-art hardware design.

3.2.1.2.9.1 Operating Life. As a design objective, the RMS shall be capable of performing all operations specified herein for a minimum of 10 years.

3.2.1.2.9.2 Useful Life. As a design objective, the RMS shall have a minimum useful life of 500 cycles (one cycle is defined as an operation of the RMS from the Deployed Position, through release or retrieval operation of a payload and return to the original deployed position).

3.2.1.2.9.3 Shelf Life. As a design objective, the RMS shall be capable of operating in accordance with the requirements specified herein any time within a period of 10 years from date of delivery when exposed to the applicable environment of 3.2.5.

3.2.1.2.10 EVA Handholds. The RMS shall be designed and built to accommodate EVA handholds along the entire length of each manipulator arm. The EVA handholds shall be designed per JSC Specification SC-E-0006, "Manned Spacecraft Extravehicular/Intravehicular Activity Support Equipment, Functional Design Requirements For".

3.2.2 Design Characteristics (Subsystem Design Requirements).

3.2.2.1 Structure/Mechanical Subsystem Characteristics.

3.2.2.1.1 Structural Strength. The RMS structure shall be capable of meeting the structural strength requirements specified in the Orbiter End Item Specification MJ-070-0001-1A.

3.2.2.1.2 Ultimate Combined Loads. The Ultimate Combined Loads shall be as specified in MJ-070-0001-1A.

3.2.2.1.3 Allowable Mechanical Properties. The Allowable Mechanical Properties shall be as specified in MJ-070-0001-1A.

3.2.2.1.4 Fracture Control. The RMS Fracture Control characteristics shall be as specified in MJ-070-0001-1A.

3.2.2.1.5 Fatigue. The RMS requirements shall be as specified in MJ-070-0001-1A.

3.2.2.1.6 Loads and Structural Dynamics. The RMS shall be capable of withstanding loads in accordance with the requirements of MJ-070-0001-1A. All internal and external loads, both steady state and dynamic, which are imposed during all phases of ground and flight operations, including abort conditions, shall be considered.

3.2.2.1.7 Creep. The design shall preclude cumulative creep strain leading to detrimental deformation. Analysis shall be supplemented by test data to verify the creep characteristics for the critical combination loads and temperatures.

3.2.2.1.8 Stowage. The RMS arm stowage envelope in the orbiter shall be in accordance with ICD-3-0018-01.

3.2.3 Reliability Requirements. The contractor shall establish and maintain a Reliability program in accordance with the requirements of NASA Publication NHB 5300.4(1D-1), Chapter 3, with the following exceptions and/or modification.

3.2.3.1 Modifications.

a. Paragraph ID300, part 2, Reliability Plan: Revise last sentence of subparagraph 2a to read, "The ... applicable DRL/DRD (data requirements list/data requirement description)." Delete the requirements of subparagraph 2b.

b. Paragraph ID300, part 4, Reliability Progress Reporting: Delete this entire paragraph and insert the following, "The contractor shall report on the progress of the reliability effort in accordance with the applicable DRL/DRD and through periodic engineering/management meetings."

c. Paragraph ID300, part 5, Supplier Control: Add the following statement at the end of subparagraph B, "The contractor reliability organization shall review and approve the use of "off-the-shelf" hardware."

d. Paragraph ID301, Reliability Engineering: Revise the general paragraph to read as follows, "The contractor shall accomplish the following reliability engineering tasks on all flight equipment and as specified on flight GFE. The reliability engineering tasks to support the chapter 2 safety requirement of assuring fail safe design and operation of GSE are limited to GSE used at or common to the launch, landing, and retrieval sites and are identified in paragraphs ID301-3, FMEA (Failure Mode and Effects Analysis) and CIL (Critical Items List), ID301-4, Reliability-Maintainability Interface, ID301-6, Problem Reporting and Corrective Action, and ID201-7, Reporting and Resolving NASA Parts and Materials Problems (ALERTS)."

e. Paragraph ID301, part 3, FMEA (Failure Modes and Effects Analysis) and CIL (Critical Items List): Add the following statement to the general introductory paragraph 3, "The FMEA and CIL shall be prepared in accordance with the applicable DRL/DRD's.

Revise the fourth and fifth sentences of subparagraph 3a to read as follows, "The FMEA shall include an integration of all flight hardware, including flight GFE. The contractor effort shall include the necessary...."

Add subparagraph 3d as follows, "The preparation of GSE FMEA's as applicable to ID301-3.a, 3.b, 3.c is limited to those functions containing failure modes which could cause criticality category 1 and 2 effects. The GSE FMEA and CIL tasks may be combined with the hazard analysis task to preclude duplication and analytical work and documentation. (Reference ID201-4, Hazard Analysis)."

f. Paragraph ID301, part 4, Reliability-Maintainability: Add the following sentence to paragraph b, "The contractor shall report limited life items in accordance with the applicable DRL/DRD."

g. Paragraph ID301, part 6, Problem Reporting and Corrective Action: Delete this entire paragraph and insert the following, "The contractor shall be responsible for insuring that the problem reporting and corrective action system will meet the quality assurance requirements of paragraph 3.2. The contractor reliability organization shall have the responsibility for closeouts of design oriented failures."

h. Paragraph ID301, part 7, Reporting and Resolving NASA Parts and Materials Problems (ALERTS): Subparagraph d, add the following statement: "Reporting of ALERTS shall be in accordance with the applicable DRL/DRD."

i. Paragraph ID301, part 8 EEE (Electrical, Electronic and Electro-mechanical) Parts Control: Add the following statement to subparagraph 8.c(1), "The controlling specification shall designate EEE parts quality levels as

follows: Microcircuits shall be at least level B as described in MIL-M-38510; diodes and transistors shall be at least JANTXV; other discrete parts shall be at least second highest level of the appropriate MIL-ER (Military Established Reliability) except relays and switches which will be procured to the highest ER levels. NOTE: On receipt of JANTXV diodes and transistors, each lot shall receive a LTPD (lot, tolerance, percent, defective) check on all parameters at the appropriate environmental conditions as stated in MIL-S-19500 and MIL-STD-750. If the lot samples pass the above desired check, all devices of that lot may be used to fabricate production and certification equipment. In the event that any device fails to pass the aforementioned check, each device of that lot shall be screened to the 100 percent parameter check as described and all defective devices removed from fabrication lot."

Revise subparagraph c(4) to read as follows: "All EEE parts specifications shall be submitted for NASA review in accordance with the applicable DRL/DRD."

Revise the first sentence of subparagraph d(3) to read as follows: "Qualification...shall be in accordance with the applicable DRL/DRD."

Revise paragraph e to read as follows: "...in accordance with applicable DRL/DRD."

Add the following statement at the end of paragraph f: "Parts application review and stress analysis data shall be available for NASA review to support the preliminary design review and critical design review; and maintained for NASA review upon requests. The results of the analysis shall be reported in accordance with the applicable DRL/DRD."

Add the following statement to the end of the last sentence at paragraph i: "...in accordance with the applicable DRL/DRD."

j. New paragraph: Add the following reliability requirements: "Paragraph ID301, part 10, Waiver/Deviation: The contractor shall establish and maintain a system for the review and concurrence on all contractor initiated waiver/deviations. A waiver is utilized for acceptance of an article which does not meet specified requirements. A deviation is a specific authorization, utilized before the fact, to depart from a particular requirement. Waiver/deviation requests shall be processed in accordance with the applicable DRL/DRD."

k. Paragraph ID302, Testing: Retitle this paragraph to read, "Certification/Acceptance Testing," and add the following.

(1) Certification

(a) Certification Management

1. Organization - The contractor shall include provision for the planning, management, and monitorship of hardware certification.

Explicit identification or organizational responsibilities for all activities of this task shall be provided, including interfaces with Reliability Quality Control, Design Engineering, Systems Safety, and other functional organizations.

2. Certification Test Specification and Test Plan - The contractor shall prepare a Certification Test Specification in accordance with the applicable DRL/DRD which defines the overall philosophy of certification and which includes the groundrules for testing, the requirements for analysis, the controls required, and specific requirements for component, subsystem and combined system testing, and the environmental exposure conditions to be applied during tests. The plan shall describe how these items are to be accomplished.

3. Status Reviews - The contractor and the cognizant JSC organizational elements shall periodically review the status and implementation of the certification activity. The frequency of these reviews shall be mutually agreed to between the contractor and JSC. Documentation shall be in accordance with the applicable DRL/DRD.

(b) Certification Methods.

1. Certification by Test - Certification tests are accomplished on production hardware. The objective is to demonstrate the capability of the hardware to operate successfully at design limit environmental conditions. The quantities of hardware used for these tests are tailored for the specific hardware under consideration; however, criticality, schedule, and usage play important parts in the determination of hardware quantities. The results of testing are to be documented in the test report as described in the applicable DRL/DRD.

2. Certification by Analysis - Appropriate engineering analyses may be allowed to provide fulfillment of the certification plan objectives. Certification analyses will normally be conducted because of one or more of the following factors and are submitted in accordance with the applicable DRL/DRD.

a. The inability to simulate flight conditions in an effective ground test.

b. Certification testing would not be practical.

c. The need to extrapolate test data beyond the performed test points to provide demonstration of design conditions.

d. Where it can be shown that the article is similar or identical in design, manufacturing processes, and quality control to another article that has been previously certified to equivalent or more stringent criteria.

(2) Acceptance Test.

(a) Acceptance Test Specification - The contractor shall prepare an Acceptance Test Specification. The specification shall include as a minimum the following and shall be submitted in accordance with the applicable DRL/DRD:

1. Test objective
2. Acceptance and rejection criteria
3. Environmental conditions
4. Reference to applicable safety standards for hazardous operations
5. Allowable types of adjustments, repairs, rework, or maintenance operations
6. Requirements for data recording
7. Retest criteria
8. Requirements for the reporting of test results
9. Disposition of tested articles
10. Special photographic coverage (if required)

(b) Acceptance Vibration Test - Level: The acceptance vibration test spectrum shall be to the expected mission level of the acceptance vibration test minimum, whichever is the greater, as defined by the spectrum shown in SP-T-0023.

(c) Acceptance Thermal Test - Thermal tests shall consist of a minimum of one and one-half cycles with the optimum of six cycles of thermal variation under the conditions stated in the following paragraph. Temperature Levels: The acceptance thermal test temperature levels shall be to the expected mission levels or to the control temperature range which is a minimum of a 100°F temperature sweep, whichever is greater. The lower temperature limit should be below freezing (30°F) where possible. The initial temperature excursion should be in the direction of the equipment's expected flight operating temperature (hot or cold) so that the specified temperature extreme is achieved twice. The acceptance thermal test shall be performed as defined by repeating the spectrum shown in SP-T-0023, Specification, Environmental Acceptance Testing.

3.2.3.2 RMS Functional Redundancy Requirements. The RMS shall be able to deploy or retrieve a payload following any single failure. Additionally, it shall be designed such that no two failures result in an unsafe condition

for the orbiter (i.e. failure to cease motion on command, exceeding acceleration/deceleration rates).

3.2.3.2.1 Primary Structure. The RMS primary structure shall be designed to preclude failure by use of adequate design safety factors, or fail safe characteristics.

3.2.3.3 Isolation of Subsystem Anomalies. Isolation of anomalies of time critical functions shall be provided such that a faulty subsystem element can be deactivated either automatically or manually without disrupting or interrupting alternate or redundant functional paths or other subsystems. During ground operations, capability to fault--isolate to the line replaceable unit or group of units without disconnections or use of carry-on equipment, shall be provided.

3.2.3.4 Short Circuit Protection. Isolation between test/monitor points and internal circuits shall be such that a test/monitor point short to ground shall not degrade the equipment.

3.2.3.5 Power Supply Protection. Independent power source protection shall be governed by ICD-3-0018-04.

3.2.3.6 Switching Devices. Solid state switches and amplifiers shall be given preference over relays and other vibration-sensitive electrical/electronic equipment in baseline design configurations consistent with range safety requirements. Sealed-type terminal blocks shall not be used.

3.2.3.7 Protection Against Reverse Installation. RMS mechanical components which are not functionally interchangeable or reversible shall be designed to prevent inadvertent interchange or reverse installation.

3.2.3.8 Reliability Documentation Requirements. The contractor shall submit the required reliability documentation in accordance with the DRL/DRD's identified in addendum 1.

3.2.4 Maintainability.

3.2.4.1 Design Allocations. The design shall satisfy the following maintainability allocations:

a. Scheduled maintenance required for equipment shall be limited to replacement of time/cycle sensitive equipment. Physical inspection of installations and lubrication of mechanical devices shall be permitted once every (TBS) operating hours or TBS months while the device remains installed in the orbiter vehicle.

b. The RMS shall be designed to allow failed SRU's to be replaced at intermediate level maintenance in (TBS) hours or less after failure identification.

c. The RMS shall be designed to allow bench verification of LRU operating capability (Ref. Section 6) within (TBS) hours following maintenance action using suitable support equipment in the maintenance area.

3.2.4.2 Design Features. The design shall incorporate the following maintainability features.

3.2.4.2.1 Maintenance.

a. The RMS shall not require scheduled overhaul, except as noted in 3.2.4.1.a.

b. The RMS shall be designed to preclude the need for special tools and equipment for organizational level maintenance. Special tools, if required, shall be designed to withstand the intended normal use throughout the life of the equipment.

c. Items designated as LRU's in 3.1.6 shall be designed to satisfy the definition of an LRU (Ref. 6.1.12).

d. LRU's shall be designed so that their routine corrective maintenance can be accomplished. Repair of LRU's shall be accomplished by the replacement of Shop Replaceable Units (SRU's).

e. SRU's shall be designed so that maintenance actions not requiring extensive refabrication, refurbishment, or overhaul can be accomplished. Corrective maintenance of SRU's shall be accomplished by the replacement of minor subassemblies or piece parts. SRU's shall be designed to preclude the loss or dropping of hardware which could cause internal damage or affect the LRU's serviceability or increase maintenance time.

f. Scheduled maintenance of the RMS when installed in the orbiter shall be limited to organizational level maintenance.

g. The necessity for any in-flight maintenance, servicing or checkout tasks, other than built-in test capability, is prohibited.

h. Items requiring forming (rolling) or welding of attaching surfaces at disassembly points shall be designed so that removal of material upon disassembly during repair, overhaul, or modification does not destroy or render unusable any repairable subassemblies or components of the item.

i. No on-vehicle adjustments or calibration shall be required except as identified elsewhere in this specification.

j. Suitable warnings shall be provided on instruction plates or service placards if hazardous conditions exist when maintenance is performed.

k. Standard torque values shall be used for all threaded fasteners that require torquing unless justified variance is warranted.

l. The RMS shall be designed so as to preclude the need for carry-on support equipment for organizational level maintenance.

3.2.4.2.2 Installation.

a. The equipment design shall physically prevent the incorrect installation of LRU's and SRU's. In addition, clearly visible color coding and labeling in close proximity to maintenance disconnect points shall be used to facilitate removal and replacement of any item of equipment.

b. Equipment installed within the procured item shall be mounted in a manner to avoid blind adjustment.

c. Mechanical retention devices for LRU's and those SRU's that require frequent removal shall not require safety wiring.

d. Threaded fasteners used for securing a single item, where practical, shall be the same type, size, and tensile strength.

e. LRU/SRU installations shall be designed such that access to threaded fasteners may be accomplished without the use of universal joints, angular extensions, handle extensions, or combinations thereof, in conjunction with torque tools to the maximum extent possible.

f. Captive fasteners shall be utilized to fasten LRU's.

3.2.4.2.3 Accessibility.

a. LRU servicing and test points shall be clearly marked and shall be accessible without requiring removal of seller installed access plates or covers, except service caps. Calibration controls shall be accessible and clearly marked.

b. LRU's installed in the procured item shall provide adequate personnel access to and tool clearance between LRU's. The removal of such LRU's shall not require removal of any other functional hardware or wiring. Tubing and wire run protection shall be incorporated for such LRU's in traffic areas and wire bundle accessibility shall be provided without invalidating other wiring circuits or their related equipment.

c. On LRU's external electrical connectors shall be accessible without disassembly or removal of functional equipment or components.

3.2.4.2.4 Replacement.

a. Mounting provisions shall permit SRU removal and replacement without disconnecting any equivalent level SRU in the line replaceable unit. If removal of an LRU structural element is required for access, such removal shall not affect electrical or mechanical alignment, except to the extent that it may be readily reset and verified during bench functional checkout of the LRU, nor shall the mechanical strength of the unit be impaired to the point that bending of the unit, its assemblies, electrical harness, or plumbing attachments, will occur during normal bench handling of the unit.

b. Plumbing and wire runs within the procured item shall be of suitable attachment, length, and mounting to facilitate LRU/SRU replacement. Attach fittings for components routinely removed shall be operable without hand tools and shall be accessible without requiring removal of access panels or covers.

3.2.4.3 Self Test Provisions.

3.2.4.3.1 General Requirements. The RMS shall contain the necessary built-in-test capability to detect and report failures which affect operation. This built-in-test capability in conjunction with the integrated avionics shall provide the means for accomplishing functional path failure detection during flight along with the necessary LRU fault isolation to support ground turnaround requirements.

3.2.4.3.2 Minimum Requirement. At a minimum, the built-in-test capability shall provide, at the electrical interface, in accordance with ICD-3-0018-02, information to enable reporting of the results of unaugmented tests.

3.2.4.3.3 LRU Peculiar Requirements. Provisions shall be incorporated to detect and report failure of redundant capabilities. This level of failure detection is required for both automatic reconfiguration and for those cases where reconfiguration is under manual control.

a. Means of indicating the validity of data received via the serial digital data bus interface shall be provided.

b. Capability to provide status of redundant functional paths in the installed flight configuration shall be provided.

3.2.4.3.4 Implementation. Built-in-test may be implemented utilizing an appropriate mixture of Built-In-Test-Equipment (BITE), self test circuitry or by providing adequate test points at the electrical interface. It may be designed for automatic continuous, or iterative operation. However, it shall be designed to operate in all modes and conditions in both flight and ground operation. The type of implementation shall be selected in accordance with the following restraints:

a. Continuous testing or monitoring shall be used only when it can be performed simultaneously with operational use and where such testing does not degrade operational performance.

b. Iterative testing not under computer control shall not interfere with equipment's operational performance.

c. Any technique that requires external control or evaluation shall require buyer approval prior to implementation.

3.2.4.3.5 Test Status Signals. Test results shall be available at the electrical interface of the RMS. These signals parameters shall conform to that specified for a 5 volt discrete input signal.

a. Serial digital transmission may be utilized for status words consisting of summarized Go/No-Go status, operating mode indication, health and data validity status, plus additional bits of RMS status data.

3.2.5 Environments. The following environmental criteria is to be used in formulating the RMS Design and Test Requirements. The data was derived from MF 0004-014, Environmental Requirements and Test Criteria for Orbiter Vehicles. These environmental requirements are descriptions of the conditions to which the RMS may be exposed during its useful lifetime. These are parameters, generally defined as extreme levels with design margins that the designer of the RMS must consider in order to assure the RMS performance capability during or after exposure to the reflected environments. All the listed environments must be considered in the RMS design unless special provisions are taken to preclude the environment. This environmental section does not establish the Qualification Test Program. Only those tests adjudged to be necessary for demonstration of the RMS capability shall be selected for incorporation in the RMS test program.

3.2.5.1 Payload Bay Installed Equipment.

3.2.5.1.1 Operating. The RMS shall be capable of meeting the operating performance requirements specified herein during exposure to any feasible combination of the following environmental conditions.

a. Pressure — Minimum: 1×10^{-10} (Torr) (Testing to be at 10^{-6} Torr)

b. Temperature — The temperature of the operational RMS will be dependent upon boundary temperatures (mounting structure and that portion of the spacecraft visible to the RMS) the magnitude of the conduction and radiation heat transfer paths and the degree of exposure to external environments. Definition of boundary temperatures, thermal design mission requirements and heat transfer parameters are presented in Thermal ICD 3-0018-06. The following are the primary space environmental parameters which will be used for RMS thermal design and analysis:

(1)	Solar Radiation	443.7 Btu/Ft^2-Hr.
(2)	Earth Albedo	30 Percent
(3)	Earth Radiation	77 Btu/Ft^2-Hr. (maximum)
(4)	Space Sink Temperature	0 (Zero) Degrees Rankine

c. Solar Radiation (Nuclear)

The natural nuclear radiation environment in terrestrial space consists of (1) galactic cosmic radiation, (2) geomagnetically trapped radiation, and (3) solar flare particle events.

(1) Galactic Cosmic Radiation (Mainly Protons)

Composition: 85% protons, 13% alpha particles, 2% heavier nuclei

Energy Range: 10^7 to 10^{19} electron volts; predominant 10^9 to 10^{13}

Flux outside earths magnetic field: 0.2 to 0.4 particles/Cm^2/steradian/sec

Integrated yearly rate: Approximately 1 x 10^8 protons per sq cm

Integrated yearly dose: Approximately 4 to 10 rads

(2) Trapped Radiation (Protons, Electrons)

Energy: Electrons >0.5MeV, Protons >34MeV

Peak Electron Flux: 10^8 Electrons per sq cm per sec (omnidirectional)

Peak Electron Flux Altitude: Approximately 1000 n mi at equator

Peak Proton Flux: 10^4 to 10^5 protons per sq cm per sec (omnidirectional)

Peak Proton Flux Altitude: Approximately 1900 n mi at equator

(3) Solar Particle Events

Composition: Energetic protons and alpha particles

Occurrence: Sporadically and lasting for several days

Particle Event Model (free space): See Section 2.4.3 of TMX 64627

$$\text{Protons: } Np(>T) = \begin{cases} 7.25\times10^{11}T^{-1.2} & 1\text{MeV}\leq T\leq 10\text{MeV} \\ -3.54\times10^{11}E^{-P(T)/67} & 10\text{MeV}\leq T\leq 30\text{Mev} \\ 2.64\times10^{11}E^{-P(T)/73} & T>30\text{MeV} \end{cases}$$

$$\text{Alphas: } Nd(>T) = \begin{cases} Np(>T) & T<30\text{MeV} \\ 7.07\times10^{12}T^{-2.14} & T\geq 30\text{MeV} \end{cases}$$

Where $Np(>T)$, $Nd(>T)$ = protons/cm^2, alphas/cm^2 with energy >T

$P(T)$ = particle magnetic rigidity in mV

$$P(T) = \frac{1}{Ze}\,[T(T+2m\,C^2)]^{1/2}$$

Ze = 1 for protons, 2 for alphas

$m\,C^2$ = 938 MeV for protons, 3728 MeV for alphas

For near-earth orbital altitudes the above free-space event model must be modified since the earth's magnetic field deflects some of the low-energy particles that would enter the atmosphere at low latitudes to the poles.

d. Meteoroids

The meteoroid model encompasses particles of cometary origin in the mass range between 1 and 10^{-12} grams for sporadic meteoroids and 1 to 10^{-6} grams for stream meteoroids.

Average Total Environment:

Particle Density	0.5g/cm^3
Particle Velocity	20 km/sec
Flux Mass Models:	

(1) For $10^{-6} \leq m \leq 10^{0}$,

$$\log Nt = -14.37 - 1.213 \log m$$

(2) For $10^{-12} \leq m \leq 10^{-6}$,

$$\log Nt = 14.339 - 1.584 \log m - 0.063 (\log m)^2$$

Nt = Number particles/m^2/sec of mass m or greater

m = Mass in grams

Defocussing factor for earth, and if applicable, shielding factor are to be applied.

e. Acceleration

As specified in paragraph 3.3.2.8.9 of MJ 070-0001-1A, Orbiter Vehicle End Item Specification, (these values are presently being developed).

3.2.5.1.2 Nonoperating. The RMS shall be capable of meeting the operating performance requirements specified herein after exposure to any feasible combination of the following conditions:

a.	Pressure	Maximum: 15.23 psia	
		Minimum: 10^{-10} Torr	
b.	Transportation and Storage (Air Temperature)	-23°F	+115°F
	(1) Prelaunch Thermal Environment [1] (Air Temperature)	Min. 45°F (Nominal 70 ± 5°F)	Max. +100°F
	(2) On Orbit Thermal Environment	See Para. 3.2.5.1.1	
	(3) Entry/Postlanding Thermal Environment [1]		
	Radiation Sink Temperature	Up to +200°F	
	Air Temperature	Up to +200°F	
	(4) Conduction (Mounting) Temperature	-150°F	+200°F
	(5) Ferry Flight Thermal Environment	-65°F	+115°F

[1] See JSC 07700, Vol. XIV for Temperature Histories

c.	Humidity	Maximum: 100% relative
		Minimum: 0% relative
d.	Acceleration	The RMS shall be designed to withstand the acceleration loads shown in Table IV. Operating performance is not required after exposure to the crash loads reflected in Table IV.

Table IV. Limit Design Accelerations

	LINEAR - g			ANGULAR - RAD/SEC^2		
CONDITION	X	Y	Z	X-X	Y-Y	Z-Z
LIFT-OFF	-0.1 -2.9	+1.0 -1.0	+1.5 -1.5	+0.10 -0.10	+0.15 -0.15	+0.15 -0.15
HIGH-Q BOOST	-1.6 -2.0	+0.5 -0.5	+0.6 -0.6	+0.10 -0.10	+0.15 -0.15	+0.15 -0.15
BOOST-MAX. LF (STACK)	-2.7 -3.3	+0.2 -0.2	-0.3 -0.3	+0.20 -0.20	+0.25 -0.25	+0.25 -0.25
BOOST-MAX. LF (ORB ALONE)	-2.7 -3.3	+0.2 -0.2	-0.75 -0.75	+0.20 -0.20	+0.25 -0.25	+0.25 -0.25
ENTRY AND DESC PITCH UP	+1.06 -0.02	0 0	+2.5 -1.0	+0.25 -0.25	+0.75 -0.75	+0.30 -0.30
ENTRY AND DESC YAW	+0.75 +0.75	+1.25 -1.25	+1.0 +1.0	+0.25 -0.25	+0.30 -0.30	+0.75 -0.75
LANDING	+1.0 -0.8	+0.5 -0.5	+2.8 +2.2	+0.25 -0.25	+1.25 -0.75	+0.30 -0.30
CRASH	+9.00 -1.5	+1.50 -1.50	+4.5 -2.0			
CRASH (CREW COMPARTMENT INTERIOR)	+20.0 -3.3	+3.3 -3.3	+10.0 -4.4			

Sign convention follows that of the Orbiter coordinate system.
Angular accelerations follow the right hand rule.

Crash accelerations are ultimate.
The longitudinal accelerations are directed in all aftward azimuths within a cone of 20 degrees half-angle. The specified accelerations shall operate separately.

e. Ozone

3 to 6 parts per hundred million (phm). Total oxidant concentrations may reach 60 phm for 1 to 3 hours in any 24 hour period.

f. Fungus

As specified in MIL-STD-810 Method 508.

g. Lightning

In accordance with MF0004-002 for indirect strike effects.

h. Salt Fog

Exposure to one percent by weight salt solution.

i. Shock

(1) Basic

20g terminal sawtooth shock pulse of 11ms duration in each direction of three orthogonal axes.

(2) Landing

Rectangular pulses of the following peak accelerations, durations and number applications in the vertical/up direction.

Acceleration (g peak)	Duration (MS)	Applications
0.23	170	22
0.28	280	37
0.35	330	32
0.43	360	20
0.56	350	9
0.72	320	4
1.50	260	1

(3) Transient

5 to 35 Hz; plus and minus 0.25 g peak (can be simulated by vibration, one sweep, 5 to 35 Hz at one octave per minute).

(4) Pyrotechnic Shock

(TBD)

j. Vibration

(1) Ground Induced Vibration

Equipment which is subjected to acceptance vibration tests in accordance with the Specification - Environmental Acceptance Testing, SP-T-0023B, must consider in the design the following vibration spectrum:

20 to 80 Hz	Increasing at 3 dB/octave to 0.067 g^2/Hz at 80 Hz
80 to 350 Hz	Constant at 0.067 g^2/Hz
350 to 2000 Hz	Decreasing at 3 dB/octave from 0.067 g^2/Hz at 350 Hz

Duration: five minutes per axis.

(2) Random Vibration

Main Longeron Mounted Components

Level A

Acceleration spectral density increasing at the rate of 6 dB/octave from 20 Hz to 90 Hz; constant at 0.1 g^2/Hz to 300 Hz, decreasing at the rate of 6 dB/octave to 2000 Hz.

Duration: 34 min/axis.

Level B

Acceleration spectral density increasing at the rate of 6 dB/octave from 20 Hz to 40 Hz; constant at 0.05 g^2/Hz to 150 Hz, decreasing at the rate of 6 dB/octave to 2000 Hz.

Duration: 14 min/axis.

NOTE: These are Orbiter Main Longeron Attach Point levels. RMS attach point input levels are not presently available. Due date for this data is March 1976. It is not expected that any significant change will result from RMS attach fitting design.

k.	Acoustics	The estimated payload bay acoustic spectra generated by the engine exhaust and by aerodynamic noise during atmospheric flight are shown in Figure 11(a). The estimated time history of the payload bay and cabin overall internal noise level are shown in Figure 11(b).

3.2.5.2 Flight Deck and Mid-Deck (Displays and Controls). The RMS Displays and Controls Panel will have no thermal conditioning provided.

3.2.5.2.1 Operating. The RMS Displays and Control Panel shall be capable of meeting the operating performance requirements specified herein during exposure to any feasible combination of the following environment conditions:

a.	Pressure	Maximum:	16 psia
		Minimum:	13.7 psia
b.	Temperature	Maximum:	90°F Entry and Ground Operations 65°F to 84°F Control Range on Orbit
		Minimum:	35°F Ground Operation
c.	Oxygen Partial Pressure	Maximum:	3.45 psia
		Minimum:	2.70 psia
d.	Relative Humidity	Maximum:	85 percent RH at 65°F Dry Bulb
		Minimum:	17 percent RH at 90°F Dry Bulb
e.	Salinity	Exposure to 1 percent salt solution by weight.	
f.	Acceleration	See Section 3.2.5.1.1.e	

3.2.5.2.2 Non Operating. The RMS Displays and Controls shall be capable of meeting the operating performance requirements specified herein after exposure to any feasible combination of the following conditions:

a.	Pressure	Maximum:	30 psia Leak Check after structural repair 18 psia Operational Leak Check
		Minimum:	12.36 psia 8 psia Emergency deorbit
b.	Temperature	Maximum:	120°F
		Minimum:	35°F -10°F Ferry Flight

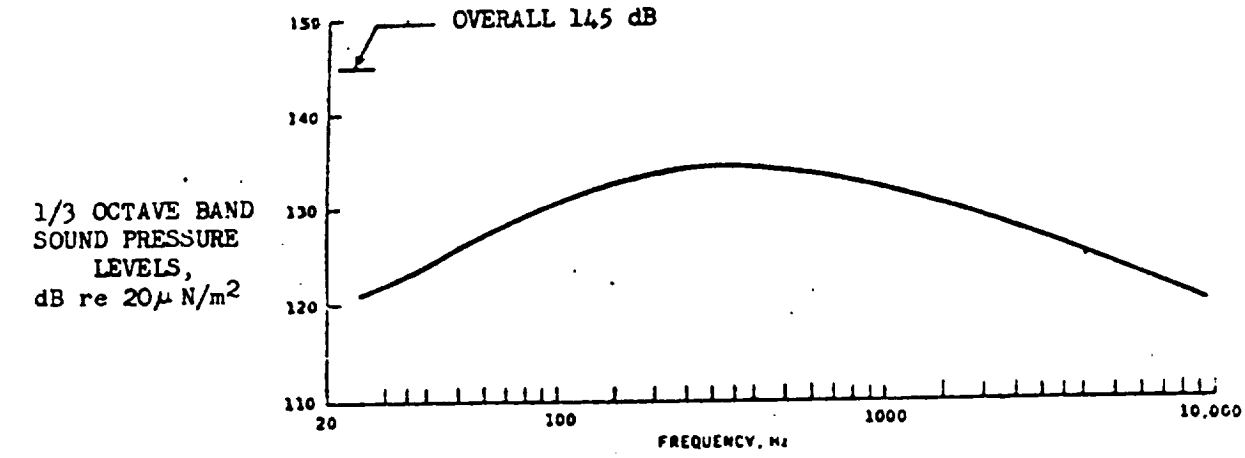


Figure 11(a). Analytical Predictions Maximum Orbiter Payload Bay Internal Acoustic Spectra

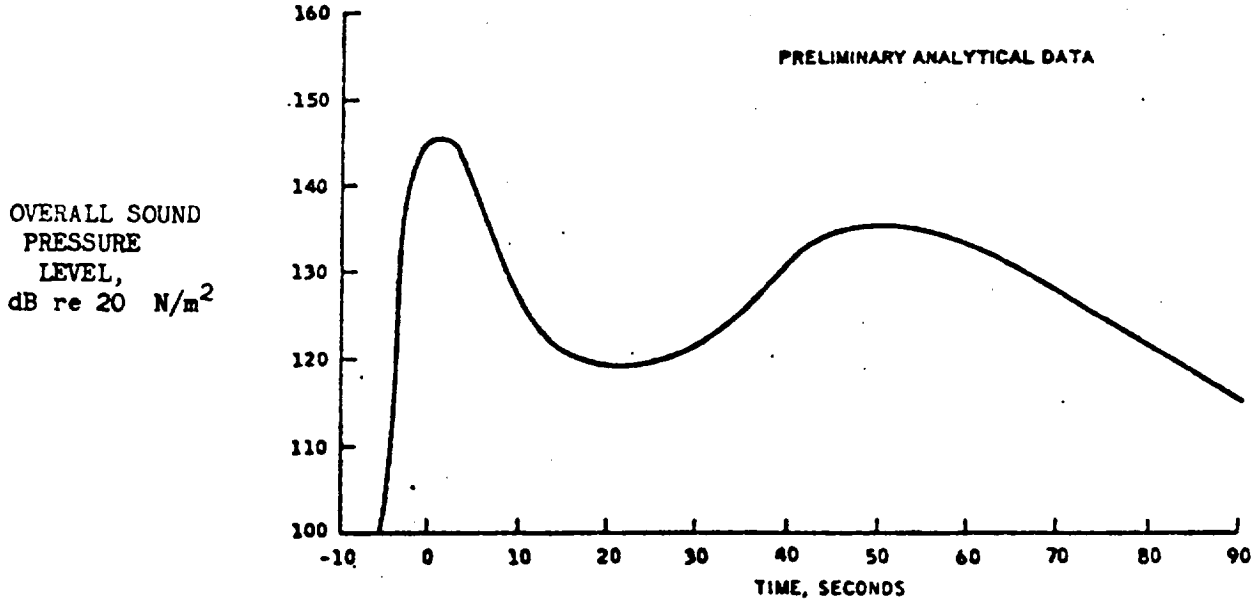


Figure 11(b). Orbiter Payload Bay Internal Acoustic Time History

c. Humidity — Maximum: 100 percent RH; Minimum: 8 percent RH

d. Acceleration — Refer to Table IV.

e. Shock (Unpackaged)

(1) Bench Handling: — As specified in MIL-STD-810 Method 516.1 Procedure V.

(2) Basic Design: — 20 g terminal sawtooth shock pulse of a 11 ms duration in each of three orthogonal axes (both directions).

(3) Transient — 5 to 35 Hz; plus and minus 0.25 g peak (can be simulated by vibration, one sweep, 5 to 35 Hz at one octave per minute).

(4) Landing — Rectangular pulses of the following peak accelerations, and numbers of applications in the vertical/up direction during landing:

Acceleration (g Peak)	Duration (Milliseconds)	Applications (per 100 missions)
0.23	170	22
0.28	280	37
0.35	330	32
0.43	360	20
0.56	350	9
0.72	320	4
1.50	260	1
		125

(5) Pyrotechnic — (TBD)

f. Ozone — 3 to 6 parts per hundred million (phm). Total oxidant concentrations may reach 60 phm for 1 to 3 hours in any 24 hour period.

g. Lightning — In accordance with MF0004-002 for indirect strike effects.

h. Fungus — As specified in MIL-STD-810 Method 508.

i. Acceleration — Plus and minus 5 g's in each of three orthogonal axes for a minimum of 5 minutes per axis.

j. Vibration

(1) Ground Induced Vibration

Equipment which is subjected to acceptance vibration tests in accordance with the Specification - Environmental Acceptance Testing, SP-T-0023B, must consider in the design the following vibration spectrum:

20 to 80 Hz	Increasing at 3 dB/octave to 0.067 g^2/Hz at 80 Hz
80 to 350 Hz	Constant at 0.067 g^2/Hz
350 to 2000 Hz	Decreasing at 3 dB/octave from 0.067 g^2/Hz at 350 Hz

Duration: Five minutes per axis

(2) Randon Vibration

Acceleration Spectral Density

20 to 150 Hz	Increasing, at plus 6 dB/octave, to 0.2 g^2/Hz at 150 Hz
150 to 300 Hz	Constant at 0.2 g^2/Hz
300 to 400 Hz	Decreasing, at minus 6 dB/octave, to 0.12 g^2/Hz at 400 Hz
400 to 1000 Hz	Constant at 0.12 g^2/Hz
1000 to 2000 Hz	Decreasing, at minus 9 dB/octave, from 0.12 g^2/Hz at 1000 Hz

Duration: 48 minutes per axis

k. Acoustics

The estimated cabin acoustic spectra generated by the engine exhaust and by aerodynamic noise during atmospheric flight are TBD.

NOTE: Maximum acoustic levels for the Orbiter crew compartment are limited by JSC 8080 Design Standard Number 145 to 135B octave band level and since the random vibration spectrum for the crew compartment will excite the equipment in excess to that expected from a 135db acoustic spectrum, it is not considered necessary to test to the acoustics environment for equipment stowed in the crew compartment.

3.2.5.3 Forward Avionics Bay.

3.2.5.3.1 Operating. The RMS MCIU shall be capable of meeting the operating performance requirements specified herein during exposure to any feasible combination of the following environmental conditions:

a.	Pressure	See Section 3.2.5.2.1a
b.	Temperature	Temperature control is provided by an atmosphere circulating system, including fans and heat exchangers, which transfers heat to the water coolant loop. Coldplates are provided as required in each bay. Gas coolant flowrates for each item of air cooled equipment will be supplied at a rate that will limit the gas coolant rise across the equipment to 30°F when operating at 14.7 psia cabin pressure. Maximum pressure drop across each unit at this flowrate shall be 1.5 inches of water. Where air flow is required through the packages, duct connection size to the package shall be 1.5 inch inside diameter. Maximum: 100°F Supply Temperature Minimum: 35°F Supply Temperature (Ground Operations)
c.	Relative Humidity	See Section 3.2.5.2.1d
d.	Salinity	See Section 3.2.5.2.1e
e.	Acceleration	See Section 3.2.5.1.1e

3.2.5.3.2 Non Operating. The RMS MCIU shall be capable of meeting the operating performance requirements specified herein after exposure to any feasible combination of the environmental conditions in 3.2.5.2.2.

3.2.5.4 Transporation and Storage. The RMS shall be protected from the environments specified in 3.2.5 by adequate packaging or protective processes unless the design to vehicle flight requirements precludes the need.

3.2.6 Transportability. The RMS shall be designed so as to be capable of being handled and transported to using facilities without damage or degradation, utilizing available methods of transport with the item prepared for shipment in accordance with Section 5 requirements. The planned packaging shall be compatible with the equipment design and transportation system to the extent that loads induced in the equipment during transportation will not produce stresses, internal loads or deflections resulting in damage to the equipment.

3.2.6.1 Tiedown Capability. The equipment design shall incorporate structural provisions adequate to permit the hardware to be secured to the transport vehicle, device or container by bolting, blocking, strapping, or other feasible means.

3.2.6.2 Integral Protective Capability. The equipment design shall incorporate one or more of the following provisions for protection of components which are highly vulnerable to damage during transport and associated handling:

a. Provide attach points for installation of temporary protective device (covers, reinforcing structure, desiccant cartridge, heater, etc.).

b. Make provisions for removal of sensitive component(s) for separate shipment.

c. Provide "built-in" protective device (e.g., cover, caging of free-moving components, desiccant chamber, heater, etc.).

3.3 Design and Construction.

3.3.1 Selection of Specifications and Standards. Specifications and standards for use in the design of RMS components shall be selected in accordance with MIL-STD-143 and JSCM 8080, except that NASA documents, where specified herein, shall take precedence. A list of applicable JSCM 8080 Manned Spacecraft Criteria and Standards for the RMS is presented in addendum 2 of this RDD.

3.3.2 Materials, Parts, and Processes.

3.3.2.1 General Requirements. Materials and processes for the Remote Manipulator System shall be in accordance with SE-R-0006, and with MSCM 8080.

3.3.2.2 Selection of Materials and Processes. The selection of materials and processes shall be based upon the philosophy of obtaining the lowest cost, highest quality, most reliable and safe approaches consistent with performance requirements and schedule constraints. Wherever possible, materials and processes which have a long history of satisfactory service shall be used. Any known factors such as flaws, degrading environments, improper or detrimental processing, etc., which may cause a part to fail prematurely shall be brought to the attention of the buyer along with a recommended corrective course of action.

3.3.2.3 Allowable Material Properties Criteria. Allowable material strengths used in design shall reflect the effects of load, temperature, and time associated with the design environment. Design strength allowables shall be taken from MIL-HDBK-5 (metals), MIL-HDBK-17 (laminates), MIL-HDBK-23 (bonded structures, and USAF Advanced Composites Design Guide).

Where values for mechanical properties of new materials or joints or existing materials or joints in new environments are not available they shall be determined by the seller.

3.3.2.4 Material "A" and "B" Allowables. Material "A" allowables, determined by the statistical methods of MIL-HDBK-5, shall be used in all applications where failure of a single load path would result in loss of vehicle structural integrity.

Material "B" allowables, calculated by the statistical methods of MIL-HDBK-5, may be used in redundant structures in which failure of a component would result in a safe redistribution of applied loads to other load-carrying members.

3.3.2.5 Soldering. The soldering of electrical and electronic assemblies shall be performed in accordance with NASA Document NHB 5300.4(3A) and JSC 08800 by certified operators.

3.3.2.6 Moisture and Fungus Resistance. Materials which are non-nutrient to fungi as defined in MIL-STD-810, Method 508, shall be used. When fungi nutrient materials must be used, they shall be sealed or treated to prevent fungus growth.

3.3.2.7 Threads and Fasteners. Screw threads shall be in accordance with MIL-S-7742 or MIL-S-8879 for fastener ultimate tensile strengths below 160,000 lbs per square inch (psi). MIL-S-8879 shall be used for fastener ultimate tensile strengths of 160,000 psi or greater. External threads in accordance with MIL-S-8879 for fastener tensile strengths of 160,000 psi and greater shall be produced by a single thread-rolling process after final heat treat.

3.3.2.8 Locking Threaded Parts. All threaded parts shall be positively locked. Preferred locking methods in order of preference are as follows: self locking nuts, castellated nuts and cotter pins, screw-locking screw thread inserts, self locking bolts or screws and lock washers, and safety wiring in accordance with MS33540. Cotter pins shall not be used in areas where snagging of garments could result.

3.3.2.9 Retaining Methods. Staking, press fits, or crimping (except electrical connectors) shall not be used as the primary means of retaining detail parts or sub-assemblies. No retaining rings or snap-rings shall be used. Retention devices shall not require lock wire.

3.3.2.10 Weight. The maximum allowable weights for the various RMS components shall be in accordance with Table V.

Table V. RMS Components Weights

Functional Items	Baseline Maximum Weights
Manipulator Arm Assembly	TBD
Arm Assemblies	
Pivot Joints	
End Effector	
Arm Mounted TV	
Arm Mounted Light	
Arm Wire Harness	
Manipulator Controller Interface Unit	TBD
Manipulator Hand Controller	TBD
Manipulator Display and Control Panel	TBD
TOTAL	546

3.3.3 Parts Selection.

3.3.3.1 EEE Parts Selection. EEE parts shall be selected in accordance with MF0004-400 specification.

3.3.3.2 Mechanical Parts Selection. MIL-STD-143, "Standards and Specifications, Order of Precedence for the Selection of," shall apply in selecting specifications for standard mechanical parts. Rationale for the selection of company specifications and standards over existing higher order of precedent standards and specifications shall be made available to the procuring activity upon request. This rationale shall include an identification of each higher order of precedent specification or standard examined and state why each was unacceptable.

3.3.4 Moisture and Fungus Resistance. Materials shall be selected and treated in accordance with the moisture and fungus resistance requirements specified in paragraph 3.3.2.6.

3.3.5 Corrosion of Metal Parts.

3.3.5.1 Stress Corrosion. The control of stress corrosion cracking shall be in accordance with 3.6.5.1.1 of the Space Shuttle Flight and Ground System Specification JSC 07700, Volume X.

3.3.5.2 Corrosion Protection. Corrosion protection of materials shall be in accordance with 3.6.5.1.2 of the Space Shuttle Flight and Ground System Specification JSC 07700, Volume X.

3.3.6 Electromagnetic Interference. The RMS shall satisfy the electromagnetic interference requirements specified in 3.6.7 of the Space Shuttle Flight and Ground System Specification JSC 07700, Volume X.

3.3.7 Storage. The RMS hardware shall have the storage capabilities specified in 5.1 of this document.

3.3.8 Coordinate System Standards. Coordinate system standards for the RMS shall be in accordance with 3.6.11 of the Space Shuttle Flight and Ground System Specification JSC 07700, Volume X.

3.3.9 Contamination Control. Contamination control for the RMS shall, as a minimum, comply with paragraphs 2.3, 2.4, 2.5, 2.9, 2.15, 2.18, and 2.23 of SN-C-005, Specification, Contamination Control Requirements for the Space Shuttle Program. Contamination control procedures shall be submitted in accordance with Addendum I, DRL line item 27.

3.3.10 Electrical Bonding. The RMS shall comply with the electrical bonding requirements specified in 3.6.14 of the Space Shuttle Flight and Ground System Specification JSC 07700, Volume X.

3.3.11 Electrical Installation. Installation of RMS electrical equipment shall be in accordance with the requirements specified in 3.6.15 of the Space Shuttle Flight and Ground System Specification JSC 07700, Volume X.

3.3.12 Identification and Marking.

3.3.12.1 Identification of Parts. Each part fabricated shall be identified with a part number. The same specification or part number shall be used to identify all like materials, processes, and parts. Seller shall assign a new part number to the part when authorized changes make the superseded part not interchangeable with respect to interface, reliability, safety, logistics, traceability, or performance. For traceable items, the part identification shall additionally include the manufacturer's identification code in accordance with DOD Handbook H4-1, and be lot/member number or serial numbered when required.

3.3.12.2 Identification of Pipes, Hose, and Lines. Tubes, lines, hose and pipes shall be identified in accordance with MIL-STD-1247.

3.3.12.3 Identification of All Development/Qualification Test Specimens. Test specimens shall be permanently and obviously identified prior to testing with the words "ENG TEST ONLY" in addition to the identification required by the Drawing/Specification to preclude their use on production items. The letters shall be indelible and provide a distinctive and vivid contrast with the color of the specimen. The lettering size and identification location shall be clearly visible to casual observation. Materials used for the identification shall be compatible with the test specimen and its operating environment. When the size or configuration of the test specimen is such that identification cannot appear on the specimen, other suitable means such as attached metal tags shall be used.

3.3.12.4 Nameplates. Nameplates shall be marked in accordance with MIL-STD-130 and shall include (as applicable) item name; buyer's control number; National Stock Number (NSN); manufacturer; date of manufacture; and manufacturer's serial number, part number, lot number, and code identification number. Abbreviations, in accordance with MIL-STD-12, may be used.

3.3.13 Traceability. Traceability shall be provided by assigning traceability identification to end items or major components as identified in 3.1.6. Each component, part, and subassembly comprising or contained within the end item or major component shall be classified and processed as exempt or traceable, in accordance with the criteria contained herein and the traceability requirements of JSC 07700 Volume X.

3.3.13.1 Traceability Classification. Each component, subassembly, and part within the end item shall be evaluated and receive a traceability classification. Seller and subordinate supplier engineering documentation (e.g., drawings and specifications) shall specify the traceability classification for each part, component, and subassembly as classified by the seller.

3.3.13.1.1 Serial Traceability (T_S). Serial traceability requires the assignment of a unique serialized identifier and processing of each part, subassembly, major component, or end item identified (T_S) as a separate item, and maintaining historical records pertaining to that item alone.

The historical records in turn will provide the capability for backward traceability to the identification of its procurement, fabrication, inspection, processing, test, and operating records and any other pertinent data deemed necessary by the seller. The capability shall also provide for backward traceability to the procurement document(s) and receiving record(s) of part(s), components, and subassemblies within the end item designated as traceable (exempt items excluded).

3.3.13.1.1.1 Serial Traceability Criteria. Sub-tier items comprising or contained within the end item which satisfy any of the following criteria shall be traceable by serialization:

a. Limited life

b. Fracture control

c. Requires progressive comparative measurements of performance (i.e., transducer curves)

d. Contains traceable subordinate items, assemblies, or parts.

3.3.13.1.2 Lot Traceability (T_L). Lot traceability requires lot serial numbering of sub-tier items produced by the lot, batch, mix, heat, or melt in a given time sequence and the maintaining of historical data equally pertinent to all items in the lot. Separate lot numbers shall be assigned when planned differences between individual items in the lot occur due to changes in materials (substitution) or processes which affect form, fit, or function. The "given time sequence" includes identification of work on the production order for a specific part number, from initiation of work through completion of the last operation.

3.3.13.1.2.1 Lot Traceability Criteria. Sub-tier items which satisfy the following criteria shall be lot traceable:

a. All functional electrical, electronic, and electromechanical (EEE) parts in accordance with MF0004-400.

b. Parts with materials identified by the seller as critical.

c. Parts identified by the seller as controlled by unique manufacturing process(es).

3.3.13.1.3 Member Traceability (T_M). Member traceability requires processing of items in numbered lots, serial numbering each item in the lot, and maintaining records common to all members of the lot, as well as specific data about each item.

3.3.13.1.3.1 Member Traceability Criteria. Member traceability shall be used on all sub-tier items requiring both serial and lot traceability so that they can be handled as members of a lot and also controlled as individual items. Items to be controlled by member traceability shall be identified by the buyer or receive buyer approval prior to implementation. (Normally applicable to ordnance/pyrotechnic items only.)

3.3.13.1.4 Exempt From Traceability (E). This classification identifies those items which are exempt from traceability requirements. All items which have not been classified and identified as T_S, T_L, T_M shall be exempt (E) from traceability.

3.3.13.2 Traceability Identification. Each item identified as traceable (T_S, T_L, T_M) shall have a traceability identifier consisting of the manufacturer's code identification number as listed in DOD Handbook H 4-1 and a serial, lot, or member number as illustrated below. The serial, lot, or member number shall be assigned by the manufacturer and shall not exceed 10 characters (alphas, numerics, dashes, etc.).

	Mfr Code No.	Mfr Assigned Traceable No.
Digit	1 2 3 4 5	6 7 8 9 10 11 12 13 14 15
	EXAMPLE	
Mfr's Code and Traceability No.	0 3 9 5 3	- 0 0 0 0 A B 0 0 1

3.3.14 Interchangeability. The RMS items identified in 3.1.6, shall be interchangeable in accordance with the definition of MIL-STD-280. Interchangeability shall be a design feature for all removable items/subassemblies/parts designated as LRU's or SRU's except to the extent that resetting of alignment is permitted by paragraph 3.2.4.2.4a. When removable items subassemblies contain controls, wiring, hydraulic lines, etc., interchangeability shall be provided at the attachments of these items to their next assembly, as well as for structural attachments of the assembly.

3.4 Quality Assurance.

3.4.1 Quality Assurance Requirements. The contractor shall implement and maintain a quality assurance system which is in compliance with the requirements of NASA publication NHB5300.4(1D-1), Chapter 5, Safety, Reliability, Maintainability, and Quality Assurance Provisions for the Space Shuttle Program, with the following deletions:

Delete Para. 1D503.4c - Interrelated Source Inspection
Delete Para. 1D503.9e - Unified Survey Activities
Delete Para. 1D503.10 - Coordination of Contractor Procurement and Source Inspections and Tests
Delete Para. 1D505.9 - Quality Assurance Designees
Delete Para. 1D505.10 - Vehicle Access Control

3.4.1.1 Problem Reporting and Corrective Action. The contractor shall implement and maintain a system for problem reporting and corrective action in accordance with NASA publication NHB5300.4(1D-1), Chapter 3, Para. 1D301.6, Problem Reporting and Corrective Action.

3.4.1.2 Soldering Requirements. The contractor shall implement and maintain a soldering program which complies with the requirements of NASA publication NHB5300.4(3A), Requirements for Soldered Electrical Connections, as modified by JSC Supplement, JSC 08800, Revision A.

3.4.1.3 Quality Assurance Data Requirements. Quality assurance data shall be submitted as specified in Addendum I, DRL line items 19 through 27.

3.4.1.4 Nondestructive Inspection Requirements. RMS nondestructive inspection requirements for materials and parts shall be in accordance with MIL-I-6870.

3.4.1.5 Temporary Installations. Temporary closure devices and indicators (plugs, covers, streamers) shall be of a high-visibility color, or shall have attached colored streamers to insure that they are easily identified under casual conditions.

3.4.1.6 Blind Installations. Unspecified or excessive tolerances for fasteners used for blind installations (those installations where there is no visible means of determining bottomed-out or interference conditions which hide adjacent structures, assemblies, or components) shall be avoided when possible. If the use of threaded fasteners is required for blind installations, the design shall provide for the optimum size or provide assurance that required torque can be met with complete engagement and clearance from adjacent structures, assemblies, or components.

3.4.1.7 Tamper-Proof Method. A tamper proof method shall be implemented to provide a visual indication of the integrity of critical fastening devices subsequent to torque applications.

3.4.2 Software Quality Assurance. RMS software quality assurance shall be in accordance with JSC 07700, Volume XVIII, Computer Systems and Software Requirements, Level II Program Definition and Requirements, Volume XVIII, Book 3.

3.5 Safety

3.5.1 Safety Requirements. The safety requirements specified in chapter 2 (Safety) of NASA Publication NHB 5300.4(1D-1), dated August 1974, (Safety, Reliability, Maintainability, and Quality Assurance Provisions for the Space Shuttle Program), shall be complied with except as specified in the following:

Deletions

1. The sentence in paragraph 1, section ID 200 reading: "The Industrial Safety/Occupational Health and Safety Plan shall be incorporated or attached to the Safety Plan."

2. Paragraph 2, section ID 200.

3. "Abort" and "crew egress" in item No. a. of paragraph 3, section ID 200.

4. "Vehicle" in item No. d. of paragraph 3, section ID 200.

5. Item No. n. of paragraph 3, section ID 200.

6. "Abort", "escape", and "and public safety" in the second sentence of paragraph 3, section ID 200.

7. "Specified in this document" in paragraph 12, section ID 200.

8. "Such as the MSC 00134 Space Flight Hazards Catalog" in the second sentence of paragraph 2, section ID 201.

9. Items b, d, h, k, l, and o in paragraph 5, section ID 201.

10. Paragraph 15, section ID 201.

11. "Of paragraphs ID 201-1 through 15" in paragraph 16, section ID 201.

12. Paragraph 19, section ID 201.

13. Sections ID 202 and ID 203.

Changes

1. Change item No. c. of paragraph 3, section ID 200 to read: "Flight-oriented test programs."

2. Insert "and" before "failure detection and display." in the second paragraph of paragraph 3, section ID 200.

3. Change paragraph 5, section ID 200 to read: "System safety activities shall be fully coordinated with industrial, test operations, and other safety activities to ensure an effective and integrated total safety effort and to avoid redundant effort among technical disciplines."

4. In first sentence of paragraph 6, section ID 200, substitute "review" for "audit".

5. Change the last sentence of paragraph 8, section ID 200, to read: "The contractor shall provide to NASA, on request, relevant accident and incident information impacting crew (flight and/or ground) safety."

6. In the first sentence of paragraph 2, section ID 201, substitute "system design" for "vehicle systems design."

7. In the last sentence of paragraph 2, section ID 201, substitute "system" for "vehicle".

3.5.2 Safety Data Requirements. Safety data requirements shall be as specified in Addendum I, DRL line items 28 and 29.

3.5.3 Monitoring Provisions. Monitoring provisions shall be provided for the RMS for those events/functions whose malfunction would result in potential hazardous conditions and intelligence of those conditions shall be appropriately displayed at the Payload Specialist station for corrective action.

3.5.4 Current Limiting Devices. The design of the system shall incorporate current limiting devices to limit the electrical energy that could be imparted by the RMS to a safe level. Consideration should be given to incorporation of automatic shutdown devices to de-energize the system in the event of a critical failure.

3.5.5 Stop Features. The design of the RMS shall provide automatic braking or stop features in the event of a failure and when critical limits are exceeded.

3.5.6 Sharp Edges, Corners, and Protrusions. The subsystem design shall include enclosures for all electrical wiring in chaf-resistant protective material and be clamped to clear sharp edges and moving parts to preclude damage to the RMS. All machined parts shall be free from sharp corners or edges.

3.5.7 Safety Guards. The RMS display and control panel shall provide safety guards for critical or emergency controls and switches to prevent inadvertent activation.

3.5.8 Heater Design. Electrical heaters, if incorporated in the design of the RMS, shall be designed such that the heating elements do not cross or overlap to preclude potential hot spots.

3.5.9 Explosion Proofing. Electrical/Electronic components that could serve as an ignition source for explosive atmospheres shall be explosive proof.

3.5.10 Transient Signals. The design shall ensure that transient effects to the RMS cannot introduce erroneous signals which are hazardous during critical operations. EMC performance of the RMS Arm shall meet the EMC requirements specified in SL-E-002, June 4, 1973.

3.5.11 Extravehicular (EV) Crewman Safety. The RMS design shall incorporate safety requirements to preclude safety hazards to the extravehicular crewman in accordance with the provisions established in NHB5300.4 (1D-1). RMS equipment, structures along EV crewman translation routes, or any RMS-associated equipment requiring a man-machine interface or within access of the crewman during EVA shall be free from sharp edges, burrs, protrusions, thermal extremes, etc. to avoid crew injury or damage to the crewman's space suit, life support and personnel rescue equipment. Radiological, electrical, electromagnetic, and pyrotechnic equipment safety relative to EVA operations must be considered.

3.6 Human Engineering. The RMS man-machine interfaces, both intravehicular and extravehicular, shall be designed using accepted human engineering practices to optimize crew operations of the RMS.

The RMS design shall be consistent with the following requirements:

a. The RMS shall be operable by one shirtsleeve crewman.

b. The RMS shall be operable by personnel (both male and female) within the dimensional range from the 5th percentile female (USAF 1968 population) to the 95th percentile male (USAF population extrapolated to 1980).

c. Crew stabilization aids and/or restraints shall be provided for efficient RMS operations. The restraints shall be adjustable as necessary to accommodate the population specified in b.

d. The RMS workstation shall be laid out to accommodate a crewman standing in a zero-g posture and at least restrained at the feet.

e. The RMS operator shall have the capability to direct the control of the RMS throughout all operational modes.

f. RMS controls and displays shall be placed to allow operation and viewing from a maximum range of operator's eye positions.

g. Variable intensity for integral control and display lighting from TBD to TBD candlepower shall be provided.

h. The intravehiclular RMS components accessible to the crewman shall be designed to preclude crew safety hazards (e.g., sharp edges, protrusions, burrs).

i. The manipulator assembly shall be designed to support EVA rescue of crewmen equipped with self-contained life support systems.

j. The manipulator arm surface reflectivity shall be no greater than 50 percent total of which no more than 10 percent may be specular.

4. VERIFICATION REQUIREMENTS

4.1 General Requirements. Unless otherwise specified, the RMS verification program will be based on the guidelines and criteria provided in JSC 07700-10, MVP-01.

4.1.1 General Verification Guidelines and Criteria. The verification program plan shall be responsive to approved RMS design and performance requirements as well as those allocated Shuttle System Requirements defined in Section 4 of the Space Shuttle Flight and Ground System Specification JSC 07700, Volume X. The seller shall use the following general requirements in developing a verification program.

a. Each performance and design requirement specified in Section 3 of this specification shall be verified by test, assessment, or analysis in support of certification of the design for operational use.

b. Verification of maintainability, accessibility, and ease of operation shall be demonstrated.

c. As a general guideline, off-limit testing will not be conducted. However, off limit testing will be considered:

   (1) When design margins are relatively small with respect to off-nominal abort conditions.

   (2) When uncertainty exists in the definition of the design criteria.

   (3) When single failure point modes exist.

d. Application of non-destructive evaluation (NDE) techniques for materials and parts shall be verified during the development test program.

e. Certification shall be structured to verify the full range of the design requirements under specified environments.

f. Wherever practical and technically sound, accelerated life test techniques shall be utilized.

g. All qualification test specimens shall be processed through specified acceptance testing prior to qualification test.

h. Where redundancy in design exists, each redundancy shall be verified through normal output sources designed for that purpose.

4.1.2 Verification Requirements Matrix. A verification requirements matrix is shown in Table VI. The purpose of this matrix is to provide correlation between performance/design requirements and verification requirements/methods.

4.2 Verification Methods. The following paragraphs of this section define the tests, analyses, and assessments necessary to verify that the requirements of Section 3 of this specification are met.

4.2.1 Development. The contractor shall perform development engineering evaluation of hardware, software, manufacturing processes, and techniques for the purpose of acquiring engineering data; identifying sensitive parameters; evaluating the development configuration; providing the necessary confidence that the hardware will meet the specification requirements; and assurance that the manufacturing process will produce an acceptable product. Development objectives shall encompass the following as a minimum:

a. Design and performance capability, including redundancy.

b. Ability to meet specified requirements with adequate design margin.

c. Integration of each component and subsystem with other components, subsystems, facilities, support equipment, etc., to be provided for delivery by the seller.

d. Establishment of process, procedures, equipment, and test levels for manufacturing acceptance testing, maintenance, checkout, and operational phases of the program.

e. Identification of significant failure mode and effects.

f. Determination of the effect of various combinations of tolerance and drift of design parameters.

g. Determination of the effect of combinations and sequences of environments and varying stress levels.

h. Identification of safety hazards, parameters, requirements, and procedures.

4.2.2 Acceptance. Acceptance tests and inspections shall be performed on all RMS systems to be employed in qualification test programs and on all systems delivered. These acceptance tests and inspections shall be performed to demonstrate that specified requirements have been met. Environmental acceptance testing shall be performed in accordance with SP-T-0023. Final acceptance tests and inspections shall be performed in a manner and under conditions which simulate end-use to the highest degree practicable without damage to the RMS. All final acceptance tests and inspections (TBS) determined to be necessary to demonstrate end item compliance to contract, drawing and specification requirements shall be performed.

Table VI. Performance and Design Verification Matrix

VERIFICATION METHOD

1. Analysis
2. Assessment
   a. Inspection
   b. Review of Design

N/A - Not Applicable

3. Test
   a. Development
   b. Qualification — Seller-conducted
   c. Acceptance
   d. Vehicle Acceptance
   e. Pre-Flight Checkout
   f. Horizontal Flight — Buyer-Conducted
   g. Vertical Flight
   h. Major Ground Test

Section 3 and 5 Requirement No.	N/A	1	2		3								Section 4 Requirement No.
			a	b	a	b	c	d	e	f	g	h	
Includes all paragraphs, subparagraphs, and items containing "design to" requirements in Sections 3.						TBS							

4.2.3 Certification. The seller shall certify the requirements of Section 3 by the methods specified below; however, the seller shall utilize his expertise and experience in the hardware design, his most cost effective and practical approach to certify these requirements wherever possible by analysis or assessment in lieu of test.

4.2.3.1 Certification Tests. Certification testing combined with other methods shall be performed to satisfy the requirements specified in the performance and design verification matrix (Table VI).

4.2.3.1.1 Test Hardware. Qualification test hardware shall be of the same configuration as flight hardware.

4.2.3.1.2 Performance Requirements. The RMS shall be subjected to the appropriate functional/performance tests of 4.2.2 before and after each environmental test and to selected functional/performance test during each environmental exposure. Parameter shifts during and after each environment shall not exceed the allowable values. Where complete functional/performance verification cannot be accomplished during exposure due to limited test time, the most critical failure modes and the normal operating functions associated with the environment shall have priority. Tolerance bands or pass/fail criteria shall be established for each parameter.

4.2.3.2 Certification by Analysis. Analytical certification shall be used as a supplement to and may be used in lieu of test for the following conditions:

a. When sufficient historical data or usage is available to fulfill certification requirements.

b. When specified conditions cannot be accurately or economically simulated on the ground. This includes environmental conditions as well as interaction effects under specified conditions.

4.2.3.3 Certification by Other Test Data. Test data generated from articles previously certified may be used as a certification method when it can be shown that the article is similar or identical to the article being certified. Features to be considered shall include design, performance, environmental duration and limits, manufacturing process, and quality control. Special effort shall be made to avoid duplication of previous tests from this or similar programs. Where certification by testing is required, data from other than qualification tests may be used to satisfy the requirements under the following conditions:

Predeclaration	The intent to use the test for certification is declared prior to test conduct.
Configuration	Production configuration or approval (where allowed) for differences.

Facilities	Certified
Inspection	Required
Test requirement/ procedure/pass-fail criteria	Formally approved by the NASA
Acceptance	Required
Functional test pre-, post- and during environment	Required (except for nonoperating tests such as packaging tests)
Documentation	Configuration description, failure reports, and test results

4.2.3.3.1 Mature Hardware (Off-the-Shelf).

a. Evaluate and document equipment capability utilizing a comparison matrix which includes considerations such as configuration, performance and environment versus specified requirements.

b. Where the environmental levels are more stringent than previous qualification levels, analyze or test to verify that the item can withstand the higher level design requirements.

c. For items that require minor modifications or have not been qualified to all environments, only the design modifications for the additional environments need to be certified, if cumulative and interaction effects do not exist. If cumulative and interraction effect do exist, complete qualification testing is required.

4.2.4 Test Conditions.

4.2.4.1 Operational Environments. The system level environmental conditions are as defined in paragraph 3.2.5.

4.2.4.2 Test Methods. The specified test environments shall be defined in the Verification Plan. MIL-STD-810B Test Methods shall be applicable.

4.2.4.3 Standard Test Conditions. Environmental standard test conditions for tests required by this specification shall be: an atmospheric pressure of 28.5 plus 2 or minus 4.5 inches of mercury (Hg), a temperature of 73 plus or minus 18 F and a relative humidity of 50 plus or minus 30 percent.

4.2.4.4 Test Tolerance. Test tolerances shall be used as specified in MIL-STD-810, or FED-STD-101 as applicable, except as follows:

4.2.4.4.1 Random Vibration. Test tolerances and procedures random vibration shall be in accordance with MF0004-032.

4.2.4.4.2	Shock. (acceleration vs time)	Peak amplitude:	Plus or minus 10 percent
		Pulse duration:	Plus or minus 10 percent
4.2.4.4.3	Acceleration.	Specified acceleration:	Plus 10 percent minus 0 percent
		Specified duration:	Plus 10 percent minus 0 percent

4.2.4.4.4 Measuring Instrumentation. Allowable error shall not exceed one-tenth of the tolerance specified for the parameter being measured.

4.2.4.5 Thermal Instrumentation. Instrumentation for thermal monitoring and control, as applicable, shall be as follows:

4.2.4.5.1 Test Chamber. Test chamber control instrumentation shall be in accordance with MIL-STD-810.

4.2.4.5.2 Test Article. All test articles shall be instrumented in a manner conducive to monitoring the largest internal mass of the test article for thermal stabilization and the operating temperature of critical components. The following shall also apply as applicable:

a. Thermal Vacuum. Thermal sensors shall be located on the test article surfaces being irradiated and be thermally insulated from the radiation source.

b. Ambient Pressure. Thermal sensors shall be located on the test article surfaces, but not between the test article and the heat exchanger.

c. Coldplate. Thermal sensors shall be located on the coldplate surface adjacent to the test thermal as required to monitor and control the average coldplate surface temperature. Sensors shall not be located between the test article and the coldplate surface.

d. Air Cooling. Sensors shall be located at the cooling air inlet and outlet of the test article to monitor the delta temperature and delta pressure across the test article.

4.2.5 Test Responsibility and Location. The contractor shall be responsible for implementing the requirements specified herein. Except as otherwise noted, the contractor may use his own facilities or any commercial laboratory acceptable.

5. PREPARATION FOR DELIVERY

5.1 General. Capability shall be provided for shipment of RMS hardware by truck and aircraft. The manipulator shall be shipped in a reusable shipping container designed to protect the manipulator during truck and air shipment. The container or installed support equipment shall adequately protect the manipulator from damage or degradation of performance due to the natural and induced environments encountered during transportation and subsequent storage.

5.1.1 Detailed Requirements. Packaging handling and transportation shall be in accordance with applicable requirements and guidelines of NHB6000.1(1B) as supplemented by the following:

a. Preservation and packaging shall be in accordance with the requirements of Level A of MIL-STD-794.

b. Packing shall be in accordance with the requirements of Level B of MIL-STD-794.

c. Handling capability shall be provided for hoisting and tiedown.

5.1.2 Reusable Containers. Where analysis in accordance with NHB6000.1(1B) indicates a requirement for reusable containers, maximum practical utilization shall be made of standard off-the-shelf, low cost, metal or plastic containers.

5.1.3 Monitoring Devices. MIL-I-26860 humidity indicators shall be installed in the container wall, or flexible barrier wall, of all Method II (desiccation) packages. A portable recording accelerometer, GSE Model P70-0554, furnished as GFE, shall be installed in the manipulator arm container to record in-transit shocks.

5.1.4 Packaging of Precision Clean Items. Prior to packaging in accordance with the requirements, items cleaned to the level of cleanliness specified in Section 3 shall first be pre-packaged to assure maintenance of the prescribed cleanliness level. Materials and methods shall be in accordance with Paragraph 3.6.12 of JSC07700, Vol. X.

5.1.5 Temporarily Installed Hardware Identification. All temporarily installed devices such as caps, plugs, covers, support bracketry, protective plates, etc. shall be higher, visible, red in color or shall have attached highly visible red colored streamers to ensure that they are easily identified under casual observation.

5.1.6 Pre-Production Packaging Qualification Tests. Testing to verify the functional capability of the package or transport methods/equipment shall be accomplished only if qualification cannot be verified by analysis and/or assessment.

5.1.7 Marking for Shipment. Interior and exterior containers shall be marked and labeled in accordance with MIL-STD-129 including precautionary markings necessary to ensure safety of personnel and facilities and to ensure safe handling, transport, and storage. For hazardous materials, markings shall also comply with applicable requirements governing packaging and labeling of hazardous materials. Packages with reuse capability shall be identified with the words "REUSABLE CONTAINER - DO NOT DESTROY - RETAIN FOR REUSE". NASA Critical Item Labels (Form 1368 series) shall be applied in accordance with NHB6000.1 (1B). Identification information on interior and exterior containers shall be in the following format and shall include:

CONTROL NUMBER _____

ITEM NAME _____

FSN/NATO STOCK NUMBER _____ (WHEN APPLICABLE) _____

MANUFACTURER'S TYPE OR PART NUMBER _____

QUANTITY IN PACKAGE _____ TRACEABILITY IDENTIFICATION _____

AGE CONTROL MARKING _____

CLEANING MARKING *THIS PART HAS BEEN CLEANED TO LEVEL (TBD)

SERIAL NUMBER _____

MANUFACTURER _____

PURCHASE ORDER NUMBER _____

DATE OF PACKAGING _____

LEVELS OF PACKAGING AND PACKING _____

MANUFACTURER'S PACKAGE PART NUMBER (NOT REQUIRED FOR OFF-THE-SHELF CONTAINERS)

(*) or, insert "NOT APPLICABLE" if precision cleaning is not specified in Section 3.

6. NOTES

6.1 Definitions.

6.1.1 Acceptance Tests. Inspection and tests to determine that a part, component, subsystem or system is capable of meeting design and performance requirements specified herein.

6.1.2 Assessment. A verification method employing inspection and review of design techniques to verify design features not covered by verification of test and analysis such as finishes, tolerances, bonding, identification traceability, safety wiring, warning and servicing labels, Bill Of Materials, etc. These methods may employ the orderly review and evaluation of design documentation or visual inspection techniques (e.g., mockup forms, fit checks, maintainability access, tolerances, safety wire, etc.).

6.1.3 Certification. Certification is the method by which overall verification is authenticated by documenting accomplishments of the verification processes. This consists primarily of the reporting and certifying of all formal testing, analyses, and/or simulation. It may also include the reporting of special development tests/analyses where the intent to use such data as verification of a specific requirement has been previously announced.

6.1.4 Certification by Analysis. Certification by analysis allows the use of appropriate engineering analyses including simulation to provide fulfillment of certification objectives. Certification analyses will normally be conducted due to one or both of the following factors.

(1) The inability to simulate specified conditions in an effective ground test.

(2) Qualification testing would not be practical.

Analysis may be used where it can be shown that the article is similar or identical in design, manufacturing processes, and quality control to another article that has been previously certified to equivalent or more stringent criteria.

6.1.5 Classification.

Type. This term denotes differences in like items or processes as the design, model, shapes, etc., and is designated by upper case Roman numerals (e.g., Type I, Type II).

Class. This term denotes differences in performance or physical characteristics and is designated by Arabic numerals (e.g., Class 1, Class 2).

Grade. This term denotes differences in quality of an item and is designated by capital letters (e.g., Grade A, Grade B).

6.1.6 Development Tests. Those tests performed with minimum rigors and control to verify a design approach.

6.1.7 Dummy Load. For the purposes of shock tests, a dummy load is a duplicate of the shape, size, rigidity, mounting methods, weight, mass distribution and center-of-gravity of the qualification unit. There is no requirement that it be a functioning device.

6.1.8 Fail Operational. The ability to sustain a failure and retain full operational capability for safe mission continuation.

6.1.9 Fail Safe. The ability to sustain a failure and retain the capability to successfully terminate the mission.

6.1.10 Failure. The inability of a system, subsystem, component, or part to perform its required function within specified limits, under specified conditions for a specified duration.

6.1.11 Functional Path. A functional path is a serial set of one or more functional elements (e.g. LRU's) constrained by the following:

a. It is either the only path capable of performing the given function, or it is the smallest set (shortest string) of serial elements for which identical or similar serial elements can be substituted by automatic or manual control (on-board or via GSE) to perform the same function for fail safe or fail operational capability.

b. The functional path may contain redundancies within itself to assure a satisfactory MTBF for the string (e.g. redundant components within an LRU), but redundancies within the functional path shall not be needed to provide fail safe or fail operational capabilities.

c. The point on a path at which several "downstream" paths originate must constitute the termination point of the "upstream" functional path and the starting point of each "downstream" functional path.

6.1.12 Line Replaceable Unit (LRU). A combination of components, units, parts, assemblies, subassemblies, etc., that are contained in one package or are so arranged that together the combination is common to one mounting; and in addition, provides a complete function(s) to the larger entity within which it operates.

In order to aid in the further definition on an individual basis, the following list of characteristics which can be attributed to a Line Replaceable Unit are provided:

b. After installation readiness verification, it can be installed in any vehicle or GSE end item without regard to serial number.

c. The installation does not require manufacturing type tooling of dimensional or other similar nature.

d. It does not require engineering support during the installation or removal.

e. It does not require more time or involve more spares costs or other resources that is next assembly for installation or removal.

6.1.13 Maintenance.

a. Organizational- Level Maintenance. Maintenance performed on vehicle subsystems and related support equipment in direct support of the turnaround flow. It includes scheduled and unscheduled servicing and maintenance action. It involves removal and replacement of LRUs, but does not include disposition, repair, service, calibration, and verification of the removed LRUs.

b. Intermediate-Level Maintenance. Maintenance that is performed in direct support or organizational-level maintenance and involves disposition, repair, service, calibration, and verification of items removed during organizational maintenance. It normally excludes activities requiring equipment, facilities, or skills which can be provided more economically at the depot level.

c. Depot-Level Maintenance. Maintenance that is performed by designated maintenance sources, e.g. manufacturers USAF Air Material areas, NASA development centers, etc. It normally consists of maintenance that requires equipment, facilities, or skills that are not economically available at the intermediate level, e.g., repairing, modifying, overhauling, reclaiming, or rebuilding parts, assemblies, subassemblies, components, and end items; emergency manufacturing of unavailable parts; technical assistance for the organizational and intermediate maintenance levels.

d. Unscheduled Maintenance. The unscheduled actions performed, as a result of failure (including incipient failures), to restore an item to a specified condition.

e. Scheduled Maintenance. The attempt to retain an item in a specified condition through systematic inspection, detection, and servicing for the prevention of incipient failure.

6.1.14 Operating Capability. The capability of an item to perform its intended function in accordance with its predetermined design/performance criteria.

6.1.15 Operating Cycles. The cumulative number of times an item completes a sequence of activation and return to its initial state; e.g., a switched-on/switched-off sequence, a valve-opened/valve-closed sequence, a tank pressurized/depressurized, or dewar cryogenic exposure/drain.

6.1.16 Operating Life. The specified operating time/cycles which an item can accrue before replacement or refurbishment without risk of degradation or performance beyond acceptable limits.

6.1.17 Preflight Checkout. Verifies that the flight hardware functions within prescribed limits when the subsystems are operated alone, or together as an integrated vehicle.

6.1.18 Positions of the Manipulator Arm While in RMS Retention Fittings. Reference ICD-3-0018-01.

6.1.19 Qualification. Qualification is defined to mean the demonstration of required performance under environmental conditions which is accomplished on individual units or subassemblies (LRU's) to substantiate the compliance of that particular design of hardware to the orbiter environmental requirements and specified condition. Environmental qualification may consist of test or of comparative analyses and will establish the functional capabilities of each unit under orbiter environmental conditions.

6.1.20 Shelf Life. That period of time during which an item remains in storage without having its operability affected. Preventive maintenance, servicing, and replacement of age-sensitive material parts shall be permitted on a scheduled basis during the storage period.

6.1.21 Sheltered. A warehouse type facility, enclosed, and providing protection against environmental conditions.

6.1.22 Shop Replaceable Unit. A SRU is an integral subassembly of an LRU consisting of units and parts or a combination of parts so arranged that together the combination is common to one mounting; and in addition provides a complete function(s) to the larger entity within which it operates.

6.1.23 Significant Surface. That surface area which contacts the service fluid(s) of the system.

6.1.24 Single Failure Point. A single element of hardware, the failure of which would lead directly to loss of life, vehicle or mission. Where safety considerations dictate that abort be initiated when a redundant element fails, that element is also considered a single failure point.

6.1.25 Stress. For the purpose of interpretation of this section, the following definitions will apply:

a. Limit Load. The maximum load or maximum operating pressure expected on the structure during mission operation, including intact abort.

b. Ultimate Factor of Safety. The factor by which the limit load is multiplied to obtain the ultimate load.

c. Ultimate Load. The limit load multiplied by the ultimate factor of safety.

d. Allowable Load. The maximum load which the structure can withstand without rupture or collapse.

e. Maximum Operating Pressure (Limit Load). The maximum pressure applied to a pressure vessel by the pressurizing system with the pressure regulators and relief valves at their upper limit and with the maximum regulator fluid flow rate.

f. Proof Pressure. The pressure to which production pressure vessels, including lines and components, are subjected to fulfill the acceptance requirements, in order to give evidence of satisfactory workmanship and material quality. Proof pressure is the maximum operating pressure times the proof factor which is determined by fracture mechanics analysis or 1.10, whichever is greater.

g. Burst Pressure. Burst pressure shall be the product of the maximum operating pressure and the ultimate factor of safety.

6.1.26 Structures.

a. Primary Structure. That structure consisting of the forward fuselage, crew compartment, midfuselage, aft fuselage, wing and vertical tail as they pertain to the basic framework to distribute and react external and internal loads resulting from all design flight and ground loads and their associated operational environments.

b. Secondary Structure. Those structures that interface with the primary structure for structural accommodations and attachment provisions for payloads, equipment, handling, other subsystem groups, and any item requiring structural interface with the Orbiter.

c. Secondary Structure Attach Points. Those load elements that secure secondary structures to primary structures. This includes all mechanical or physical bonding means (e.g., weld, rivet, threaded fasteners, etc).

6.1.27 Structural Safe-Life. A design approach under which structural failure will not occur because of undetected flaws and/or fatigue damage during the specified service life of the article; also, the period of time for which the integrity of the structure can be ensured in the expected operating environments.

6.1.28 Torr. The Torr is defined as 1/760 of a standard atmosphere of 1,013,250/760 dynes per square centimeter. This is equivalent to defining the Torr as 1333.22 microbars, and differs by only one part in seven million from the International Standard millimeter of mercury.

6.1.29 Unsheltered. An open area, unprotected against environmental conditions.

6.1.30 Useful Life. The item's total life span including operating life and storage with normal preventive maintenance, servicing, repair, and replacement of parts before item is considered unacceptable for further usage. This life span may be equal to (throw-away), or greater than (repair, refurbishable) the value specified for "operating life".

6.1.31 Manipulator Stiffness. Manipulator stiffness is defined as the ratio of tip deflection to tip force for a fully-extended arm. The primary consideration in developing this requirement is to insure a natural frequency for the arm which is compatible with the control system such that a controllable manipulator results.

6.1.32 Resolved Rate Control. Resolved rate control is a rate system where the motion of the end effector or some other pre-selected reference can be driven in a rectilinear translational motion at a rate proportional to the deflection of the translational hand controller, and a rotational rate proportional to the deflection of the rotational hand controller. Essentially, Resolved Rate relates translational and rotational commands of the reference system to the Remote Manipulator arm joint angle rates in a manner where the commanded motion of the reference system is obtained. Figure 5 shows the Resolved Rate reference system located in the end effector. It should be noted that the commands move with the orientation of the end effector. For example, if the end effector were in the horizontal plane with respect to the Shuttle, a plus X command would move parallel to the Shuttle X axis, as shown on Figure 12(a). If the end effector were rotated 90° down, a plus X command would be in the Shuttle Z direction, Figure 12(b).

6.1.33 Control. That part of the equipment which is used by the operator to bring about changes in equipment performance; e.g., pushbutton, toggle switch, rotary selector, knob, crank, handwheel, level and pedal.

6.1.34 Control Guarding. A method used to prevent the inadvertent actuator of a control that usually affects crew safety, mission success, involves one-way irreversible functions (including pyrotechnics), or where inadvertent actuation, if undetected, may allow functions to be performed incorrectly.

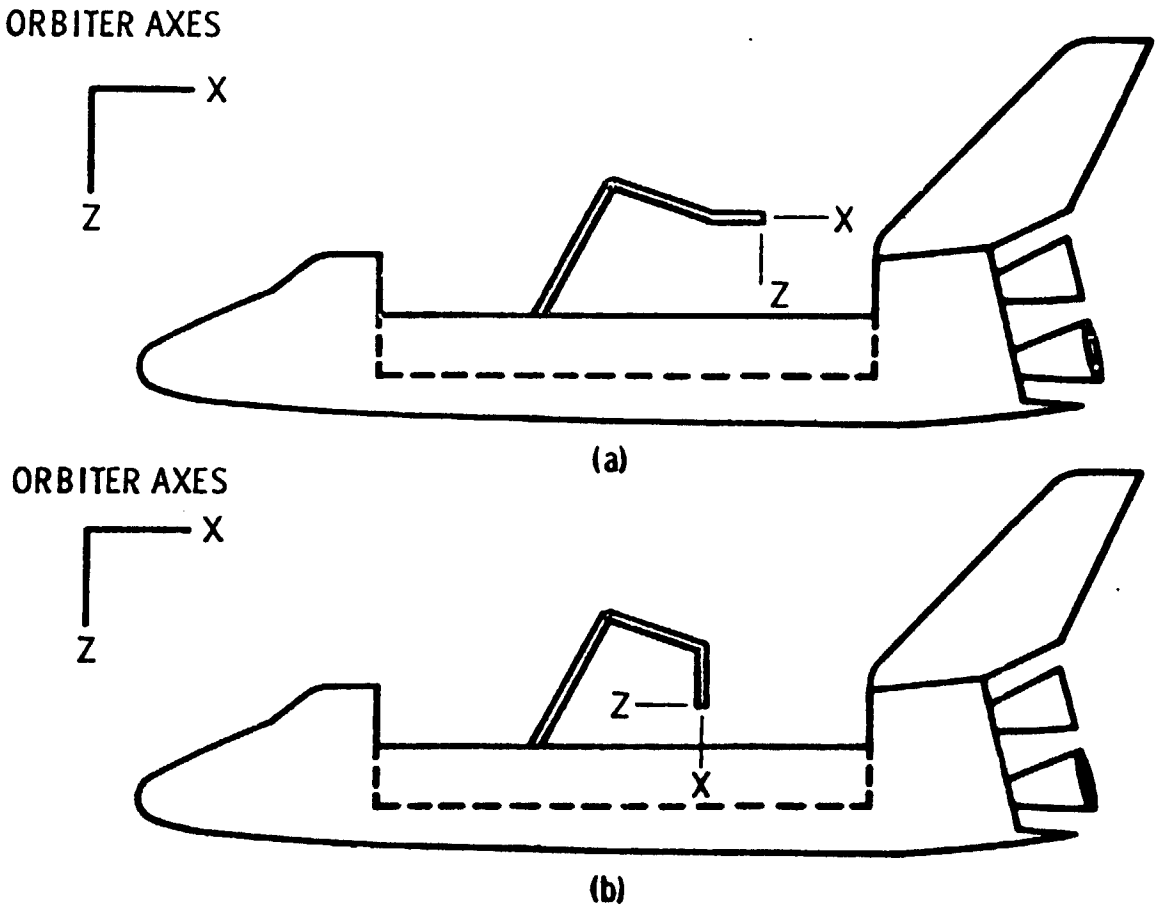


FIGURE 12. RESOLVED RATE MOTION WITH END EFFECTOR ORIENTATION

6.1.35 Display. A device which presents information to an operator; e.g., meter, digital indicator, signal light, flag indicator, cathode ray tube (CRT), or similar device.

6.1.36 Flight Crew Equipment. Any spaceborne equipment provided for or operated by the flight crew.

6.1.37 Time-Shared Display. A display not requiring continuous monitoring, which may be used to display parameters from other sources. Generally used with a select switch for selection of parameters to be displayed.

6.1.38 Legend Plate. The surface on which the legend (words, symbols, or numbers) is depicted.

6.1.39 Verification. The orbiter verification program is defined as the process by which the design of the orbiter systems and the implementation of that design is demonstrated by proof or positive evidence to meet the requirements established in the End Item Procurement Specification. The elements leading to final verification include development tests, analyses, simulations, environmental qualification/certification tests, major ground tests, and orbiter flight tests.

6.1.40 Augmented Tests. Those tests which use external aids; i.e., GSE, to accomplish the test.

6.1.41 Unaugmented Tests. Those tests which are self contained, requiring no support equipment to accomplish the test.

6.2 Abbreviations and Acronyms. Abbreviations and acronyms used in this specification are defined as follows:

ac	Alternating current
amp	Ampere
BITE	Built-in test equipment
Btu	British thermal unit
CCTV	Closed circuit television
CFE	Customer Furnished Equipment
CG	Center of Gravity
dB	decibel
dc	Direct current
D&C	Displays and controls
DPS	Degrees per second
DSKY	Display Keyboard
DOF	Degrees of Freedom
EEE	Electronic/Electrical/Electromechanical
EIA	Electronic Industries Association
EMC	Electromagnetic compatibility
EOS	Earth Observation Satellite
F	Fahrenheit
ft	Foot or feet
ft^2	Square foot or feet
ft^3	Cubic feet
FS	Feet per second
FSN	Federal stock number
FPS	Feet per second
g	Gravity
GFE	Government Furnished Equipment
GSE	Ground Support Equipment
GPC	General purpose computer
He	Helium
Hg	Mercury
hr	Hour
Hz	Hertz (cycles per second)
ICD	Interface Control Document
kHz	HiloHertz (kilocycles per second)

lb	Pound
LDEF	Long Duration Exposure Facility
LRU	Line replaceable unit
LST	Large Space Telescope
mg	Milligram
MHz	Mega Hertz (megacycles per second)
mm	Millimeter
mv	Millivolt
NASA	National Aeronautics and Space Administration
NATO	North Atlantic Treaty Organization
NDE	Non-destructive evaluation
NSN	National Stock Number
RHC	Rotational Hand Controller
RMS	Remote Manipulator Subsystem
sec	second
SRU	Shop replaceable unit
std	Standard
TBD	To be determined by buyer
TBS	To be supplied by seller
THC	Translation hand controller
TV	television
usec	Microseconds
v	Volts
vac	Volts alternating current
vdc	Volts direct current
Va	Volts along A axis
Vb	Volts along B axis
Vc	Volts along C axis
Vp	Volts along P axis
Vr	Volts along R axis
Vs	Volts along S axis

JSC 10633

ADDENDUM I

SAFETY, RELIABILITY, and QUALITY ASSURANCE DATA REQUIREMENTS

NOVEMBER 24, 1975

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XXXXXXXX MBER a Addendum I to JSC 10633	NATIONAL AERONAUTIC. 10 SPACE ADMINISTRATION LYNDON B. JOHNSON SPACE CENTER DATA REQUIREMENTS LIST (DRL) (The Center Data Manager (Code jm2) will assign numbers in blocks d, 2, and 6.) TELEPHONE NUMBER 713 483-6391	RESPONDENT f
EXHIBIT NUMBER b		PREPARATION DATE 11/24/75 g
CONTRACT/RFP NUMBER c JSC 10633		PAGE h 1
DRL NUMBER d T-1261	PROJECT/SYSTEM e RMS (Remote Manipulator System)	REVISION i none

1 LINE ITEM NO.	2 DRD NUMBER	3 TITLE	4 O P R	5 TYPE	6 JSC DOCUMENT NUMBER	7 FREQ. OF SUBM.	8 INITIAL SUBMITTAL	10 A-S OF DATE	11 COPIES A TYPE	11 COPIES B NO.
1	RA 328TA	Plan, Reliability	NB5	1		RT	Block 9	Block 9	Print	3
9. REMARKS: Block 8 - Due 45 days after contract go-ahead										
2	RA 329TA	Reports, Reliability Progress	NB5	2		MO	Block 9		Block	9
Block 8 - Combine as a section of Engineering Monthly Report - DRL _____. Block 11 - Reliability to receive one copy of Engineering Monthly Report										
3	RA 330TA	EEE Parts (where used) and Qualified Parts List, cation Status Printout	NB5	2		RT	Block 9		Print	3
Block 8 - Preliminary List is working days prior to component (black box) PDR. Maintain and update as required to support major milestone reviews.										
4	RA 331TA	Request, Approval for Irregular EEE Parts Usage and WTSC (wet tantalum slug capacitor)	NB5 Application	1		AR	Block 9		Print	3
Block 8 - 21 days prior to part procurement. If available in-house submittal is due 21 days prior to installation.										

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JSC DATA REQUIREMENTS LIST (DRL) (CONTINUATION SHEET)	DRL NUMBER T-1261	REVISION none	PAGE 2

1	2	3	4	5	6	7	8
5	RA 332TA	EEE Qualification Part Test	NB5	*		AR	Block 9

9 Block 8 - Test request submitted 30 days prior to test start date. Test plan submitted no later than 15 days after test request approval.

* Test request are type 1 data; test plans are type 2 data.

10 COPIES: A Print 3; B

1	2	3	4	5	6	7	8
6	RA 333TA	EEE Specification	NB5	2		AR	Block 9

9 Block 8 - Submit 30 working days prior to PDR or 30 days after placement of order, whichever occurs first.

10 COPIES: A Print 3; B

1	2	3	4	5	6	7	8
7	RA 334TA	EEE Parts Application and Stress Analysis	NB5	2		AR	Block 9

9 Block 8 - Submit 15 working days prior to CDR

10 COPIES: A Print 3; B

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1	2	3	4	5	6	7	8
8	RA 335TA	Report EEE Part Qualification Test	NB5	2		AR	Block 9

9 Block 8 - Test report submitted 30 days after completion of test

10 COPIES: A Print 3; B

1	2	3	4	5	6	7	8
9	RA 336TA	Documentation, NASA ALERT System	NB5	2		AR	Block 9

9 Block 8 - ALERT report (Form 863) within 5 days of problem identification; response to NASA ALERT within 21 days.

10 COPIES: A Print 3; B

JSC DATA REQUIREMENTS LIST (DRL) (CONTINUATION SHEET)	DRL NUMBER T-1261	REVISION none	PAGE 3

1	2	3	4	5	6	7	8
10	RA 338TA	Analysis, Failure Mode and Effect (FMEA)	NB5	1		RT	Block 9

9 Block 8 - Preliminary FMEA submittal 30 calendar days prior to PDR. Final FMEA submittal 30 calendar days prior to CDR or with CDR data package. Update as required to support design changes.

10 COPIES: A Print 10; Repro 1

1	2	3	4	5	6	7	8
11	RA 339TA	List, Critical Item (CIL)	NB5	1		RT	Block 9

9 Block 8 - Submittal same as FMEA schedule

10 COPIES: A Print 10; Repro 1

1	2	3	4	5	6	7	8
12	RA 340TA	Specification, Certification Test	NB5	1		RT	Block 9

9 Block 8 - Certification test specification submitted 60 days prior to initiation of testing.

10 COPIES: A Print 3; Repro 1

1	2	3	4	5	6	7	8
13	RA 341TA	Plan, Certification Test	NB5	1		AR	Block 9

9 Block 8 - Certification test plan submitted 30 days prior to initiation of testing

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10 COPIES: A Print 3

1	2	3	4	5	6	7	8
14	RA 342TA	Report, Certification Test (CTR)	NB5	2		AR	Block 9

9 Block 8 - Certification test report submitted 30 days after completion of test.

10 COPIES: A Print 3

JSC DATA REQUIREMENTS LIST (DRL) (CONTINUATION SHEET)	DRL NUMBER T-1261	REVISION none	PAGE 4

1	2	3	4	5	6	7	8
15	RA 343TA	Report, Engineering Analysis (EAR)	NB5	2		AR	Block 9

9 Block 8 - Analysis report due 30 days after completion of test.

10 | 11 COPIES | A Print 3 | B

1	2	3	4	5	6	7	8
16	RA 344TA	Specification, Acceptance Test	NB5	1		RT	Block 9

9 Block 8 - Acceptance test specification due 60 days prior to initiation of testing.

10 | 11 COPIES | A Print 3 | B

1	2	3	4	5	6	7	8
17	RA 346TA	Report, Certification Status (CSR)	NB5	2		MO	Block 9

9 Block 8 - Report due initially 30 days after qualification with monthly updates (part of monthly report)

10 | COPIES | A block | B 9

1	2	3	4	5	6	7	8
18	RA 348TA	List, Limited Life	NB5	1		AD	Block 9

9 Block 8 - Initial submittal due 45 days prior to CDR. The list shall be reviewed by the contractor and updated within 15 days of any change.

10 | 11 COPIES | A Print 3 | B | Repro 1

1	2	3	4	5	6	7	8
19	RA 375T	List, Critical Process Control Procedures	ND6	2		RT	Block 9

9 Block 8 - Preliminary list 15 days prior to PDR. Updates as required.

10 | 11 COPIES | A Print 3. | B

JSC DATA REQUIREMENTS LIST (DRL) (CONTINUATION SHEET)	DRL NUMBER T-1261	REVISION none	PAGE 5

1	2	3	4	5	6	7	8
20	RA 376T	Plan, Quality Program	ND6	1		RT	Block 9

9 Block 8 - Due 45 days after contract go-ahead. NOTE: Paragraph 2, "Site Plans," is deleted.

10 COPIES: A Print 3; B

1	2	3	4	5	6	7	8
21	RA 377T	Plans, Sampling	ND6	2		RD	Block 9

9 Block 8 - To be submitted 15 days prior to CDR.

10 COPIES: A Print 3; B

1	2	3	4	5	6	7	8
22	RA 378T	Report, Problem	ND5	1		AR	Block 9

9 Block 8 - Submittals as stated in DRD as required.

10 COPIES: A; B

1	2	3	4	5	6	7	8
23	RA 379T	Package, Acceptance Data	ND6	1		PV	Block 9

9 Block 8 - One copy with equipment. One copy to JSC, Code ND6

10 COPIES: A Print 2; B

1	2	3	4	5	6	7	8
24	RA 382T	Procedures, Handling, Storage, Preservation, Marking, Labeling, Packaging, Packing, and Shipping	ND6	2		AR	Block 9

9 Block 8 - Submittals 30 days prior to use of procedure

10 COPIES: A Print 2; B

JSC DATA REQUIREMENTS LIST (DRL) (CONTINUATION SHEET)	DRL NUMBER T-1261	REVISION none	PAGE 6

1	2	3	4	5	6	7	8
25	RA 385T	Log Books, Recording Age Control	ND6	3		PV	Block 9

9 Block 8 - To be included in acceptance data package at time of delivery.

10 COPIES: A Print 2; B

1	2	3	4	5	6	7	8
26	RA 386T	Log, Control of Temporary Installations	ND6	3		PV	Block 9

9 Block 8 - To be included at time of delivery in acceptance data package.

10 COPIES: A Print 2; B

1	2	3	4	5	6	7	8
27	RA 390T	Procedures, Contamination Control	ND6	2		RD	Block 9

9 Block 8 - To be submitted 15 days prior to CDR.

10 COPIES: A Print 2; B

1	2	3	4	5	6	7	8
28	SA 039T	Report, Safety Analysis	NS	1		AD	Block 9

9 DRD SA-039T - Requires the results of Safety Analysis to be submitted as they are completed and 30 days prior to PDR and CDR.

10 COPIES: A Print 2; B

1	2	3	4	5	6	7	8
29	SA 055T	Plan, Safety (Condensed)	NS	1		RT	Block 9

9 Draft copy submitted 60 days after contract or project started.

10 COPIES: A Print 2.; B

JSC DATA REQUIREMENTS LIST (DRL) (CONTINUATION SHEET)	DRL NUMBER	REVISION	PAGE
	T-1261	none	7

1	2	3	4	5	6	7	8
30	MA 600T	Waiver/ Deviation Request	NA2	1		AR	Block 9

9 Block 8 - Waiver/Deviation requests to be submitted immediately after identification of condition requiring such request.

10 COPIES A	B
Repro	2

1	2	3	4	5	6	7	8

9

10 COPIES A B

1	2	3	4	5	6	7	8

9

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10 COPIES A B

1	2	3	4	5	6	7	8

9

10 COPIES A B

1	2	3	4	5	6	7	8

9

10 COPIES A B

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER
DATA REQUIREMENT DESCRIPTION

DRL NUMBER: T-1261
LINE ITEM NUMBER: 1

1. TITLE
PLAN, RELIABILITY

2. NUMBER
RA-328TA

4. DATE
June 1975

3. USE
To provide a plan to describe how the contractor will ensure compliance with specified reliability requirements. This plan shall serve as the master planning and control document for reliability.

5. ORGANIZATION
NASA JSC

6. REFERENCES
NHB 5300.4(1D-1)

7. INTERRELATIONSHIP

(The Center Data Manager (Code JM2) will assign numbers in block 2.)

8. PREPARATION INFORMATION

The plan shall describe the responsibilities associated with the conduct of the reliability activity including the interfaces involving responsibilities and functions where more than one organization element is involved and the relationship of the reliability activity to program organizational elements. The contractor's method of implementation of each reliability task and a definition of what constitutes accomplishment of each task shall be included in the plan. The reliability tasks are:

a. Reliability management
b. Design specifications
c. Design reviews
d. Numerical reliability analysis
e. Failure mode and effects analysis and critical items list
f. Maintainability
g. Problem corrective action (design orientated problems)
h. Parts and materials activity
i. Testing

A summary (matrix or other brief form) shall be included which indicates for each reliability documentation requirement, the principal organization responsible for generating necessary documents. In addition, the summary shall indicate each contractor organization which has approval or review authority relative to documents generated.

The plan shall include narrative descriptions, time or milestone schedules, and supporting data which describe the contractor's plan for execution and management of the reliability activities. Directives, methods, and procedures shall be documented by the contractor, and these documents shall be referred to in the Reliability Plan and made available to NASA and submitted on request.

The plan shall identify those activities which will utilize the contractor's existing reliability practices and documents and shall identify those requiring changes.

The plan shall describe the contractor's approach for establishing reliability requirements for subcontract hardware/software including formal and informal controls and the method of selecting and implementing each.

The plan shall identify which reliability requirement shall apply to the sites and shall prepare a self-contained separate part of the Reliability Plan applicable to the sites or a separate plan for each site.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
LYNDON B. JOHNSON SPACE CENTER
DATA REQUIREMENT DESCRIPTION

DRL NUMBER: T-1261
LINE ITEM NUMBER: 2

1. TITLE: REPORTS, RELIABILITY PROGRESS

2. NUMBER: RA-329TA

4. DATE: June 1975

3. USE: To furnish visibility of technical progress for each Reliability task.

5. ORGANIZATION: NASA JSC

6. REFERENCES: NHB 5300.4 (1D-1)

7. INTERRELATIONSHIP:

(The Center Data Manager (Code JM2) will assign numbers in block 2.)

8. PREPARATION INFORMATION

Reliability progress shall be reported at monthly management meetings, monthly management meetings via telecon, or included as part of the overall monthly management progress report. The management meeting minutes will document the monthly Reliability progress. The Reliability progress that will be reported shall include the following as applicable:

a. Technical progress of each reliability task including significant accomplishments and milestones reached during the reporting period.

b. Reliability problem areas and proposed corrective actions.

c. Decisions and actions during the reporting period having impact on the reliability effort and description of their anticipated effect on hardware reliability.

d. Revised scheduled for contract work and significant events in the succeeding reporting period.

e. Anticipated reliability tasks slippages and their effects.

f. Planned and actual manpower data applicable to the implementation of the Reliability tasks.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION LYNDON B. JOHNSON SPACE CENTER **DATA REQUIREMENT DESCRIPTION**	DRL NUMBER T-1261 LINE ITEM NUMBER 3
1. TITLE LIST, EEE PARTS (WHERE USED), AND QUALIFICATION STATUS PRINTOUT	2. NUMBER RA-330TA 4. DATE June 1975
3. DESCRIPTION/PURPOSE To provide a summary of EEE parts usage.	5. ORGANIZATION NASA JSC 6. REFERENCES NHB 5300.4(1D-1) 7. INTERRELATIONSHIP

(The Center Data Manager (Code JM2) will assign numbers in block 2.)

8. PREPARATION INFORMATION

The where-used EEE parts list identifies flight equipment and EEE parts used in contractor, subcontractor, and supplier equipment design applications. The contents of the list should include identification of parts by generic part name and type, common designation, specification control drawing (e.g., ME number), manufacturer's H4 code or name, manufacturer's part number, qualification status, quantity used per application, and component (black box) part number.

The format of the list shall be indexed by the following topical headings followed by the remaining data listed above:

a. Generic part name and type and common designation (e.g., diode, zener, 1N2970).

b. Component (black box) part number (e.g., MEXXX-XXXX).

c. Limited usage controlled parts list by generic part name and type and common designation.

d. Irregular parts list by generic part name and type and common designation.

Initial submittal of parts lists, format optional, are required 15 working days prior to component (black box) PDR's and CDR's. If a PDR or CDR is not held at the component level, a parts list, format optional, shall be submitted 15 working days prior to the subsystem PDR and CDR. Printouts in accordance with format a and b incorporating all the individual parts list, including design changes, shall be submitted monthly. Printouts in accordance with format c and d incorporating all individual parts lists, including design changes, shall be submitted on request to support major milestone reviews.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER
DATA REQUIREMENT DESCRIPTION

DRL NUMBER: T-1261
LINE ITEM NUMBER: 4

1. TITLE
REQUEST, APPROVAL FOR IRREGULAR EEE PARTS USAGE AND WTSC (WET TANTALUM SLUG CAPACITOR) APPLICATION(S)

2. NUMBER: RA-331TA
4. DATE: June 1975

3. DESCRIPTION AND PURPOSE
To identify and provide rationale for approval to use irregular EEE parts and wet tantalum slug capacitors.

5. ORGANIZATION: NASA JSC
6. REFERENCES: NHB 5300.4 (1D-1)
7. INTERRELATIONSHIP

(The Center Data Manager (Code JM2) will assign numbers in block 2.)

8. PREPARATION INFORMATION

Scope - To coordinate approval to use parts which lack any characteristics of a controlled part and to coordinate sound design practices in the use of WTSC's in orbiter and launch/landing critical ground support equipment.

Definition - Irregular parts: A part which is deficient in or lacking one or more of the following controls: a) specification, b) qualification test to the specification, c) traceability, and d) screen and burn-in.

Contents

a. Irregular parts usage request shall, as a minimum, contain the following information:

(1) Equipment name, function and criticality, component number and serial number, supplier/subcontractor and effectivity.

(2) Subassembly name, number, and criticality.

(3) Part name, type and common designation (closest commercial equivalent), specification number and part manufacturer of the parts contained in the as-designed equipment.

(4) Irregular part number, part manufacturer and specification number, part name, part type, common designation (closest commercial equivalent).

(5) Salient differences including SCD reliability and quality requirements and screening and burn-in between design baseline and irregular parts.

(6) Qualification status and basis of qualification of irregular part.

(7) Limited life (yes, no).

(8) Justification for use of the irregular part including technical adequacy.

Where a limited life item is affected, the contractor shall ensure that proper changes are made to limited life control lists. 96

JSC Form 2341 (Nov 71)

8. Preparation Information (cont'd)

Contents (cont'd)

b. WTSC Application

(1) Requesting Orbiter Project Parts Authorization Request.

(2) Complete identification of proposed part.

(3) The intended application of the part. For WTSC's a circuit diagram and circuit analysis is required to demonstrate absence of adverse conditions on the WTSC such as reverse bias, ripple current, etc.

(4) Part manufacturer(s).

(5) Other type capacitors listed in the OPPL (Orbiter Project Parts List) which could be used in lieu of the WTSC.

(6) Justification for requiring the non-OPPL part.

(7) Part specification (refer to IRD RA-273TA).

(8) Qualification status and schedule impact if qualification test is required (refer to IRD RA-263TA).

Format - SD report - or letter with enclosures as appropriate.

Schedule - Submittal of request is due no later than 21 working days prior to part procurement. If part is in-house, 21 working days prior to part installation.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
LYNDON B. JOHNSON SPACE CENTER

DATA REQUIREMENT DESCRIPTION

DRL NUMBER: T-1261
LINE ITEM NUMBER: 5

1. TITLE
REQUEST/PLAN, EEE PART QUALIFICATION TEST

2. NUMBER: RA-332TA

4. DATE: June 1975

3. USE
To establish the plan for accomplishment of EEE part qualification tests.

5. ORGANIZATION: NASA JSC

6. REFERENCES: NHB 5300.4(1D-1)

7. INTERRELATIONSHIP

(The Center Data Manager (Code JM2) will assign numbers in block 2.)

8. PREPARATION INFORMATION

The EEE Part Qualification Test Request/Plan serves as the vehicle for coordinating approval for expenditure of funds to qualify a part. The request for part qualification shall include the following:

a. Part identification and manufacturer.

b. Application (black box).

c. Tests required.

d. Tests not required on the basis of existing data.

e. Schedule impact.

f. Part specification.

The Parts Qualification Test Plan shall as a minimum describe the following:

a. Completed Parts Procurement Drawing/Specification for each part covered by the plan as a separate document.

b. Detail description of the test. Where appropriate, refer to MIL-STD-202, etc., for test methods used. Where appropriate, identify the facility or agency that will do the test, the equipment to be used, and whether the agency is certified by NASA or the buyer.

c. Show a detailed schedule of events and show how part qualification meets end item schedules.

Initial submittal of qualification test requests are due 30 days prior to scheduled initiation of the specific part qualification test. The parts qualification test plan shall be submitted no later than 15 days after test request approval and updated as necessary.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION LYNDON B. JOHNSON SPACE CENTER DATA REQUIREMENT DESCRIPTION	DRL NUMBER T-1261 LINE ITEM NUMBER 6
1. TITLE SPECIFICATION, EEE PART	2. NUMBER RA-333TA 4. DATE June 1975
3. USE Required to control EEE parts, including qualification, screen and burn-in, traceability, and Quality Assurance requirements.	5. ORGANIZATION NASA JSC 6. REFERENCES NHB 5300.4(1D-1) 7. INTERRELATIONSHIP

(The Center Data Manager (Code JM2) will assign numbers in block 2.)

8. PREPARATION INFORMATION

The specification shall completely describe performance, design, qualification, and Quality Assurance requirements for EEE parts specified in the end item design. EEE parts in the end item shall be purchased to a controlling specification. (Not required where existing JAN-TX and MIL-ER or other existing specifications satisfy NHB 5300.4(1D-1) for this type documentation.)

The drawings/specifications shall delineate, as a minimum:

a. A complete identification of the part including generic equivalent, physical, environmental, and performance requirements; quality and reliability assurance requirements including inspections and tests for qualification, acceptance, and lot sampling where required; explicit requirements to be satisfied in accepting parts for use in the contract hardware including 100 percent screen and burn-in; packaging, storage, and handling requirements; traceability requirements; and data retention and submittal requirements.

b. Where a combination of specifications is used collectively to provide all the above requirements for a single part type, the detail specification (slash sheet, specification or source control drawing, etc.) for that part type shall provide detailed cross-reference to all other applicable specifications.

c. Each EEE parts drawing/specification shall be identified by a unique number and shall be subject to a formal system of change control.

d. Seller-originated requirements documents which are incorporated into the part specification by reference shall be submitted along with the part specification in order to facilitate review of the total requirements.

Available 30 days prior to supplier Preliminary Design Review (PDR) or 60 days after placement of order, whichever occurs first, and for those items requiring qualification 30 days prior to scheduled qualification test start date. Updated as necessary to reflect authorized changes.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
LYNDON B. JOHNSON SPACE CENTER

DATA REQUIREMENT DESCRIPTION

DRL NUMBER: T-1261

LINE ITEM NUMBER: 7

1. TITLE: DATA, EEE PART APPLICATION AND STRESS ANALYSIS

2. NUMBER: RA-334TA

4. DATE: June 1975

3. USE: To provide sufficient analysis to verify authorized EEE parts are not overstressed in worst-case environments, operating conditions, and duty cycles. These data are part of those data required prerequisite to design reviews and available for parts problem analyses.

5. ORGANIZATION: NASA JSC

6. REFERENCES: NHB 5300.4(1D-1)

7. INTERRELATIONSHIP:

(The Center Data Manager (Code JM2) will assign numbers in block 2.)

8. PREPARATION INFORMATION

The data are to verify appropriate derating and stress considerations of EEE parts in design applications.

These data shall document the results of EEE parts applications and stress analysis reviews conducted prior to design release for black boxes as follows:

a. Determination of electrical, thermal, and mechanical stresses experienced by parts in their equipment applications and verification of compliance with derating requirements.

b. Consideration of functional adequacy and possible sensitivity of parts to specific applications.

To be prepared in Contractor's report format.

Submittal due 15 days before component (black box) Critical Design Review (CDR) or subsystem CDR, whichever occurs first. Updated for each design change by page revisions/reissuance.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
LYNDON B. JOHNSON SPACE CENTER
DATA REQUIREMENT DESCRIPTION

DRL NUMBER - T-1261

LINE ITEM NUMBER - 8

1. TITLE
REPORT, EEE, PART QUALIFICATION TEST

2. NUMBER
RA-335TA

4. DATE
June 1975

3. USE
To document the results of EEE part qualification tests.

5. ORGANIZATION
NASA JSC

6. REFERENCES
NHB 5300.4(1D-1)

7. INTERRELATIONSHIP

(The Center Data Manager (Code JM2) will assign numbers in block 2.)

8. PREPARATION INFORMATION

The document will cover each new EEE part qualified by test to its specification.

The test reports shall contain:

a. Reference to related qualification test plan/description of test.

b. Sample size, measurements taken, test procedure, sequence, equipment used and acceptance criteria.

c. Identification of measurements outside acceptable criteria, identification all failures, failure analysis.

d. Statement as to successfulness of test, and qualification status of the part.

e. Reference to the controlling specification to which the qualification is applicable.

To be prepared in Contractor's report format or as letter. Due 30 calendar days after EEE part qualification test completion.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
LYNDON B. JOHNSON SPACE CENTER

DATA REQUIREMENT DESCRIPTION

DRL NUMBER: T-1261

LINE ITEM NUMBER: 9

1. TITLE

DOCUMENTATION, NASA ALERT SYSTEM

2. NUMBER: RA-336TA

4. DATE: June 1975

3. DESCRIPTION

NASA distributed ALERTS identify hardware problems noted on other programs or projects and provide instructions for contractor investigation and response on usage on the Space Shuttle Program with recommendations/corrective action information. Contractor initiated ALERTS are disseminated by NASA JSC to other NASA JSC contractors and NASA Centers.

5. ORGANIZATION: NASA JSC

6. REFERENCES: NHB 5300.4(1D-1)

7. INTERRELATIONSHIP

(The Center Data Manager (Code JM2) will assign numbers in block 2.)

8. PREPARATION INFORMATION

Documentation is to provide controlled method for ALERT initiation, investigation, resolution, and response.

The responses shall identify hardware to which the response applies, problem analysis, recommendations, and/or corrective action accomplished to resolve the problem. No response is required or desired on ALERTS for nonusage items.

The contractor prepared ALERTS shall be submitted to NASA JSC for formal NASA release.

Contractor letter (NASA Form 863) is to be submitted for contractor initiated ALERTS.

Response due to NASA within 21 work days of receipt, except during near-in launch time when ALERTS will be closed in an expeditious manner. Contractor initiated ALERTS are due to NASA within 5 work days of identification of reportable item.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
LYNDON B. JOHNSON SPACE CENTER

DATA REQUIREMENT DESCRIPTION

DRL NUMBER: T-1261

LINE ITEM NUMBER: 10

1. TITLE

ANALYSIS, FAILURE MODE AND EFFECT (FMEA)

2. NUMBER: RA-338TA

4. DATE: June 1975

3. USE

To identify critical failure modes to be used as bases for:

a. Additional design action
b. Support of safety analyses
c. Support of hardware test planning
d. Support of mission contingency planning
e. Preparation of mandatory inspection points

5. ORGANIZATION: NASA JSC

6. REFERENCES: NHB 5300.4(1D-1)

7. INTERRELATIONSHIP: Provides basis for CIL

(The Center Data Manager (Code JM2) will assign numbers in block 2.)

8. PREPARATION INFORMATION

The FMEA should be prepared on as many pages as necessary using the FMEA form, a sample of which is provided on page 4, as a guide for each page and submitted to NASA for approval.

System/Subsystem/Assembly - Identify the item for which the FMEA is being conducted to the level of its identity.

Prepared By/Approved - Identify the analyst preparing the FMEA and the appropriate individual(s) responsible for the overall FMEA effort.

Page/Date/Superseding - All pages should be numbered consecutively, and the total number of pages in the FMEA should be entered on each page. The date on which each page is approved should be entered. If the page being submitted supersedes a previously submitted page, the date of the previous page should be entered on the superseding line.

A. Name - Name of component under analysis for failure mode and effects. Breakdown of a system for analysis should normally be down to the lowest practical level at the time of the FMEA. In special cases, such as electronic systems using integral modular units as system building blocks, the modules may be listed rather than listing its parts.

B. Identification Number - Drawing number by which the contractor identifies and describes each component or module.

C. Drawing Reference Designation - Reference designation used by the manufacturer to identify the component or module on the schematic. Applicable schematic and wiring numbers should also be listed.

D. System Logic Diagram Number (if applicable) - Identification number of FMEA system logic block diagram and of the function.

E. Function - Concise statement of the function performed.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION LYNDON B. JOHNSON SPACE CENTER DATA REQUIREMENT DESCRIPTION	DRL NUMBER T-1261
	LINE ITEM NUMBER 10
1. TITLE ANALYSIS, FAILURE MODE AND EFFECT (FMEA)	2. NUMBER RA-338TA
	4. DATE June 1975
3. USE	5. ORGANIZATION NASA JSC
	6. REFERENCES NHB 5300.4(1D-1)
	7. INTERRELATIONSHIP Provides basis for CIL

(The Center Data Manager (Code JM2) will assign numbers in block 2.)

8. PREPARATION INFORMATION

F. Failure Mode and Cause - Identification of the specific failure mode after considering the four basic failure conditions:

1. Premature operation.
2. Failure to operate at a prescribed time.
3. Failure to cease operation at a prescribed time.
4. Failure during operation.

For each applicable failure mode, describe the major cause(s) including operational and environmental stress factors if known.

G. Mission Phase - Phase of mission in which failure occurs, e.g., Prelaunch: checkout, countdown; Flight: boost phase, earth orbit, etc.

H.) Failure Effect on - Assembly, subsystem, system, element and/or vehicle
I.) as required.
J.)

K. Failure Detection Method - A description of the methods by which the failure could be detected.

L. Corrective Action Time Available/Time Required - A description of what corrective actions that the flight crew and the ground crew could take to circumvent the failure. Include statement of alternate means of operation and redundancy after failure.

M. Failure Mode Criticality Category and Functional Criticality Designation - Categorize the failure mode and functional criticality in relation to crew safety and mission effect. Criticality I has a detrimental effect on crew safety. Criticality 2 or 3 equipment shall be further evaluated in accordance with the redundancy hardware screens described below. A notation will be made identifying each screen the hardware does not pass.

1. The redundant elements are not capable of checkout during the normal mission turnaround sequence.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION LYNDON B. JOHNSON SPACE CENTER DATA REQUIREMENT DESCRIPTION	DRL NUMBER T-1261
	LINE ITEM NUMBER 10
1. TITLE ANALYSIS, FAILURE MODE AND EFFECT (FMEA)	2. NUMBER RA-338TA
	4. DATE June 1975
5. [illegible]	5. ORGANIZATION NASA JSC
	6. REFERENCES NHB 5300.4(1D-1)
	7. INTERRELATIONSHIP Provides basis for CIL
(The Center Data Manager (Code JM2) will assign numbers in block 2.)	

8. PREPARATION INFORMATION

2. Loss of a redundant element is not readily detectable by the flight crew.

3. All redundant elements can be lost by a single credible cause or event such as contamination or explosion.

N. Ground Rules and Assumption - Statement of all ground rules and assumptions followed during the performance of FMEA.

O. Remarks/Hazards - Statement of any remarks, recommendations, and potential hazards as required.

P. Revision - A notation should be made opposite each entry which has been changed since the previous submittal.

FAILURE MODE AND EFFECT ANALYSIS

SYSTEM _____

SUBSYSTEM _____

ASSEMBLY _____

PREPARED BY _____ PAGE _____ OF _____

APPROVED _____ DATE _____

SUPERSEDING _____

ITEM IDENTIFICATION				FUNC-TION	FAILURE MODE AND CAUSE	MISSION PHASE	FAILURE EFFECT ON			FAILURE DETEC-TION METHOD	CORRECTIVE ACTION TIME AVAILABLE/ TIME REQUIRED	FAILURE MODE CRITI-CALITY CATEGORY	REVISION
NAME	IDENT. NUMBER	DRAWING REFERENCE DESIGNA-TION	SYSTEM LOGIC DESIGN NUMBER				ASSEMBLY	SUBSYSTEM	SYSTEM				
(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)	(L)	(M)	(N)

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RA-338T

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
LYNDON B. JOHNSON SPACE CENTER
DATA REQUIREMENT DESCRIPTION

DRL NUMBER - T-1261

LINE ITEM NUMBER - 11

1. TITLE
LIST, CRITICAL ITEM (CIL)

2. NUMBER RA-339TA

4. DATE June 1975

3. DCP
To provide a summarization of criticality 1 and 2 single failure points and selected criticality 3 components.

5. ORGANIZATION NASA JSC

6. REFERENCES NHB 5300.4(1D-1)

7. INTERRELATIONSHIP Derived from FMEA

(The Center Data Manager (Code JM2) will assign numbers in block 2.)

8. PREPARATION INFORMATION

The Critical Item List shall be completed in accordance with the provisions of the Reliability FMEA procedure as outlined on DRD RA-338T.

The Critical Item List shall contain the following:

a. System/Subsystem/Assembly/Item - Identify the item on the CIL. Include on the CIL all criticality 1, 2, and 3_I items.

b. Criticality Category - Identify the criticality category of entries considered on the CIL. The entries should be grouped into criticality categories 1, 2, and 3_I.

c. FMEA Reference - Entries should refer to the FMEA from which they were derived.

d. Prepared by/Approved - Identify the analyst preparing the CIL and the appropriate individual(s) responsible for the overall FMEA/CIL effort.

e. Revision - The date that each page is revised will be entered.

f. Item Identification - Identifies the item name and item number with the entry.

g. Failure Mode and Cause - Identifies the failure mode and major cause(s) associated with the entry.

h. Failure Effect On - Subsystem, interfacing subsystem, mission/crew, element, and/or vehicle as required.

i. Disposition and Rationale - Identifies the rationale or justification for retaining the critical item within the following categories:

(1) Design.
(2) Test.
(3) Inspection.
(4) Failure history.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION LYNDON B. JOHNSON SPACE CENTER DATA REQUIREMENT DESCRIPTION	DRL NUMBER - T-1261 LINE ITEM NUMBER - 11
1. TITLE LIST, CRITICAL ITEM (CIL)	2. NUMBER RA-339TA 4. DATE June 1975
3. USE	5. ORGANIZATION NASA JSC 6. REFERENCES NHB 5300.4(1D-1) 7. INTERRELATIONSHIP Derived from FMEA

(The Center Data Manager (Code JM2) will assign numbers in block 2.)

8. PREPARATION INFORMATION

j. Redundancy Hardware Screens - Indicates each redundancy screening criterion which the redundant item fails as described in item M. of the FMEA DRD. If the item passed all redundancy screening criteria, indicate the criticality.

k. Critical Item Identification - For each item identified in paragraph i., indicate the total number of critical items resulting from use of more than one of the items in the design. Where only one is used, so indicate.

l. Total Critical Items - Include the total number of critical items by criticality. The summation shall be performed in a manner such that one item shall be counted uniquely.

Normally, pages change only for updates.

Preliminary CIL submittal is 15 working days prior to the individual preliminary design reviews. Final CIL submittal is 15 working days prior to the individual subsystem critical design reviews. Updated CIL (for each vehicle) submittal is 15 working days prior to the flight readiness reviews. Revision submittal is made as necessary prior to subsequent flights.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER
DATA REQUIREMENT DESCRIPTION

DRL NUMBER: T-1261
LINE ITEM NUMBER: 12

1. LE
SPECIFICATION, CERTIFICATION TEST

2. NUMBER: RA-340TA

4. DATE: June 1975

3. USE
The Certification Test Specification will be used to define the total test activity to verify that the end item hardware meets the performance and design requirements of the CEI Specification.

5. ORGANIZATION: NASA JSC

6. REFERENCES: NHB 5300.4(1D-1)

7. INTERRELATIONSHIP

(The Center Data Manager (Code JM2) will assign numbers in block 2.)

8. PREPARATION INFORMATION

A. The contractor shall prepare a Certification Test Specification which defines the overall philosophy of certification and includes the groundrules for testing, the requirements for analysis, the program controls required, and specific environmental exposure conditions to be applied during test.

B. This specification shall recommend the number of CEI test specimens required for certification testing. The recommended number of certification test specimens shall reflect the results of any previous certification testing of similar hardware. Components of certification test hardware which require testing at overstress or off-limit conditions shall be identified.

C. Changes to the approved Certification Test Specification shall be accomplished only through the approval of Engineering Change Proposals/Specification Change Notices. The test program shall be designed to provide only the minimum tests necessary, on the basis of the criticality and complexity of the equipment, to meet the requirements of the CEI Specification. The spectrum of tests shall be analyzed as an integrated effort to minimize test requirements and prevent duplication. The Certification Test Specification shall define each test by test type as defined in the statement of work. Testing shall be conducted at the highest hardware level of assembly consistent with good practice and within the requirements of the CEI Specification.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION MANNED SPACECRAFT CENTER DATA REQUIREMENT DESCRIPTION	DRL NUMBER T-1261 LINE ITEM NUMBER 13
1. TITLE PLAN, CERTIFICATION TEST	2. NUMBER RA-341TA 4. DATE June 1975
3. USE To provide NASA JSC with cognizance of the elements of the contractor's plan for hardware certification.	5. ORGANIZATION NASA JSC 6. REFERENCES NHB 5300.4(1D-1) 7. INTERRELATIONSHIP

(The Center Data Manager (Code JM2) will assign numbers in block 2.)

8. PREPARATION INFORMATION

A. The Certification Test Plan shall define the specific methods to be used to verify that the hardware meets the technical requirements of the applicable CEI Specification. When a method other than test is to be used, the specific method (i.e., stress analyses, thermal analyses, radiographic inspections, etc.) shall be identified, and the objectives of these methods shall be defined. Wher a requirement is to be verified by test, the Certification Test Plan shall include:

1. Definition of the specific tests to be conducted.
2. Description and identification of equipment components, parts, etc., to be tested.
3. Objectives of the tests.
4. Serial and part numbers of specimens to be tested.
5. Environmental and performance test conditions.
6. Testing time or cycles.
7. Allowable maintenance.
8. Logging requirements.
9. Manner of analysis and utilization of test results.
10. Disposition of test specimens.
11. Retest requirements.
12. Reliability goal allowable failures per test.
13. Definition of failure.

Certification by test shall be in accordance with NHB 8080.1, section 3.6. Components of certification test hardware which are to be disassembled after testing is completed and inspected to determine margins of safety and potential failure modes shall be defined in the Certification Test Plan.

B. Certification methods to verify that the hardware meets the technical requirements of the applicable CEI Specification shall be defined in a certification matrix which shall be prepared in accordance with the form shown in Figure 1 and included in the Certification Test Plan.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION LYNDON B. JOHNSON SPACE CENTER DATA REQUIREMENT DESCRIPTION	DRL NUMBER - T-1261 LINE ITEM NUMBER - 13
1. TITLE PLAN, CERTIFICATION TEST	2. NUMBER RA-341TA 4. DATE June 1975
3. USE	5. ORGANIZATION NASA JSC 6. REFERENCES NHB 5300.4(1D-1) 7. INTERRELATIONSHIP

(The Center Data Manager (Code JM2) will assign numbers in block 2.)

8. PREPARATION INFORMATION

C. Contents:

1. Certification Index

   a. Part name and part number.

   b. Environments and life/cycle requirements.

   c. Certification method (test, analysis, etc.).

   d. Acceptance environmental test requirements.

   e. Requirements for test start approval (TSA) and quality site approval (QSA).

   f. Number of specimens.

CERTIFICATION MATRIX

CERTIFICATION METHOD:

NA-NOT APPLICABLE
1-SIMILARITY
2-ANALYSIS
3-INSPECTION
4-DEMONSTRATION
5-TEST

CEI SPECIFICATION REFERENCE	CERTIFICATION METHOD						DESCRIPTION	OBJECTIVE
	NA	1	2	3	4	5		
(Each requirement of section 3.0 of the CEI Specification shall be listed by paragraph number in this column.)							(A very brief description of the specific type of certification method to be used for verification of each requirement of section 3.0 of the CEI Specification shall be listed in this column.)	(The objective of the specific certification method to be used for verification of each requirement of section 3.0 of the CEI Specification shall be listed in this column.)

Figure 1: Certification Matrix

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER
DATA REQUIREMENT DESCRIPTION

DRL NUMBER: T-1261
LINE ITEM NUMBER: 14

1. TITLE
REPORT, CERTIFICATION TEST (CTR)

2. NUMBER: RA-342TA

4. DATE: June 1975

3. DPT

The Certification Test Report will be used to provide NASA JSC with the results of the system certification activity in order to assess the acceptability of the equipment design.

5. ORGANIZATION: NASA JSC

6. REFERENCES: NHB 5300.4(1D-1)

7. INTERRELATIONSHIP

(The Center Data Manager (Code JM2) will assign numbers in block 2.)

8. PREPARATION INFORMATION

The report shall contain references to the test procedures used and shall include the pertinent Certification Test Plan as an appendix. Formal reports of certification of each test specimen shall be issued as early as practicable following completion of certification of that specimen. The report shall include complete results of the tests conducted and complete reduction of test data, analyses, conclusions, and any recommendations for further actions. In addition, a summary of any failures or abnormal test conditions will be included and discussed. The report will also include test objectives, test hardware description, test setup description including photographs and drawings, test procedure as run with validation, and laboratory notes with validation.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
LYNDON B. JOHNSON SPACE CENTER

DATA REQUIREMENT DESCRIPTION

DRL NUMBER *
T-1261

LINE ITEM NUMBER *
15

1. TITLE
REPORT, ENGINEERING ANALYSIS (EAR)

2. NUMBER
RA-343TA

4. DATE
June 1975

3. USE
The Engineering Analysis Report will supplement the Certification Test Report for those tests in which failures or abnormal test conditions occur.

5. ORGANIZATION
NASA JSC

6. REFERENCES
NHB 5300.4(1D-1)

7. INTERRELATIONSHIP

(The Center Data Manager (Code JM2) will assign numbers in block 2.)

8. PREPARATION INFORMATION

The Engineering Analysis Report will contain:

a. Certification requirements definition and identification of Certification Report number.

b. Test/analysis objectives.

c. Certification analysis logic and details.

d. Test results summary and explanation.

e. Identification of hardware experiencing anomalies.

f. Failure resolution and test anomaly explanation.

g. Test analysis conclusion and results.

h. Formal certification recommendations.

i. Reference to test procedure number and date.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION MANNED SPACECRAFT CENTER DATA REQUIREMENT DESCRIPTION	DRL NUMBER - T-1261 LINE ITEM NUMBER - 16
1. TITLE SPECIFICATION, ACCEPTANCE TEST	2. NUMBER RA-344TA 4. DATE June 1975
3. USE The Acceptance Test Specification will be used to define the total acceptance test activity to verify that the end item hardware meets the performance and design requirements for acceptance.	5. ORGANIZATION NASA JSC 6. REFERENCES NHB 5300.4(1D-1) 7. INTERRELATIONSHIP

(The Center Data Manager (Code JM2) will assign numbers in block 2.)

8. PREPARATION INFORMATION

A. The contractor shall prepare an acceptance test specification which defines the philosophy of acceptance testing and includes the ground rules for testing, requirements for analysis, the program control required, and the specific acceptance test environment exposure conditions to be applied during the tests. The acceptance test specification shall define those tests to be conducted to determine that a component is capable of meeting performance requirements prescribed in purchase requests or other documents identifying adequate performance capability for the item in question.

B. This specification shall recommend the number of test specimens to be tested and which are representative of each component or subsystem for which a certification test requirement has been written. The recommended number of acceptance test specimens shall reflect the results of any previous acceptance testing of similar hardware.

C. The acceptance test specification shall include the test objective, acceptance and rejection criteria, the environmental limits, references to applicable safety standards for hazardous operations, allowable types of adjustments for data recording. Requirements shall be specified for retest criteria, reporting of test results, disposition of tested articles, and special photographic coverage (if required).

D. Changes to the acceptance test specification shall be accomplished only through approval of Engineering Change Proposals (ECP's)/Specification Change Notices (SCN's). The test activity shall be designed to provide only the minimum tests necessary on the basis of the criticality and complexity of the equipment. The acceptance test specification shall define each test by test type as defined in the Statement of Work.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER
DATA REQUIREMENT DESCRIPTION

1. NUMBER: T-1261
LINE ITEM NUMBER: 17

1. TITLE
REPORT, CERTIFICATION STATUS (CSR)

2. NUMBER: RA-346TA
3. DATE: June 1975

4. USE
The Certification Status Report is used by the contractor and NASA to track all certification operations.

5. ORGANIZATION: NASA JSC
6. REFERENCES: NHB 5300.4(1D-1)
7. INTERRELATIONSHIP:

(The Center Data Manager (Code JM2) will assign numbers in block 2.)

8. PREPARATION INFORMATION

The CSR provides visibility of completion status of each certification item including both hardware and documentation.

The CSR is made up by charting all certification issues and operations against a schedule timeline and includes:

a. Certification planned test/analysis schedule and status.
b. Identity of current test/analysis by CR number.
c. Test hardware and documentation status.
d. Test agency identity.
e. NASA approval status.

The format is optional (manual or computerized).

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION LYNDON B. JOHNSON SPACE CENTER DATA REQUIREMENT DESCRIPTION	DRL NUMBER T-1261 LINE ITEM NUMBER 18
1. TITLE LIST, LIMITED LIFE	2. NUMBER RA-348TA 4. DATE June 1975
3. DESCRIPTION/PURPOSE The limited life list shall identify and document time/cycle restricted items, age-controlled items, and related requirements for the purpose of inspection, maintenance, and replacement of these items.	5. ORGANIZATION NASA JSC 6. REFERENCES NHB 5300.4(1D-1) 7. INTERRELATIONSHIP
(The Center Data Manager (Code JM2) will assign numbers in block 2.)	

8. PREPARATION INFORMATION

Contents

a. Time/cycle significant items list:

(1) Definition of criteria for selection.

(2) Equipment requiring action such as inspection, maintenance, or replacement giving milestone points, replacement points, and where required, special measuring devices.

(3) Establish general requirements for acquisition of operating time/cycle data.

b. Age-controlled/time action list:

(1) Definition of criteria for selection.

(2) Age life limits for age-controlled items and assemblies and periodic action required for monitoring and control of these items.

(3) Requirements for historical data/records to verify that age-sensitive items are controlled within acceptable limits.

c. Waiver report will be required to document instances where an item has exceeded its time/cycle limit and the rationale for accepting an item for flight or in support of flight:

(1) The waiver shall include item name, number, serial number, time or cycle limit, reason the item has (or will) exceed its time/cycle limit, and Contractor rationale for accepting the item for flight or proposed action.

(2) Special waiver form submitted as an enclosure to Contractor letter is required.

d. Limited life data shall be updated and available for review in support of milestone reviews.

Format - To be prepared in Contractor-released specification format.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
LYNDON B. JOHNSON SPACE CENTER

DATA REQUIREMENT DESCRIPTION

DRL NUMBER - T-1261

LINE ITEM NUMBER - 19

1. TITLE
List, Critical Process Control Procedure

2. NUMBER
RA-375T

4. DATE
October 1974

3. USE
To tabulate critical process control procedures

5. ORGANIZATION
NASA/JSC ND

6. REFERENCES
NHB 5300.4 (1D-1)
Par. 1D504-4C3

7. INTERRELATIONSHIP

(The Center Data Manager (Code JM2) will assign numbers in block 2.)

8. PREPARATION INFORMATION

An up-to-date listing shall be maintained of all critical process control procedures and critical process specifications used in the fabrication, control, and inspection of the materials and articles fabricated. New or revised critical process procedures/specifications shall require NASA review. Similar information from subcontractors shall also be furnished.

JSC Form 3241 (Nov 74)

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
LYNDON B. JOHNSON SPACE CENTER

DATA REQUIREMENT DESCRIPTION

DRL NUMBER: T-1261
LINE ITEM NUMBER: 20

1. TITLE
Plan, Quality Program

2. NUMBER
RA-376T

4. DATE
October 1974

3. USE
To describe how the contractor will insure compliance with cited quality requirements defining the total quality program from the initial phase throughout the development, fabrication, and delivery of articles of required quality.

5. ORGANIZATION
NASA/JSC ED

6. REFERENCES
NHB 5300.4 (1D-1)
paragraph 1D500

7. INTERRELATIONSHIP

(The Center Data Manager (Code JM2) will assign numbers in block 2.)

8. PREPARATION INFORMATION

1. The contractor shall prepare and maintain a quality program plan which describes how the contractor will insure compliance with cited quality requirements. The quality program plan shall be submitted as required by the request for proposal or contract and/or the applicable DRL (information requirements listing). The plan shall cover all quality program activities for the time period or phase authorized, be updated and resubmitted as necessary and as specified in the contract and/or DRL, and serve as the master planning and control document.

2. Site Plans. Separate quality program plans, or a plan having separate parts, shall be prepared for the contractor's activities at the plant site and at each remote test d launch site.

3. The reproduction, distribution, and frequency of submittal of the plan(s) shall be as specified on NASA form 1106, DRL.

4. Quality Program Plan Contents. The plan shall include:

a. Charts and narrative statements describing each element of the contractor's organization (e.g., procurement, engineering, reliability, fabrication, test, safety, and quality assurance) which implement the quality program and detailed statements of duties, functions, and responsibilities relating to each quality program task. The plan shall show the relationship of the individual managing the quality program with each element performing quality program tasks, including his authority to control and monitor cited tasks.

b. Narrative descriptions which describe the contractor's execution and management of each task. These shall be detailed in terms of when, by which organizations, and by which methods each task will be accomplished. Applicable contractor policies and procedures shall be referenced in the plan.

c. Identification of those elements of the planned program which will utilize the contractor's existing quality program documents and operations and identification of those requiring change. Proposed changes needed to meet cited requirements and the time schedule for implementing such changes shall be delineated.

d. Charts indicating the flow of fabrication and assembly operations and related inspection and test points.

5. Quality Program Plan Format. The plan shall, as a minimum, encompass the following format with attendant discussions of:

a. Quality Program Management

(1) Flow charts depicting the contractor's proposed operations
(2) Contractor's organizational and functional charts
(3) Quality status reporting
(4) Relationship with the reliability program
(5) Quality documentation change control
(6) Quality training program

b. Design and Development Control

(1) Establishment, identification, review, change control, and effectivity of technical documents such as specifications, procedures, drawings, fabrication and planning documents, and process sheets defining characteristics and design criteria necessary for procurement, fabrication (including assembly), and inspection and test operations.

(2) Quality support to design review.

c. Identification and Data Retrieval

(1) Identification methods for hardware and materials.
(2) Identification of methods for location of applicable part or type numbers on technical documents so as to provide a closed loop between hardware and applicable technical documents.
(3) Identification control method for ensuring assignment of unique part, serial, and lot numbers in a consecutive manner.
(4) Identification list development to ensure that records and the related articles may be readily located and retrieval in the event that verification of, or removal of articles or materials becomes necessary.

d. Procurement Controls

(1) Selection of contractor procurement sources.
(2) Procurement document review and control; control of supplier quality programs, including how basic technical and detailed quality requirements will be delineated to suppliers.
(3) Contractor quality assurance personnel at source, if applicable.
(4) Methods for coordinating with Government personnel for which the Government agency elects Government source inspection.
(5) Receiving inspection system including receiving records, supplier rating systems, postaward surveys of supplier operations, coordination of contractor/supplier inspections and tests, and nonconformance information feedback.

e. Fabrication Controls

(1) Fabrication operations controls.
(2) Article and materials controls.
(3) Cleanliness controls and procedures; contamination controls, as applicable.
(4) Process controls and procedures.
(5) Workmanship standards.

f. Inspections and Tests

(1) Inspections and test planning.
(2) Test specifications.
(3) Inspection and test procedures.
(4) End-item inspection and test specifications, procedures, and controls.
(5) Inspection and test performance controls.
(6) Qualification test article controls, requalification, qualification based on similarity, procedures, and controls.
(7) End-item inspection and test reports; end-item reinspection and retest.
(8) Inspection and test records and data.
(9) Contractor quality assurance verification actions prior to, during, and subsequent to testing.
(10) Nondestructive evaluation (NDE)
(11) Quality program audits.

g. Nonconforming Article and Material Control

(1) Nonconforming documentation.
(2) Remedial and preventive action.
(3) Initial review dispositions.
(4) Material review board.
(5) Requests for NASA contracting officer approval.
(6) Supplier material review boards.

h. Metrology Controls

(1) Acceptance and evaluation.
(2) Article or material measurement processes.
(3) Calibration measurement processes.
(4) Traceability to NBS.
(5) Handling, storage, and transportation.
(6) Identification and labeling.
(7) Establishment of calibration intervals.
(8) Recall system.
(9) Calibration records.
(10) Environmental requirements.
(11) Remedial and preventive action.

i. Inspection status stamp control.

j. Handling, storage, preservation, marking, labeling, packaging, packing, shipping, and documentation package.

k. Sampling plans, statistical planning and analysis.

l. Government property control

NOTE: The quality program plan developed as a response to this DRD shall also, as a minimum, make reference to the DRL and other DRD's invoked within the statement of work or other parts of the contract.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
LYNDON B. JOHNSON SPACE CENTER

DATA REQUIREMENT DESCRIPTION

DRL NUMBER: T-1261

LINE ITEM NUMBER: 21

1. TITLE: Plans, Sampling

2. NUMBER: RA-377T

4. DATE: October 1974

3. USE: To establish plans for use when inspections and tests are destructive, or when data, inherent characteristics, or the noncritical application of the articles indicate that a reduction in testing or inspection can be achieved without jeopardizing quality.

5. ORGANIZATION:

6. REFERENCES: MIL-STD-105
NHB 5300.4(1D-1)ID510

7. INTERRELATIONSHIP:

(The Center Data Manager (Code JM2) will assign numbers in block 2.)

8. PREPARATION INFORMATION

The contractor shall establish and maintain a documented procedure for the preparation of proposed contractor sampling plans for internal use. All sampling plans, other than those contained in existing military documents, require the approval of the procuring NASA installation or its designated Government quality representative.

The sampling plans, as a minimum, shall provide for the following and shall be submitted to the procuring activity:

a. Justification and rationale for using sampling techniques.

b. Identify types of parts to be sampled.

c. Describe method and criteria for determining classification of characteristics.

d. Describe the method for maintaining historical data relative to sampling results.

e. Describe method for insuring random selection of samples.

f. Identify sampling plans (military or otherwise). If nonmilitary plans are used, the contractor will furnish OC (operating characteristics) curves.

g. Describe criteria used to change sampling plans (reduced, normal or tightened).

h. Routine reports will be periodically submitted to NASA which reflect the results of sampling activities.

i. Explain the method for dispositing rejected lots (purchases and/or manufactured items).

Distribution and frequency of submittal of the sampling plans shall be as specified on the NASA form 1106, IRL (Information Requirement List).

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
LYNDON B. JOHNSON SPACE CENTER
DATA REQUIREMENT DESCRIPTION

DRL NUMBER: T-1261
LINE ITEM NUMBER: 22

1. TITLE: Report, Problem
2. NUMBER: RA-378T
4. DATE: October 1974
3. USE: To document problems (as defined below) that are discovered on Space Shuttle hardware
5. ORGANIZATION: NASA-JSC ND
6. REFERENCES: NHB 5300.4 (1D-1) Par. LD301.6
7. INTERRELATIONSHIP:

(The Center Data Manager (Code JM2) will assign numbers in block 2.)

8. PREPARATION INFORMATION

SCOPE:
All reportable problems shall be reported by the most expeditious methods; i.e., telecopier, telephone, telegraph, personal courier, etc. Problems shall be reported to NASA JSC within 24 hours of occurrence or detection. Documented report due within 5 days of reportable item identification. Subsequent updates as required. The scope of the problem reports varies according to the nature of the problem.

a. Immediate Notification. All problems that occur during or subsequent to acceptance testing of flight hardware shall be reported within 24 hours of occurrence or detection. Problems that occur prior to acceptance testing that will, or have the potential to, adversely affect safety, contribute to the delay of a scheduled event, result in a design change or that occur during certification testing shall also be reported within 24 hours of occurrence or detection. Report contents shall be as shown in table 1.

b. Subsequent Report. A documented report containing additional information shall be provided within 5 days of reportable item identification. Report content shall be as shown in table 2.

c. Problem Resolution. The report shall document the problem, the failure analysis, and the corrective action that has been established. The report shall also contain a copy of the released documentation to implement the corrective action. If the cause of the problem cannot be determined, the report shall provide assurance that recurrence of the problem during a mission can be tolerated and that procedures to nullify the effects of the problem have been formulated and documented. Initial submittal due 21 days after first problem report, updated continually as problem closeout/explanations occur. The reports shall contain the information listed in table 3.

d. The contractor shall report all problems and data elements as reouired to the following JSC office:

Problem Assessment Engineering
P.O. Box 58747
Houston, TX 77058

Normal Duty Hours (8:30 am - 5:00 pm, Mon-Fri)

Voice: (713) 488-0910, x 341 (Commercial)
(713) 488-1341 (FTS)

Telecopier: (713) 488-0910, x 393 or 394 (Commercial)
(713) 488-1393 or 1394 (FTS)

After Hours - Telecopier Only

(713) 488-0993 or 5315 (Commercial)
(713) 488-1393 or 1394 (FTS)

e. A copy of the problem report shall be provided to the delegated resident Government agnecy. A copy shall also remain with the failed hardware.

CONTNETS:

Required elements for each report are listed in tables 1, 2, and 3.

Table 1

Required Elements for Immediate Problem Reports

Number	Contents
1	Date of occurrence
2	Location of article at time of occurrence
3	Test or operation being performed at time of occurrence
4	Prevalent conditions at time of occurrence (vibration, shock, etc.)
5	Nonconforming article: part number, part name, serial number, lot number, manufacturer (as applicable)
6	Contractor deliverable end item description
7	Symptom of nonconformance
8	Brief narrative description of nonconformance, including comparison of expected events with actual events, for results. (Specification versus actual)
9	Criticality with relationship to mission effects (if known)
10	Cause of nonconformance (if known)
11	Test document number
12	Subsystem affected

Table 2

Required Elements for Subsequent Problem Reports

Number	Contents
1	Date of occurrence
2	Location of article at time of occurrence
3	Test or operation being performed at time of occurrence
4	Prevalent conditions at time of occurrence (vibration, shock, etc.)
5	Nonconforming article: part number, part name, serial number, lot number, manufacturer (as applicable)
6	Contractor deliverable end-item description
7	Symptom of nonconformance
8	Brief narrative description of nonconformance, including comparison of expected events with actual events (or results). (Specification versus actual)
9	Criticality of nonconformance with relationship to mission effects (if known)
10	Cause of nonconformance (if known)
11	Test document number
12	Subsystem affected
13	Unique identifiable report number
14	Indication of whether nonconformance is a failure or unsatisfactory condition (if known)
15	Indication of whether problem is due to design deficiency or manufacturing inconsistency (if known)
16	Next higher assembly: part name, part number, manufacturer (as applicable)
17	All end items and/or missions that may be affected by the problem (if known)
18	Planned date of resolution

NOTE: Items numbered 1 through 12 are the same as on table 1.

Table 3 RA378T

Elements of Problems Resolution Report

Number	Contents
1	Date of occurrence
2	Location of article at time of occurrence
3	Test or operation being performed at time of occurrence
4	Prevalent conditions at time of occurrence (vibration, shock, etc.)
5	Nonconforming article: part number, part name, serial number, lot number, manufacturer (as applicable)
6	Contractor deliverable end-item description
7	Symptom of nonconformance
8	Brief narrative description of nonconformance, including comparison of expected events with actual events or results (specification versus actual)
9	Criticality of nonconformance with relationship to mission effects (if known)
10	Cause of nonconformance (if known)
11	Test document number
12	Subsystem affected
13	Uniquely identifiable report numbers
14	Indication of whether nonconformance is a failure or unsatisfactory condition (if known)
15	Indication of whether problem is due to design deficiency or manufacturing inconsistency (if known)
16	Next higher assembly: part name, part number, manufacturer as applicable)
17	All end items and/or missions that may be affected by the problem (if known)
18	Date of resolution
19	Vehicle effectivity of problem resolution (closeout/ explanation)
20	Results of analysis, including laboratory tests or summary of efforts made to determine nonconformance cause
21	Previous history of nonconforming article
22	Corrective action that has been established, including reference to released documentation establishing this corrective action.
23	Problem report numbers, and dates, that relate to the same problem (if applicable)

NOTE: Items numbered 1 through 12 same as tables 1 and 2. Items numbered 13 through 17 same as on table 2.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION LYNDON B. JOHNSON SPACE CENTER DATA REQUIREMENT DESCRIPTION	DRL NUMBER T-1261 LINE ITEM NUMBER 23
1. TITLE PACKAGE, ACCEPTANCE DATA	2. NUMBER RA-379T 4. DATE October 1974
3. USE The Acceptance Data Package (ADP) will provide complete documentation at the time of acceptance of the CEI	5. ORGANIZATION NASA/JSC 6. REFERENCES NHB 5300.4(1D-1) Par. 1D505-6-c 7. INTERRELATIONSHIP CEI Acceptance Review
(The Center Data Manager (Code JM2) will assign numbers in block 2.)	

8. PREPARATION INFORMATION

PURPOSE

The purpose of this instruction is to establish the minimum requirements for the acceptance data package delivered with each procured end item, in order that a chronological history of the equipment configuration and quality status will be available at all times.

SCOPE

This instruction provides guidance in establishing ADP (acceptance data packages) requirements for spaceflight and related equipment.

An acceptance data package will be delivered with each functional end item.

GENERAL REQUIREMENTS

A. A DD 250/1149 (or other Government recognized "shipper" document, such as JSC Form 290), with quality control validation, will be required for all shipments. The shipper document will indicate nomenclature, part number, serial number, and quantity of hardware shipped. Shipping documents will identify any end item shortages, and reference all the applicable waivers. The shipper will list the ADP as being part of the shipment.

B. A chronological log of the equipment's configuration and quality status, along with the DD 250/1147, is the minimum acceptance data that will accompany any shipment of functional hardware. A JSC Form 772, System and Component Historical Record, or equivalent, will be used for this purpose. A suitable inspection status tag, JSC Form 911, or equivalent, will accompany all nonfunctional items. This tag will contain as a minimum the following information:

1. Acceptable (for its intended use)
2. Identification by part number and serial number
3. Indication of Government acceptance
4. Cleanliness certification
5. Proof pressure.loading certification (if applicable)
6. Material certification (if applicable)

SPECIFIC REQUIREMENTS FOR FUNCTIONAL ITEMS

Each ADP will have, as a minimum, the following sections with data as applicable:

A. Index or Table of Contents

An index or inventory of the ADP contents, along with the brief description of each section. A negative statement at the beginning of a section is required if no entry is applicable. For example, if one of the following data requirements does not apply to a particular shipment, the section should be so noted.

B. Component/Equipment Historical Logs

During the acceptance testing and inspection, a log (JSC Form 772, System and Component Historical Record, or equivalent) will be maintained to continuously document the history of the item or component. Each log will be chronologically maintained and will account for all periods of time, including idle time and movements of the item. Entries will be complete and self-explanatory, and will reference the test and test results, configuration changes, special inspections, etc. The local Government Quality Assurance Representative will validate all entries.

C. Engineering Drawings

Engineering drawings will be required. The drawing must be complete to the extent necessary to perform receiving inspection and any test or operation to be performed at the destination.

D. Inventory of Serialized Components

A list of "field replaceable" serialized components will be included in the ADP. The list will contain the following:

1. Component part number
2. Component name
3. Component serial number

E. Waivers/Deviations

A list of waivers/deviations will be provided, sequentially numbered or indexed, in order to determine the total number applicable to hardware. For GFE, this information may be included in the JSC Form 772, System and Component Historical Record, or equivalent. Copies of the waivers/deviations will be included in the ADP.

F. Discrepancy Reports/Material Review Board Actions

All MRB actions and open DR (discrepancy reports) will be provided in the same manner as E above, and included in the ADP.

G. Operating, Maintenance and Handling Procedures

The contractor shall prepare and submit a manual covering maintenance, repair, and operation of the contract end item.

The manual shall include, but not be limited to, the following:

a. A list of special tools, support and facilities equipment, and all other materials necessary to perform maintenance.

b. A schedule chart listing the time at which all maintenance is to be performed. This shall also include inspection for required repair maintenance or replacement of parts.

c. Conditions of environment in which maintenance is to be performed.

d. Detailed maintenance procedures which describe removal, disassembly, type of maintenance or repair, cleaning, reassembly, and reinstallation of all parts or subassemblies. (Also included shall be points of inspection and notes of caution.)

e. Illustrated part breakdowns showing the details of the part being worked upon.

f. Schematic and interconnecting wiring diagrams in sufficient detail to enable troubleshooting to be performed down to the replaceable subassembly or printed circuit board level.

g. Fault analysis will be provided to facilitate maintenance. The repair procedures shall be adequate for testing, checkout, disassembly, cleaning, inspection, repair, reassembly, adjustment, calibration, and servicing of the equipment as applicable.

h. Operational instructions suitable to support operator training and containing a system description and general instructions for operating the equipment.

i. Functional flow diagrams which show, in functional terms, system requirements to depict the gross functions which must be accomplished and their sequence to meet system objectives during operation and maintenance.

G. Operating, Maintenance and Handling Procedures (Cont'd)

The manual shall be submitted in preliminary form for review and approval 30 days prior to Acceptance Review. Final draft will be submitted with the ADP.

H. Record of Limited Life/Time and Cycle Requirements

A list of limited items will be included in the ADP and, also, a list of the critical time/cycle items, including the total time or cycles allowed and a record of the time or cycle used. Such time/cycle usages will be recorded on the JSC Form 772, or equivalent.

I. Non-Flight or Temporary Installed Hardware

An itemized list of all non-flight or temporarily installed hardware will be provided. Such hardware will be suitably identified and logged to control the use and final removal. Serialized streamers will be attached to all non-flight items not requiring physical removal to complete flight installations except when the streamer might damage hardware.

J. Test Procedures and Results

Identification of the final procedure performed and a copy of the results thereto will be included in the ADP, i.e., PDA (pre-delivery acceptance), acceptance test or others, etc.

K. Weights Log and Center-of Gravity Data

A weights log and center-of-gravity data will be provided.

L. Certification of Compliance

The supplier will include in the ADP a certificate of compliance with the specifications and requirements of the contract.

M. Certification of Cleanliness

Certification describing the level to which the hardware has been cleaned and packaged will be included in the ADP.

N. Certification of Acceptance

Certification of acceptance will be noted by one of the following as applicable.

N. Certification of Acceptance (Cont'd)

1. Certificate of Flight Worthiness

2. Equipment readiness statement

3. DD250/1149 Form

4. JSC Form 772, System and Component Historical Record

O. Open Work

Open work required on the end item prior to shipment will be identified in the ADP.

OTHER REQUIREMENTS

Other special data requirements that apply to a particular CEI must be included in the ADP. These requirements will be indentified by the assigned technical monitor or engineer and included in the contract on work authorized. Examples are listed below:

A. End Item Specification: A detailed description, including all the specific requirements of the delivered end item.

B. Alignment Data: Techniques used and data obtained when aligning the end item.

C. Bent Pin Log: A record, for a specific electrical pin connector, of the number of pins which have been bent and straightened.

D. Schematics: An outline or diagram showing different parts or elements of an object or system.

E. Indentured Parts List: A list of parts depicting the configuration of the end item, with serial, lot, or batch numbers indicated for each component or part.

F. Calibration Data Report: Techniques used and data obtained during calibration of the end item.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
LYNDON B. JOHNSON SPACE CENTER

DATA REQUIREMENT DESCRIPTION

DRL NUMBER - T-1261

LINE ITEM NUMBER - 24

1. TITLE

Handling, Storage, Preservation, Procedures, Marking, Labeling, Packaging, Packing, and Shipping

2. NUMBER RA382T

4. DATE June 1975

3. USE

To verify effective implementation through controls administered by the contractor's quality activity

5. ORGANIZATION

6. REFERENCES NHB 5300.4(1D-1)

7. INTERRELATIONSHIP Plan, Quality Program

(The Center Data Manager (Code JM2) will assign numbers in block 2.)

8. PREPARATION INFORMATION

The contractor shall prepare, maintain, and implement those procedures which describe in detail the controls for handling, storage, preservation, marking, labeling, packaging, packing, and shipping operations.

The above procedures shall be reviewed prior to release by the contractor's quality activity for concurrence.

These procedures shall contain as a minimum, but not be limited to the following:

a. Verify that manufacturing planning, routing operation, documentation, and travelers are complete.

b. Handling instructions.

c. Identification of special handling equipment.

d. Evidence of initial and periodic proof testing of applicable handling equipment.

e. Controlled acceptance into and withdrawal from storage area.

f. Positive identification of limited life material and removal of materials whose shelf life has expired.

g. Periodic inspection of stored material, housekeeping, and record keeping.

h. Systematic inspection and/or testing necessary to insure maintenance of preservation, including special environments, for article in long-term storage.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
LYNDON B. JOHNSON SPACE CENTER

DATA REQUIREMENT DESCRIPTION

DRL NUMBER - T-1261

LINE ITEM NUMBER - 25

1. TITLE
Log Books, Recording Data on Age or Time-Sensitive Articles

2. NUMBER RA385T

4. DATE October 1974

3. USE
To prevent quality degradation on age or time-sensitive articles

5. ORGANIZATION JSC

6. REFERENCES
NHB 5300.4(1D -1)
Par. 1D504-2

7. INTERRELATIONSHIP

(The Center Data Manager (Code JM2) will assign numbers in block 2.)

8. PREPARATION INFORMATION

Articles having definite characteristics of quality degradation or drift with age and/or use will be marked to indicate the date, test time or cycle the critical life was initiated and the date, test time or cycle the useful life will be expended, and this same information shall be recorded in log books. Recorded data will be maintained for such articles in accordance with documented requirements, such as, manufacturers' specifications, design data, etc.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
LYNDON B. JOHNSON SPACE CENTER

DATA REQUIREMENT DESCRIPTION

DRL NUMBER - T-1261

LINE ITEM NUMBER - 26

1. TITLE

Log, Control of Temporary Installation

2. NUMBER RA386T

4. DATE October 1974

3. USE

To control and monitor articles on the vehicle which are to be installed and removed, including shipping and handling protective materials.

5. ORGANIZATION

6. REFERENCES

NHB 5300.4(1D-1)
Par. 1D504-6

7. INTERRELATIONSHIP

(The Center Data Manager (Code JM2) will assign numbers in block 2.)

8. PREPARATION INFORMATION

The contractor will record on a single log for each vehicle all temporary installations and removals of articles. This log will be initiated upon introduction of the first temporary installation. The log will be maintained during subsequent efforts throughout the life of the vehicle.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION LYNDON B. JOHNSON SPACE CENTER **DATA REQUIREMENT DESCRIPTION**	DRL NUMBER T-1261 LINE ITEM NUMBER 27
1. TITLE Procedures, Contamination Control	2. NUMBER RA390T 4. DATE October 1974
3. USE To document methods and procedures used to implement the contamination control requirements.	5. ORGANIZATION JSC 6. REFERENCES NHB 5300.4(1D-1) Par. 1D504-3 7. INTERRELATIONSHIP

(The Center Data Manager (Code JM2) will assign numbers in block 2.)

8. PREPARATION INFORMATION

The contractor shall prepare documented procedures for the processing necessary to achieve, verify, and maintain the cleanliness level required for the contract article.

The documented procedure shall stipulate the cleanliness levels to be achieved. These levels shall be compatible with the most contamination sensitive design features of the contract items and shall be consistent with application and interface requirements.

The documented procedure shall include the following:

a. Title

b. Number and latest revision

c. Date of issue and revisions

d. Signatures of approving personnel

e. Scope and applicability

f. Reference documents

g. Identification of materials and equipment required

h. Environmental requirements for the processing area

i. Cleanliness criteria for the item being processed including, as applicable, levels of moisture, halogens, nonvolatile residue, total organics, and particulates

j. Cleaning/flushing materials and detailed sequential operations

k. Equipment and detailed sequential operations for sampling, testing, and evaluation of cleanliness levels achieved

l. Handling and packaging requirements

m. Quality assurance provisions necessary for process stability and verification of required cleanliness

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION LYNDON B. JOHNSON SPACE CENTER DATA REQUIREMENT DESCRIPTION	DRL NUMBER T-1261
	LINE ITEM NUMBER 28
1. TITLE Report, Safety Analysis	2. NUMBER SA-039T
	4. DATE May 1972
3. USE To provide results of safety analyses as they are completed and 30 days prior to PDR and CDR	5. ORGANIZATION NASA/JSC
	6. REFERENCES
	7. INTERRELATIONSHIP FMEA SFPS

(The Center Data Manager (Code JM2) will assign numbers in block 2.)

8. PREPARATION INFORMATION

8.0 CONTENT

The Safety Analysis Report shall contain:

a. Applicable system safety guidelines, constraints, and requirements.

b. Results of safety studies and safety inputs developed to support trade studies.

c. Results of the hazard analyses, including the complete identification of hazards, their cause, their effect on personnel, equipment, and mission, and the results of using the Hazard Reduction Precedence Sequence to eliminate or control hazards.

d. A summary of residual hazards (catastrophic or critical), and supporting risk assessments, including rationale for retention.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION LYNDON B. JOHNSON SPACE CENTER **DATA REQUIREMENT DESCRIPTION**	DRL NUMBER T-1261
	LINE ITEM NUMBER 29
1. TITLE Plan, Safety (Condensed)	2. NUMBER SA-055T
	4. DATE June 1975
3. USE To define the contractor's approach to assure compliance with the safety requirements of the statement of work	5. ORGANIZATION NASA/JSC
	6. REFERENCES NHB 5300.4(ID-1) CHAPTER 2: SAFETY
	7. INTERRELATIONSHIP

(The Center Data Manager (Code JM2) will assign numbers in block 2.)

8. PREPARATION INFORMATION

The Safety Plan shall be prepared in accordance with the requirements to Chapter 2 of NHB 5300.4(ID-1). The contractor shall describe his methods to assure identification, elimination and/or control of potential hazards which may lead to injury, loss of personnel and/or damage or loss of flight, Class II training hardware*, or mission related ground support equipment throughout the complete cycle of the program. The Safety Plan will integrate and describe the relationship of all safety activities, and the coordination between System Safety, Industrial Safety, Test Operations Safety, and Field Site Safety.

The contractor shall describe his safety organization listing key personnel, with job titles, responsible for safety implementation, defining responsibilities, authority, interfaces and relationships with other program organizations. The Safety Plan shall provide a listing of specific safety tasks to be performed and the methods used to assure completion of these tasks.

Paragraph 3 of ID200 "General Considerations," shall be used to develop safety requirements and assure management visibility of evaluation and completion of safety considerations and analyses. The Safety Plan shall describe the contractor's execution of system safety analyses, including development of guidelines, constraints and requirements, as well as the hazard analyses activities to be performed.

*Class II training hardware are those flight items designated for training and are controlled to the same degree as flight hardware.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION LYNDON B. JOHNSON SPACE CENTER **DATA REQUIREMENT DESCRIPTION**	DRL NUMBER T-1261
	LINE ITEM NUMBER 30
1. TITLE Waiver/Deviation Request	2. NUMBER MA-600T
	4. DATE January 18, 1974
3. USE To submit written requests for acceptance of nonconformances	5. ORGANIZATION NASA/JSC
	6. REFERENCES
	7. INTERRELATIONSHIP

(The Center Data Manager (Code JM2) will assign numbers in block 2.)

8. PREPARATION INFORMATION

Waiver/deviation requests shall be prepared and submitted to NASA JSC for review and acceptance of nonconformances. A waiver is requested to authorize use of acceptance of hardware which does not meet specified requirements. A waiver is requested after the fact. A deviation is requested to authorize departure from particular requirements of specifications or related documents.

Each waiver/deviation request shall contain the following as a minimum:

a. Identification of the request as a waiver request or a deviation.

b. Identification of the condition number of the waiver/deviation.

c. Equipment name, part number, applicable serial numbers, function and criticality and effectivity.

d. Identification of the requirement to be waived or deviated from.

e. If applicable, the name, part number, serial number, and function of affected components.

f. Salient differences between the design baseline and the requested configuration.

g. Technical justification, including impact, supporting approval of the request.

h. The contractor's reliability evaluation of the request.

Affected processing, testing, acceptance, or shipment of applicable hardware shall not proceed until notification of approval of the waiver/deviation.

ADDENDUM II

JSCM 8080

MANNED SPACECRAFT CRITERIA AND STANDARDS

APPLICABLE FOR THE

REMOTE MANIPULATOR SYSTEM

Notes	No.	Dated	Title
	1A	6/7/71	Equipment Accessibility for Maintenance
	2A	11/2/71	Equipment Containers - Design for Spacecraft Decompression
	3A	6/7/71	Electrical Connectors - Keying
	4B	11/2/71	Separation of Redundant Equipment
	5	9/23/64	Transistors - Selection of Types
	6A	6/7/71	Protection of Severed Electrical Circuits
	7	3/6/70	Systems Checkout Provisions
	8A	6/7/71	Alignment of Mechanical Systems
	9	3/6/70	Protection of Spacecraft Electrical and Mechanical Systems from Debris
	10	3/6/70	Interior Design of Spacecraft for Cleanliness
	11A	6/7/71	Time Displays
	12A	5/19/75	Redundancy Requirements
	13	3/6/70	Electrical and Electronic Devices - Protection from Reverse Polarity and/or Other Improper Electrical Inputs
	14A	5/19/75	Material Selection, Review and Drawing Sign-off
	17	3/6/70	Flow Restriction Requirements - Pressurized Sources
	18	3/6/70	Spacecraft Material - Restriction on Use of Polyvinyl Chloride (PVC)
	19	3/6/70	Electrical and Electronic Piece Parts - Closure Construction
	20A	11/2/71	Redundant Electrical Circuits
	21A	7/8/70	Meteoroid Environment - Near Earth to Lunar Surface
	22A	2/1/71	Flammability of Wiring Material
	23	3/6/70	Toxicity of Materials Used in Crew Compartments - Wire Insulation, Ties, Identification Marks, and Protective Covering
	25	3/6/70	Wire Bundles - Protective Coating
	26	3/6/70	Titanium or Its Alloys - Prohibited Use With Oxygen
	28	3/6/70	Intermittent Malfunctions - Prohibited Use of Equipment
	29	3/6/70	Stainless Steel Tubing - Method of Joining
	30	3/6/70	Service Points - Positive Protection from Interchangeability of Fluid Service Lines
	31	3/6/70	Electrical Connectors - Moisture Protection
	32	3/6/70	Electrical Connectors - Pin Assignment
	33	3/6/70	Toxicity - Materials Used in Habitable Areas
1	35	3/6/70	Service Points - Fluid Systems
	36	3/6/70	Redundant Paths - Verification of Operation
	37	3/6/70	Corona Suppression
1	38A	2/8/72	Fluid Systems - Design for Flushing and Draining
	41	3/6/70	Shatterable Material - Exclusion from Crew Compartment
	42	3/6/70	Fluid Lines - Separation Provisions
	43	3/6/70	Restriction on Coatings for Areas Subject to Abrasion
	47	3/6/70	Capping of Servicing and Test Ports Which are not Required to Function in Flight
1	49	3/6/70	Fluid Line Components Whose Function is Dependent on Direction of Flow - Protection Against Incorrect Installation
	51	3/6/70	Beryllium - Restricted Use Within Crew Compartment(s)
	52	3/6/70	Tantalum Wet Slug Capacitors - Restriction on Use
	56	3/6/70	Crew Compartment Controls Requiring Tool(s) for Actuation - Position

Notes	No.	Dated	Title
	58	3/6/70	Crew Station Time Measurement Indicators
	59	3/6/70	Crew Compartment - Switch Coverguards
	62	3/6/70	Threaded Fittings - Restriction on Release of Particles and Foreign Material
	63	3/6/70	Metals and Metal Couples - Restriction on Use
	65	3/6/70	Detachable Crew-Operated Tools - Restriction in Spacecraft
1	67	3/6/70	Fluid Supplies - Verification Tests
	68	3/6/70	Electrical and Electronic Supplies and Loads - Verification Tests
	69	3/6/70	Electrical Circuits - De-energizing Requirement
	75	3/6/70	Measurement Systems that Display Flight Information to the Crew - Indication of Failure
	76	3/6/70	Pressure - Sensor Line Installation
1	78	3/6/70	Cleanliness of Flowing Fluids and Associated Systems
	79	3/6/70	Procurement Document Identification for Manned Space Flight Vehicle Items
	80	3/6/70	Protection of Electrical/Electronic Assemblies from Moisture Damage
	81	3/6/70	Ultrasonic Cleaning of Electrical and Electronic Assemblies
	83	3/6/70	Application of Previous Qualification Tests
	84A	5/19/75	Shipping and Handling Protection for Spaceflight Hardware
	85A	2/1/71	Protective Covers or Caps for Receptacles and Plugs - Electrical
	86	3/6/70	Direct Procurement of Parts
2	87A	2/1/71	Radiographic Inspection of Brazed and Welded Tubing Joints
	88	3/6/70	Wire Splicing
	89	3/6/70	Toxicity - Requirements for Nonmetallic Materials
	91	3/6/70	Liquid or Gas Containers - Verification of Contents
	92	3/6/70	Pressure - Relief Valves - Standardization of Functional Test
	93	3/6/70	Protection for Tubing, Fittings, and Fluid System Components - Flight Hardware and Associated Equipment
1	94	3/6/70	Fluid System Cleanliness - Verification in Draining, Purging, and Flushing Operations
	95A	7/8/70	Electrical Wire Acceptance Tests
1	97	3/6/70	Fluid Systems - Flushing Requirements
	98	3/6/70	Wire Insulation Potting Preparation - Etching
	99B	4/21/72	Identification and Classification of Flight and Nonflight Equipment
	100	3/6/70	Equipment Failure and Replacement - Verification of Flight Readiness
	101	3/6/70	Materials Detrimental to Electrical Connectors
	102	3/6/70	Operating Limits on Temperature Controlled Equipment
	104	3/6/70	Flight Hardware - Restriction on Use for Training
	106	3/6/70	Proprietary Rights - Requirements for Procurement
	107	3/6/70	Separate Stock for Spaceflight Parts and Materials
	108A	2/8/72	Reuse of Flight Hardware
	109	3/6/70	Etching Fluorocarbon Insulated Electrical Wire
	110B	5/19/75	Structural Analysis Requirements
	111	3/6/70	Leak Detectors - Wetting Agents
	112	3/6/70	Electrical Connectors - Disconnection for Trouble-shooting and Bench Testing

Notes	No.	Dated	Title
3	114A	5/19/75	Pressure Vessels - Materials Compatibility and Vessel Qualification Tests
	115	3/6/70	Safety Precautions - Test and Operating Procedures
	116	3/6/70	Mercury - Restriction on Use
1	117	3/6/70	Fluid Systems - Review of Cleaning, Flushing, and Purging Procedures
	118	3/6/70	Purge Gases - Temperature and Humidity Requirements
	119	3/6/70	Special Processes - Identification on Drawings
	121	3/6/70	Spacecraft Equipment - Protection from System Liquids
	122	3/6/70	Spacecraft Equipment - Moisture Protection
	125	3/6/70	Cadmium - Restriction on Use
	126	3/6/70	Verification of Adequate External Visibility
	128	3/6/70	Electrical Connectors - Shorting Springs or Clips
	129	7/8/70	Parts Identification
3	132	7/8/70	Pressure Vessels - Negative Pressure Damage
	133	7/27/70	Electrical Wire Harnesses - Dielectric Tests
	134	7/27/70	Electrical Power Distribution Circuits - Overload Protection
	136	6/7/71	Panel Mounted Displays and Controls - Maintainability
3	137	11/2/71	Pressure Vessels - Nondestructive Evaluation Plan
3	139	2/8/72	Pressure Vessel Design
3	140	2/8/72	Pressure Vessel Documentation
	141A	5/19/75	Radioactive Luminescent Devices
	142	4/21/72	Exposed Sharp Surfaces or Protrusions
	146	10/16/72	Equipment Design - Power Transients
	147	10/16/72	Qualification Fluid
	148	10/16/72	Testing Protective Devices for Solid State Circuits
	149	5/19/75	Pressure Relief for Pressure Vessels

Notes

1	Only if RMS has a fluid system.
2	Only if brazed or welded tubing is used.
3	Only if RMS uses pressure vessels.