SSP 57006

Active Rack Isolation System (ARIS) User's Guide

International Space Station Program

March 29, 1999

Type 3 Document, For Information, Surveillance, Review or Management Control

National Aeronautics and Space Administration
International Space Station Program
Johnson Space Center
Houston, Texas
Contract No. NAS15–10000 (FP05)

REVISION AND HISTORY PAGE

REV.	DESCRIPTION	PUB. DATE
–	Initial Release as specified within FP05	04/07/99

INTERNATIONAL SPACE STATION PROGRAM

ACTIVE RACK ISOLATION SYSTEM (ARIS) USER'S GUIDE

MARCH 29, 1999

PREFACE

This Users Guide provides information to the users of the ARIS. It will be updated periodically as additional information becomes available.

INTERNATIONAL SPACE STATION PROGRAM

ACTIVE RACK ISOLATION SYSTEM (ARIS) USER'S GUIDE

MARCH 29, 1999

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TABLE OF CONTENTS

TABLES

FIGURES

FIGURE PAGE

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1.0 INTRODUCTION

The ARIS provides isolation from the International Space Station (ISS) vibration environment to support the operation of sensitive microgravity experiments. This Users Guide provides additional information and guidance to assist payload developers in understanding the capabilities, constraints, and integration process with the ARIS.

1.1 ARIS SUMMARY

Mr. Johnny Souder of the Boeing Payload Operations and Integration Function (POIF) Training and Development Team has prepared an Excellent ARIS overview course, which follows:

ARIS Overview Course

ACTIVE RACK ISOLATION SYSTEM, (ARIS) OVERVIEW

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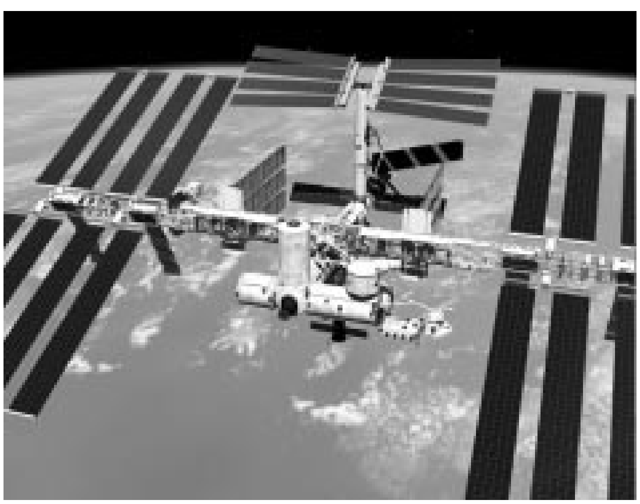
THE ARIS SYSTEM



Active Rack Isolation System (ARIS) for the International Space Station (ISS)

Class Objectives

Performance Objectives:

The student will be able to **identify and name** the major Orbit Replaceable Units (ORUs), within the assembly.

Each student will be able to **locate the major components** of the ARIS system.

The student will **understand the basic function** of each ORU within the ARIS rack assembly.

The student will be able to **recognize the relationship** between the key elements of the ARIS system.

The student will understand the **basic operating modes** and be able to **describe each**.

Lesson Overview

Lesson Synopsis

The first part of this lesson will explain the basic operational concept and function of the major components, within the Active Rack Isolation System (ARIS). The lesson will then move to the description and operating characteristics of each ORU and installed components. Finally, the lesson will cover the basic operation modes of the ARIS displays.

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Strategy

Lesson Strategy

Material discussed in this lesson relates to the ARIS system on the International Space Station (ISS) and is relevant to the Express Rack assembly as well.

First, we will discuss the overall ARIS system and its purpose and operation.

Second, we will discuss the ARIS subsystems and describe each. This will provide the student with a high level explanation of the hardware, along with basic operational concepts and purpose of those components. The lesson will cover the basic operation modes of the ARIS displays. Primary control responsibility for the hardware and software is mentioned at a cursory level.

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ARIS History

History

Some of the experiments, scheduled to be performed, onboard the International Space Station (ISS) will be **sensitive to motion and vibration** So as NOT to disturb on–orbit experiments, researchers have developed a system that isolates these experiments from disrupting vibrations which could reduce the likelihood of a successful experiment.

As a proof–of–concept, ARIS was flown on Space Shuttle Mission STS–79 to the Russian Space Station (Mir), as Risk Mitigation Experiment (RME–1313) in September of 1996.

Mechanical Disturbance Solution

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Problem

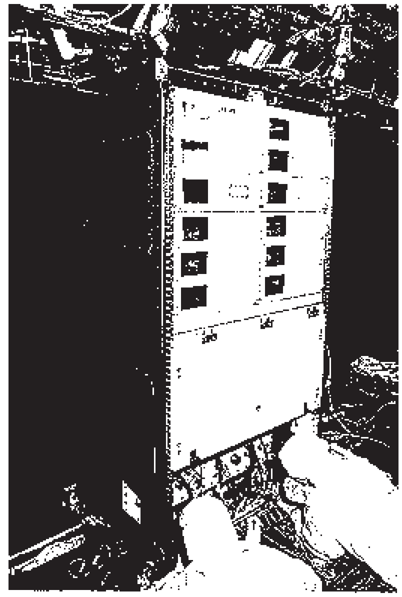
Space Station must isolate major mechanical disturbances to provide microgravity environment for certain class of science experiments

Estimated vibratory accelerations exceed acceptable levels

Initial plan to passively isolate disturbances was inadequate

Solution

Provide active isolation at the science payload rack



Rack Installation In US Lab Module

ARIS on STS Flight 79

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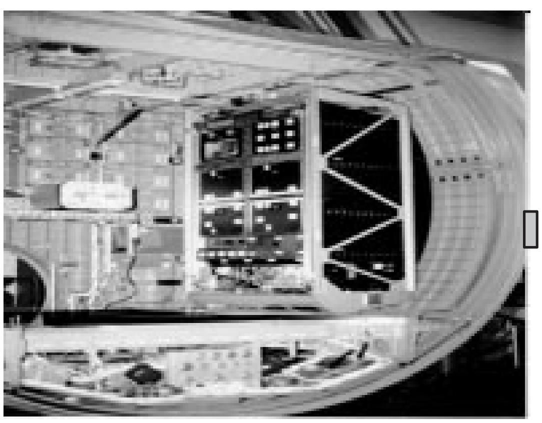
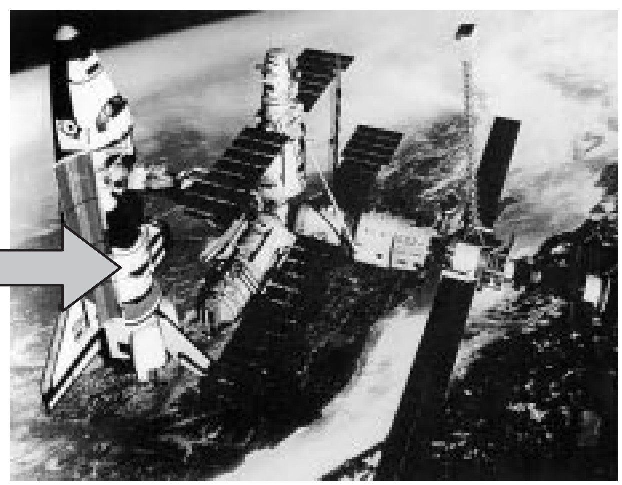
ARIS Configured In Spacehab Module





ARIS was flown aboard STS–79 in September, 1996 and tested by Boeing while Atlantis was docked to the MIR space station.

ARIS History

History (continued)

The primary RME–1313 mission objective was to mitigate Space Station ARIS hardware design, performance, and operation risks. Taking into consideration the Space Station production requirements alleviated design risks. Performance and operation risks were moderated by flight testing in zero–G which was necessary to characterize 6–DOF low frequency micro–gravity (uG) isolation behavior.

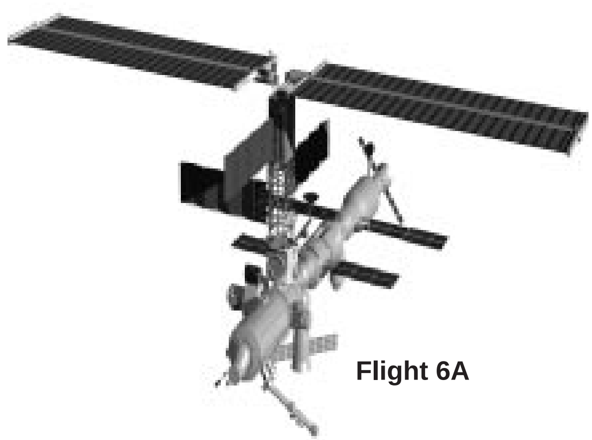
The mission to MIR also provided an excellent opportunity to test in a manned space station acceleration environment. Extensive test data was recorded during the mission in a variety of environments and configurations and proved to be particularly valuable.

ARIS on ISS

The ARIS will fly as a part of an integrated payload rack with the first unit manifested on Flight 6A. The Active Rack Isolation System is planned to be installed at twelve International Standard Payload Rack (ISPR) locations within the US LAB.

Plans for ARIS on ISS

Mission specialists Jay Apt and Carl Walz perform ARIS Station installation procedure during risk mitigation experiment.



ARIS scheduled to launch April 2000 on 6A

- 11 ARIS kits in production
- Boeing will lead first 90 day on–orbit period dedicated to ARIS characterization testing

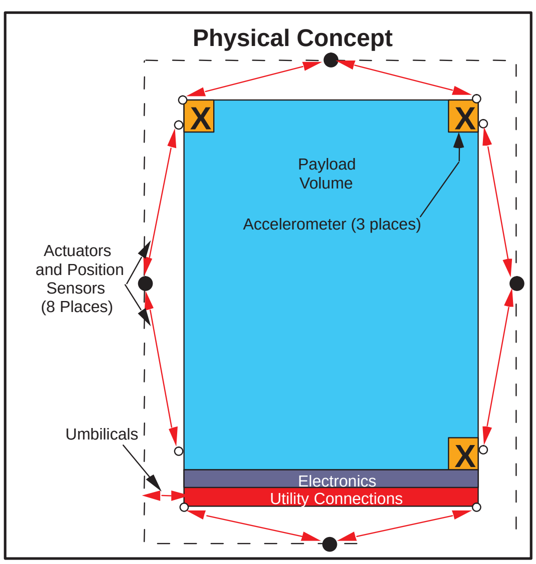
ARIS on Flight 6A

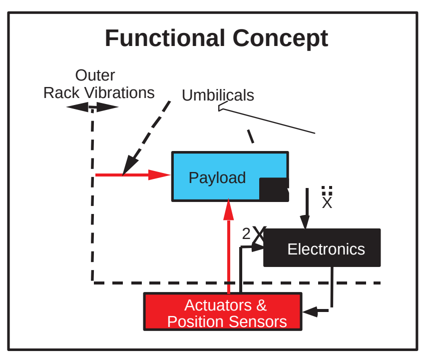
The ARIS will fly as a part of an integrated payload rack with the first unit manifested on Flight 6A. The Active Rack Isolation System is planned to be installed at twelve International Standard Payload Rack (ISPR) locations within the US LAB.

ARIS Operation Concept

ARIS attenuates vibratory disturbances at selected user payload locations. Attenuation is achieved by imparting a reactive force between the payload rack and the module in response to sensed vibratory accelerations. Eight actuators are used to move the rack in an attempt to cancel out the measured vibration/motion. The system was designed to operate at frequencies below 1000 Hz, being most effective in the 20–200 Hz region.

ARIS Rack Isolation System Concept





Purpose of the ARIS is to isolate user payloads from ISS vibratory acceleration

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ARIS Primary Control

After installation and calibration of the rack, ARIS will be primarily controlled via ground commanding.

Crew participation will be required for ORU replacement, rack reconfiguration (maneuvering or access to adjacent racks), or other off–nominal activities.

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Concept for ARIS Control

ARIS will be controlled via the payload–provided Laptop (EXPRESS or facility Laptop).

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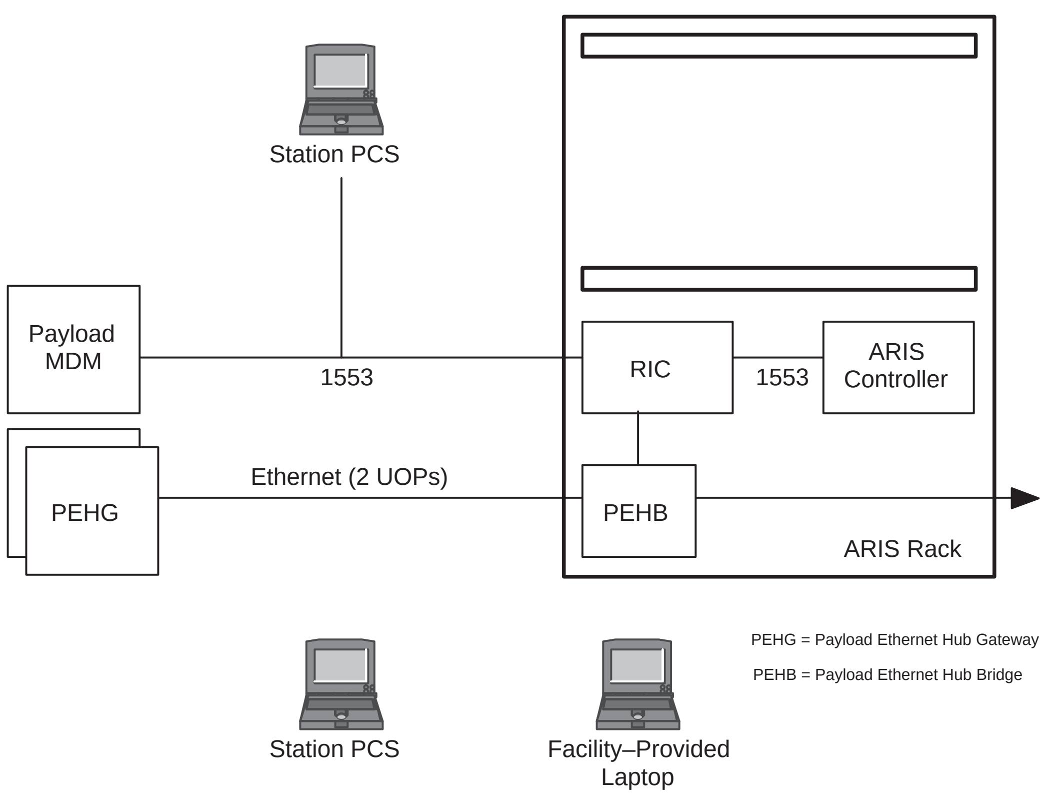
ARIS Command and Control



ARIS Data

Data generated by ARIS will be sent to the payload Payload Multiplexer Demultiplexer (MDM) via the Rack Interface Controller (RIC) or other facility controller over the 1553 bus interface. Data required for monitoring the "health" of ARIS will be designated Health and Status (H&S) data and sent from the RIC to the MDM.

Data Categories

All other data messages can be divided to **two categories:**

Those which will have **continuous downlink** (during Acquisition of Signal (AOS)) via the high rate data system.

Those that must be **requested for downlink by command** All off–nominal data will be downlinked upon request only.

Installation Overview

Stowed hardware is required in order to complete the installation once the ARIS rack is transferred during the intra–vehicular activity (IVA) from the mini–pressurized logistics module (MPLM) to the US Lab.

This hardware includes the snubbers, the upper actuators, pushrods, umbilicals and isolation plate attachments.

Once the rack is rotated into a selected ISPR location, isolation plate, snubber and actuator installations are made. The ARIS rack is then activated and checked out by the GSP or the Crew.

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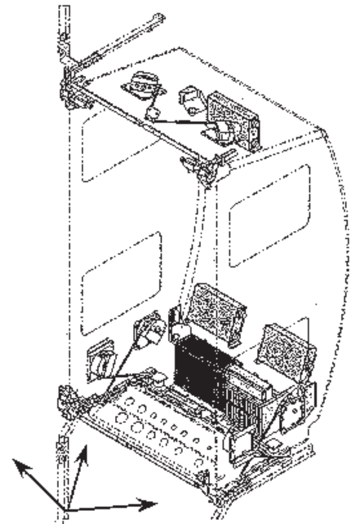
Major ARIS Components

- ARIS Controller (Control & input/output): Decoupling implemented in controller allows freedom to place actuators and sensors. Payloads have extensive command, data acquisition, and control options.
- 3 Remote Electronic Units : Programmable analog filters & gains & 16 bit analog–to–digital converters.
- 3 Tri–axial Accelerometer Heads : Built small to fit in rack corners
- 1 Actuator Driver : Pulse width modulation used to reduce power consumption
- 8 Actuators : Voice coil rotary actuator used to reduce profile and power consumption.



STATION UMBILICAL STANDOFF STRUCTURE

ARIS Operations Functions

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ARIS Nominal Ops Functions **ARIS SATS Document**

FUNCTION	OPERATOR
Retrieve Hardware/Tools for ARIS Installation	Crew only
Prepare Rack Cavity in US Lab	Crew only
Remove ARIS equipped Rack from MPLM	Crew only
Translate ARIS Rack to Installation Location	Crew only
Install ARIS Secure Rack Install ARIS Hardware on ISPR Rotate Rack into Upright Position Prepare Isolation Mechanisms Connect Utilities to ISPR	Crew only
Stow Installation Hardware	Crew only
ARIS Checkout/Activation	
Power/Initialize	Ground or Crew
Adjust Upper Pushrods	Crew only
Engage ARIS Isolation Mechanisms	Crew only
ARIS Calibration (Mass & Stiffness)	Ground
ARIS File Transfer (D/L Data)	Ground
Develop Config & Control File	Ground
ARIS File Transfer (Config & Cntl)	Ground
ARIS Operations & Monitoring	Ground or Crew
Configure ARIS for Maneuver	Crew only
ARIS Power Down	Ground or Crew
Configure ARIS for Return to MPLM	Crew only

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Snubbers

The snubbers are ”released” by the Crew for microgravity–sensitive science operations, (nominal procedure). The snubbers also provide 4–point restraint of the ISPR during payload servicing and rack maintenance.

Snubbers Use

The snubbers are locked by the Crew to secure the rack during:

1. Payload servicing.
2. Rack maintenance.
3. Orbital translation/reboost.
4. Debris avoidance maneuver.
5. Extended periods not requiring microgravity.

Major ARIS Components (ORUs)

The major components (ORUs) of the ARIS system are the Controller, Remote Electronics Units, Accelerometers, Actuator Driver, and the Actuator Assemblies.

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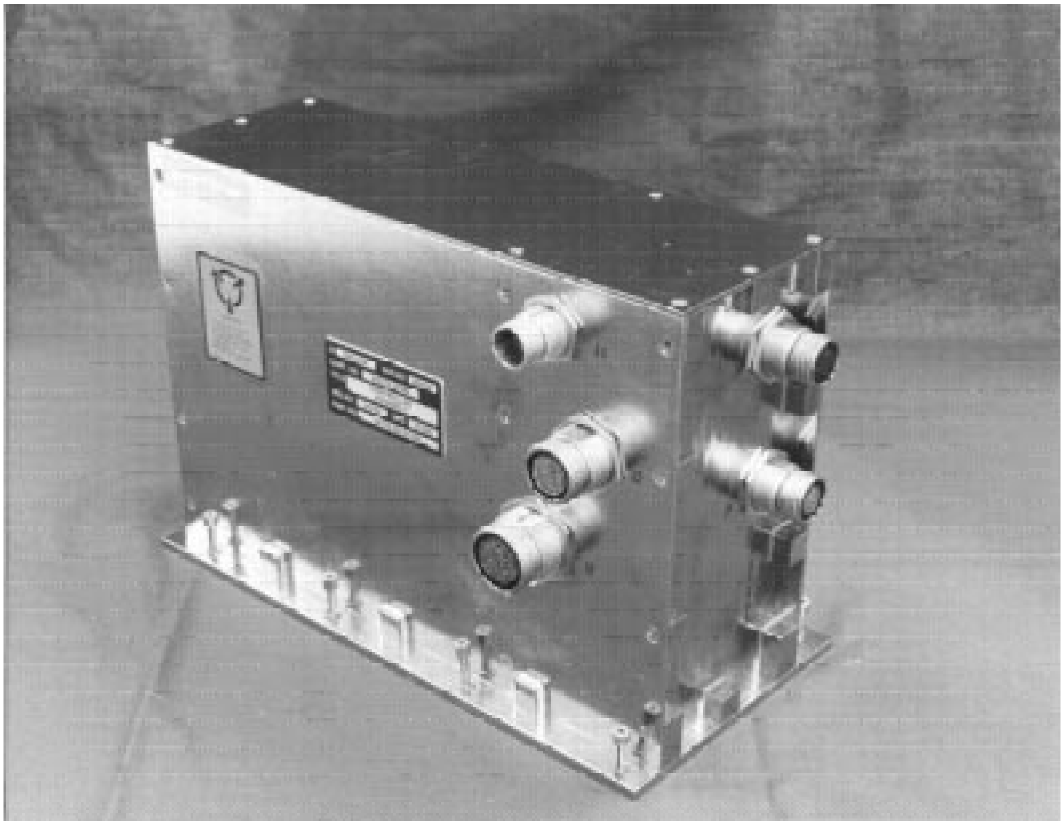
Controller Assembly



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Controller Assembly (One Unit)

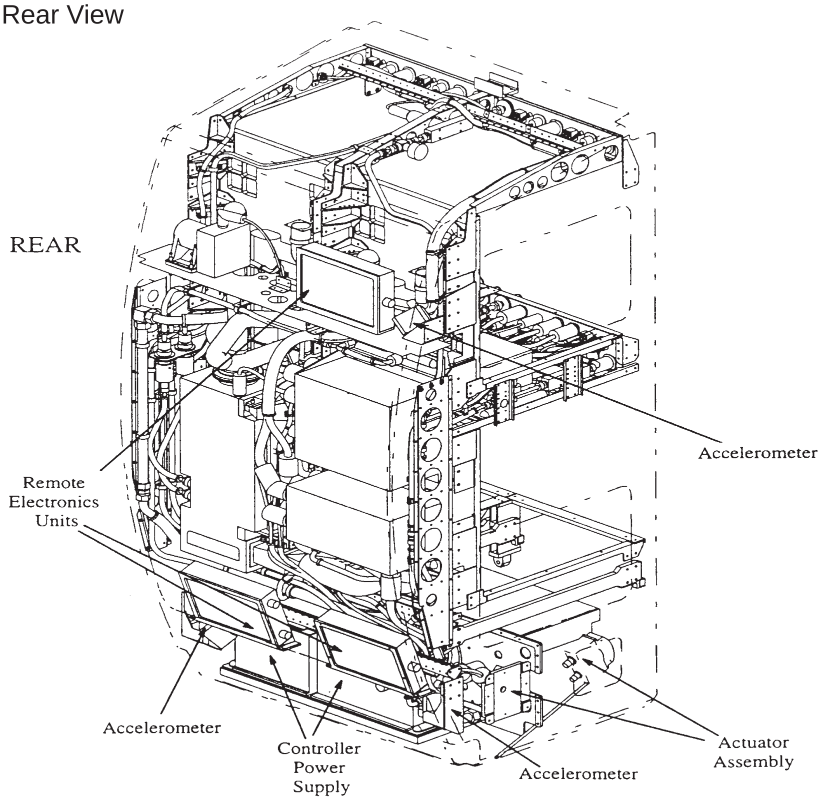
During active isolation, the Controller Assembly is fed **acceleration and position information** read from the REUs. The REUs receive this input from the Accelerometers and Actuators.

The Controller feeds these inputs into a control algorithm and then commands counteracting accelerations to the Actuator(s) through the Actuator Driver Assembly.

The Controller Assembly contains the power supply, controller circuit board and digital–to–analog converter, (DAC) circuit board.

ARIS Rack Assembly

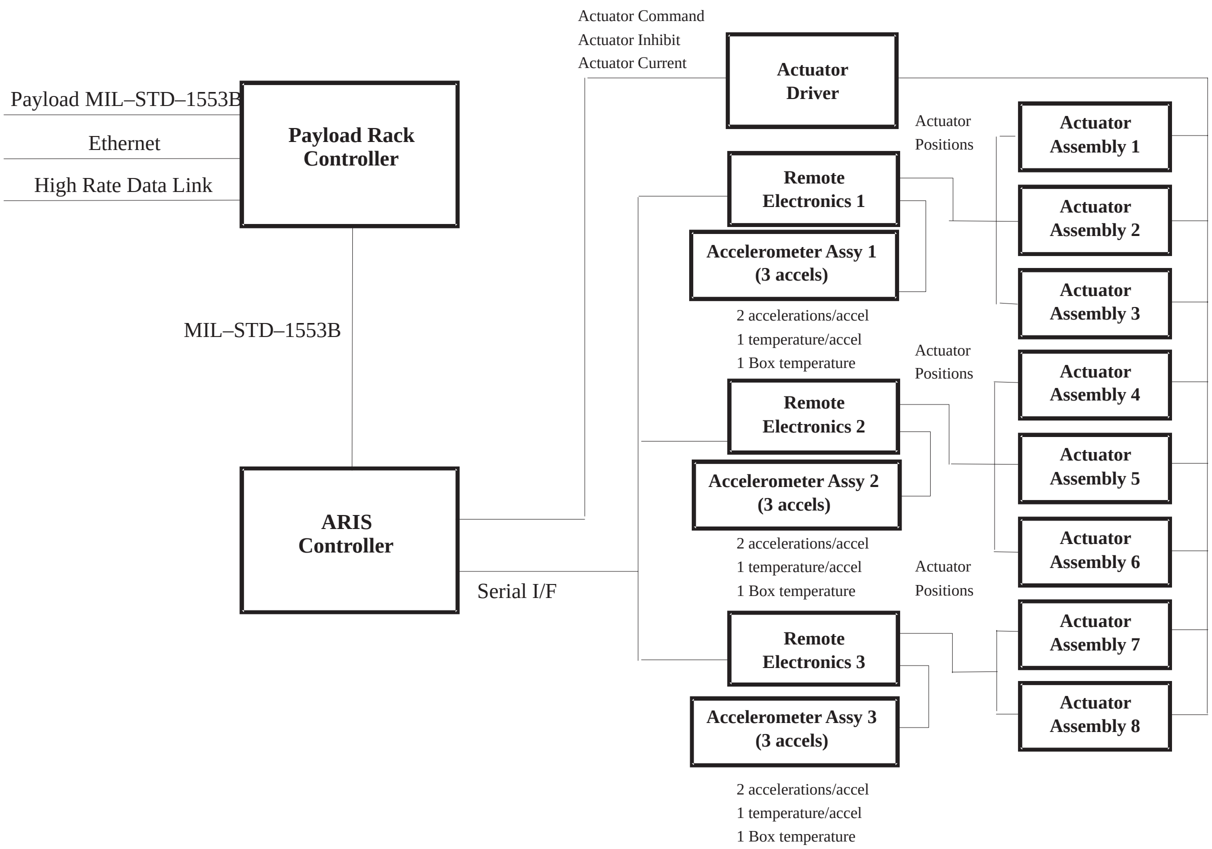
ARIS Unit– Rear View



The DAC Circuit Board

The DAC circuit board provides the interface between the Controller and Actuator Driver. The DAC contains 8 independent channels. Each DAC channel commands a channel in the Actuator Driver with a differential analog command signal and a discrete ”inhibit” signal. The command signal is used to command an ”acceleration” to the Actuator and the ”inhibit” signal is used to remove power from the Actuator. Each DAC channel receives a differential analog signal that corresponds to the current in the Actuator.

Major ARIS Component Diagram
ARIS Block Diagram



The Controller Power Supply

The ARIS controller assembly is mounted on the cold plate. The ARIS power supply is located inside the Controller Assembly.

The Controller power supply converts the 120 VDC power supplied to it, to all voltages used by the ARIS system. The Controller Assembly uses +5 VDC, ± 15 VDC for internal digital and analog electronics. The Controller Assembly feeds +5 VDC, ± 15 VDC to the REUs and to the Actuator Driver Assembly. The Controller Assembly also supplies +28 VDC to the Actuator Driver Assembly, which in turn supplies this voltage to the Actuators.

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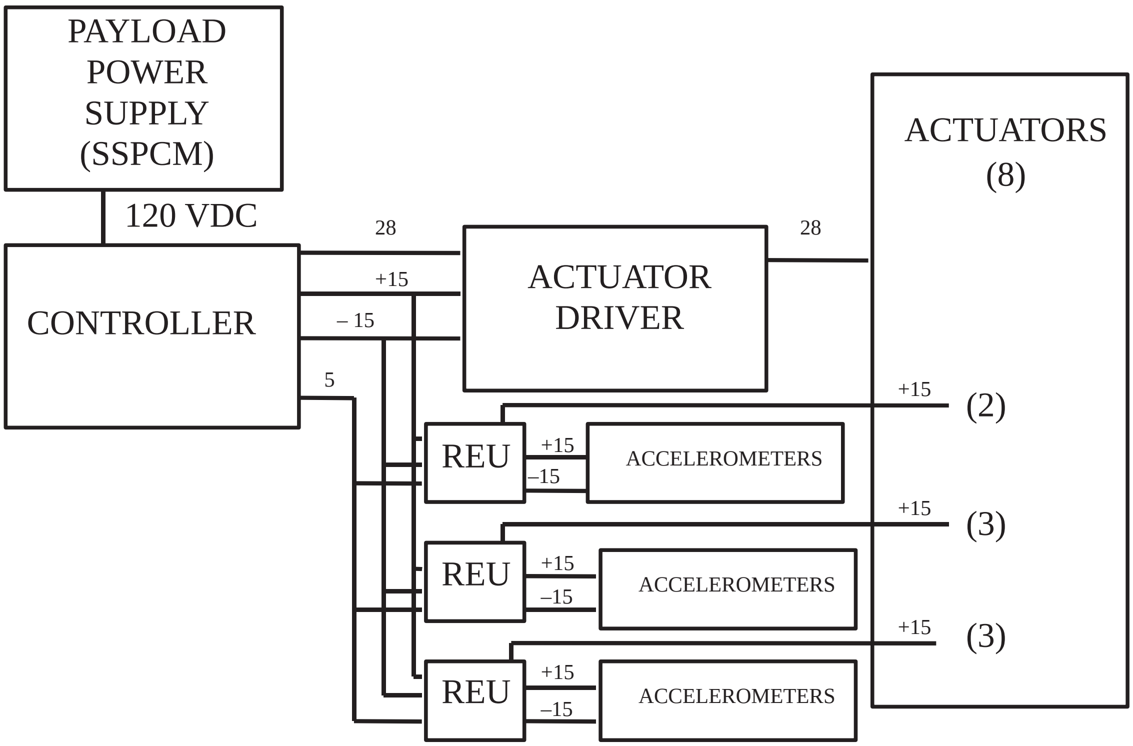
ARIS Overcurrent Protection

ARIS Power



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The Controller Over–temperature Monitoring

The ARIS controller includes an internal thermal switch that is mounted on the circuits that will shut down ARIS power outputs if an over–temperature condition above 150° degrees centigrade is detected.

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Temperature Monitoring

SUBSYSTEM	OVERTEMP DETECTION METHOD	OVERTEMP REACTION
Controller	Thermal switch in power supply set at 150 °C.	Automatically removes power to ARIS when temperature exceeds 150 °C.
Actuator driver	Thermal sensor (AD590) on each actuator driver card (8 total).	Turns off current output to actuator when temperature of driver card exceeds 78 °C.
Remote Electronics Unit	Thermal sensors (AD590) in each Remote Electronics Unit.	Sends raw temperature data to ARIS controller which sends data to EXPRESS controller for processing.
Accelerometers	Thermal sensors (AD590) for each accelerometer.	Sends raw temperature data to ARIS controller which sends data to EXPRESS controller for processing.
Actuators	None. Only significant heat source would be electrical failures which are controlled by overcurrent protection.	N/A

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Actuator Driver Assembly
(One Unit)

The ARIS **Actuator Driver Assembly** is mounted on the cold plate. The Actuator Driver monitors are active anytime the ARIS is active. The Actuator Driver includes an internal thermal switch mounted on the driver circuits that will remove power from the effected actuator if an over–temperature condition above 78degrees centigrade is detected.

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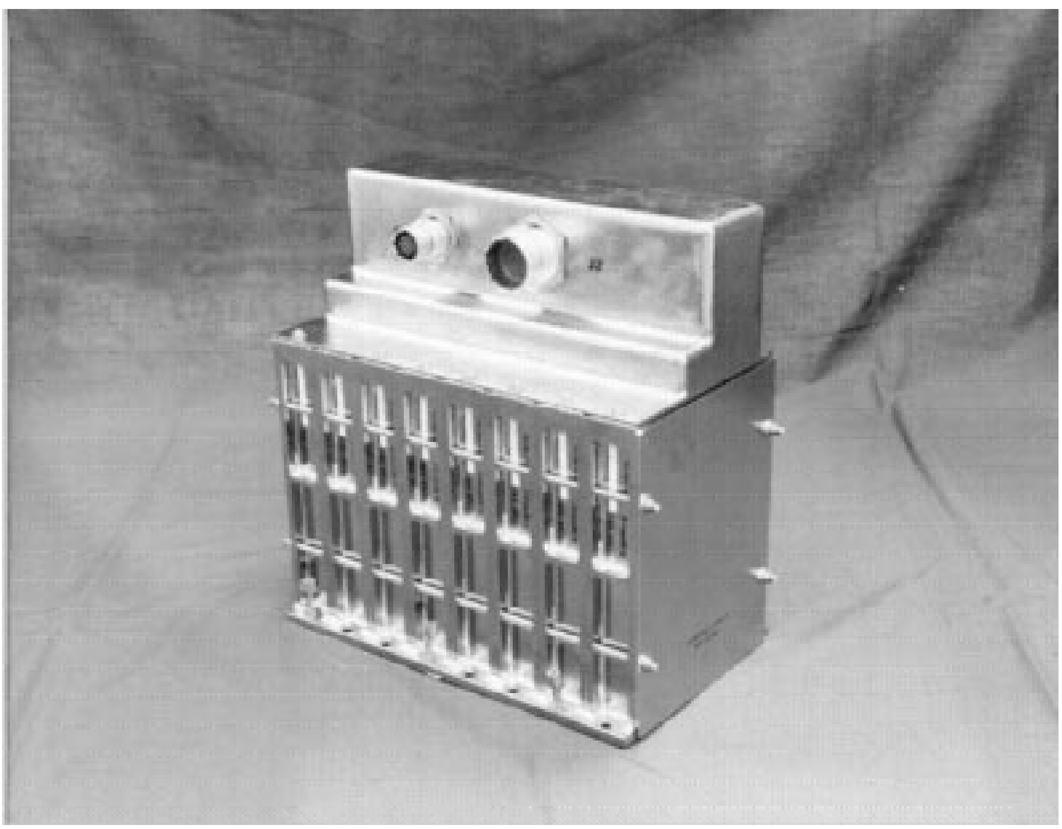
Actuator Driver Assembly



ARIS Rack Assembly

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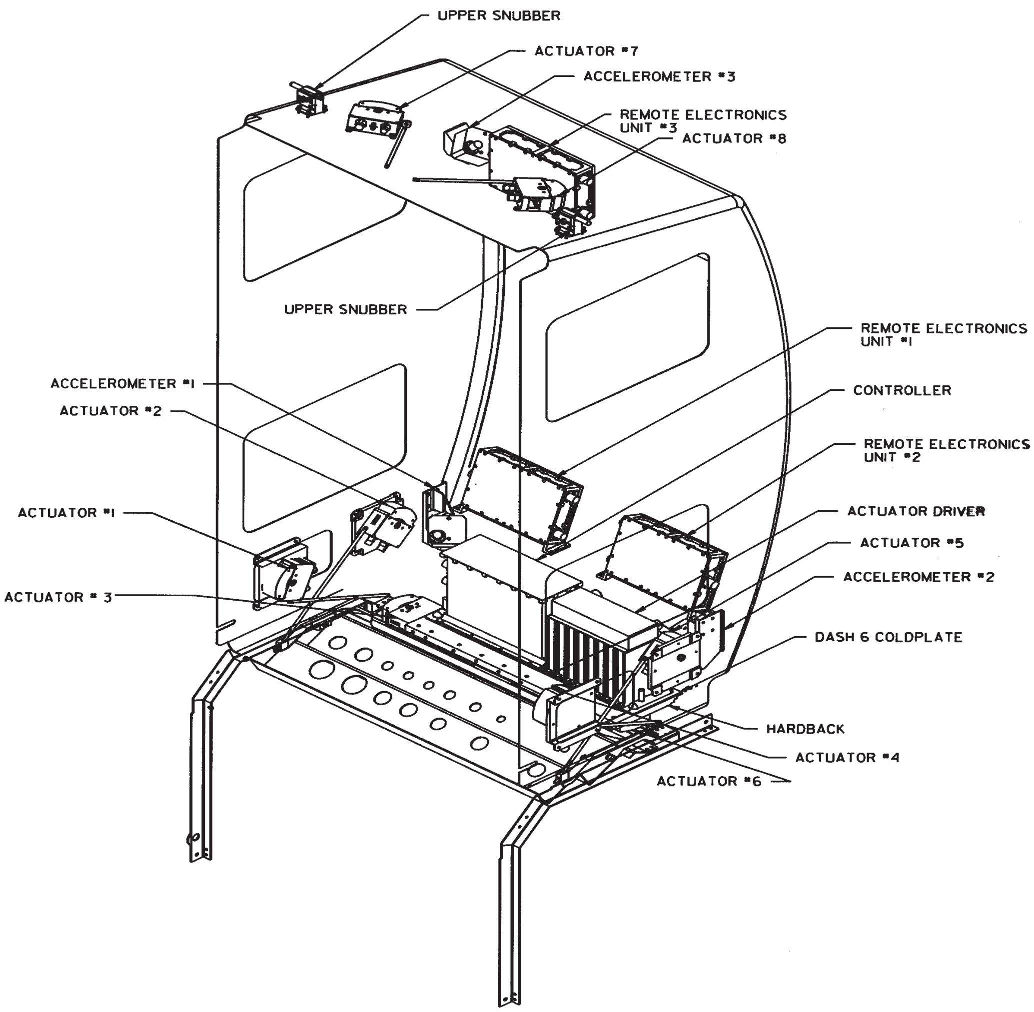
ARIS Rack Major Components



Remote Electronics Unit (REU) Assembly (Three Units)

The REU provides the **signal–conditioning** interface between the Accelerometers, position sensors and the Controller. ARIS contains **three REUs.**
Each REU connects to three accelerometer heads (contained in one Accelerometer) and **three position sensors** (one in each of three Actuators).

REU accelerometer channels

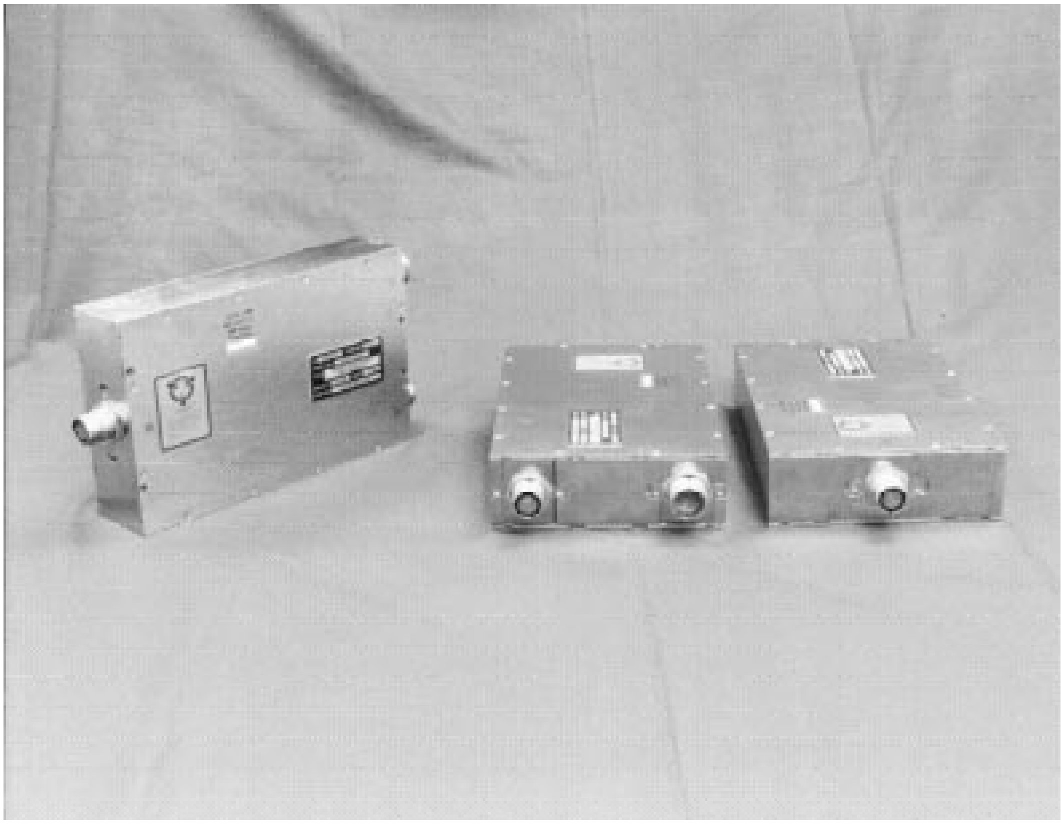
Each accelerometer channel is split to **provide two accelerations** accelerometer head.

The first acceleration is 0–10 Hz data used in the active isolation control algorithm.

The second acceleration provides 300 Hz data that is not used by ARIS, but is made available for the US LAB.

The REU converts the analog ”acceleration” and ”position” signals to a digital format and then transmits this data to the Controller over the REU serial bus.

REU Assembly



REU Circuit Boards

Each REU contains **two** printed circuit boards:

A ”Position” circuit board and

An ”Accelerometer” circuit board.

The Position circuit board interfaces to and contains the signal conditioning for the position sensors of up to three Actuators. The Position circuit board also contains the serial bus interface for the REU.

The Accelerometer circuit board interfaces to and contains the signal conditioning for one Accelerometer.

REU A/D Converters

BOEING

The ARIS Remote Electronics Unit receives sensor data from the ARIS accelerometers and position sensors and transmits this data to the ARIS Controller Assembly. The REU assembly contains programmable analog filters, gains, and 16 bit analog–to–digital converters.

The Accelerometer Assembly (Three Units)

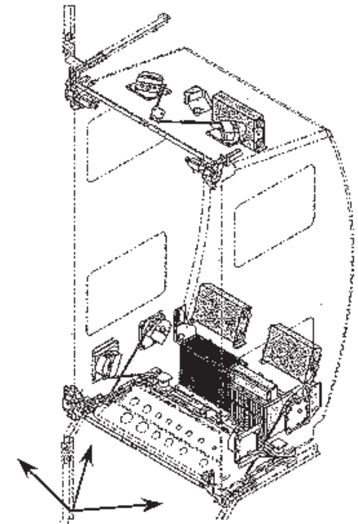
BOEING

The Accelerometer contains three accelerometer heads oriented in three orthogonal positions. The accelerometer head used is the 979–3000–001 accelerometer that has been used in space for microgravity applications by Lewis Research Center and others.

Three Accelerometer Assemblies are used in ARIS for a total of 9 accelerometer heads, allowing for redundancy.

Major ARIS Components

- 3 Tri–axial Accelerometer Heads : Built small to fit in rack corners



Accelerometer Operation

The **accelerometers measure vibratory disturbances** and return data to the ARIS control unit which then issues commands to eight actuators to move the entire rack on three axes, 6 degrees of freedom (DOF) to counteract the disturbances.

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Actuator Assembly (Eight Units)

The **Actuator Driver commands the Actuators**. The Actuators consist of eight independent, but identical, modules and a connecting wire harness. Each Actuator receives a differential analog command signal, a differential discrete inhibit signal and 28 VDC from the Controller Assembly.

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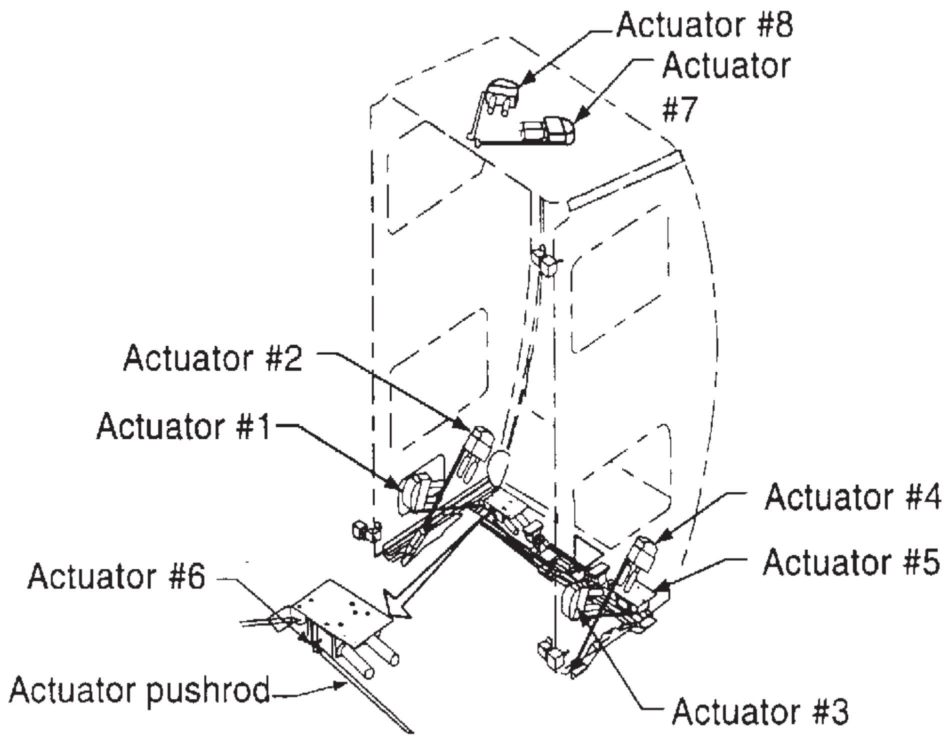
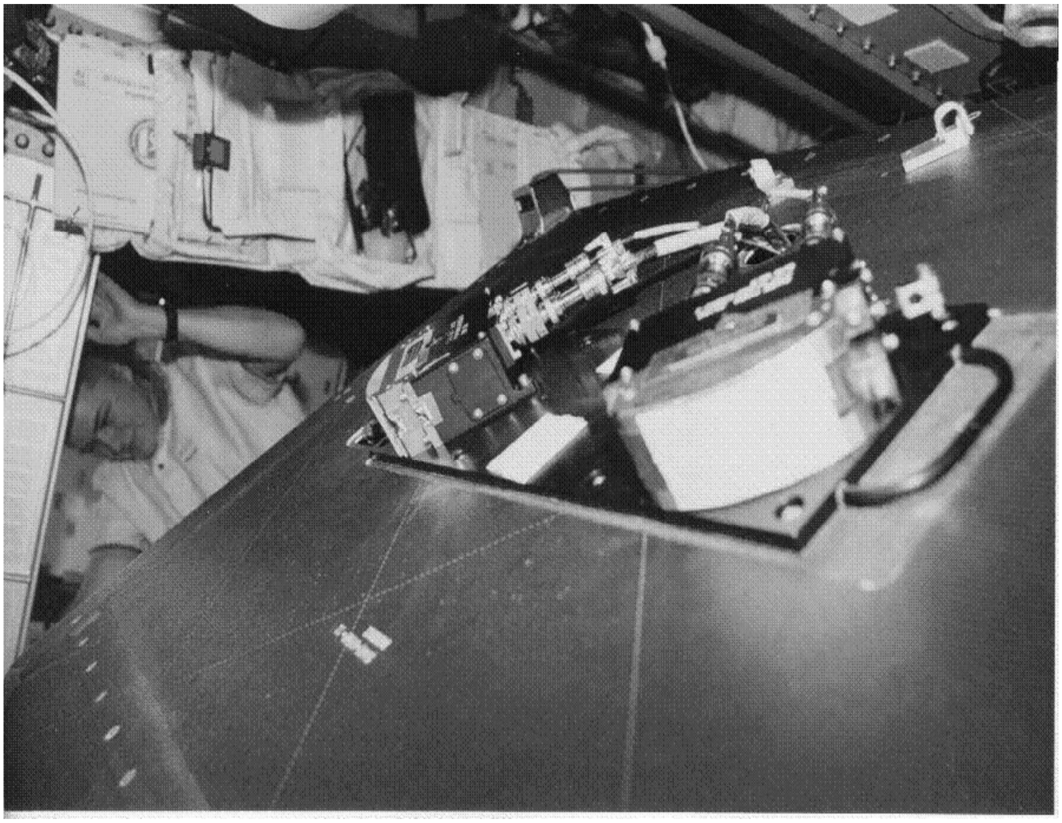
Actuator Assembly Location

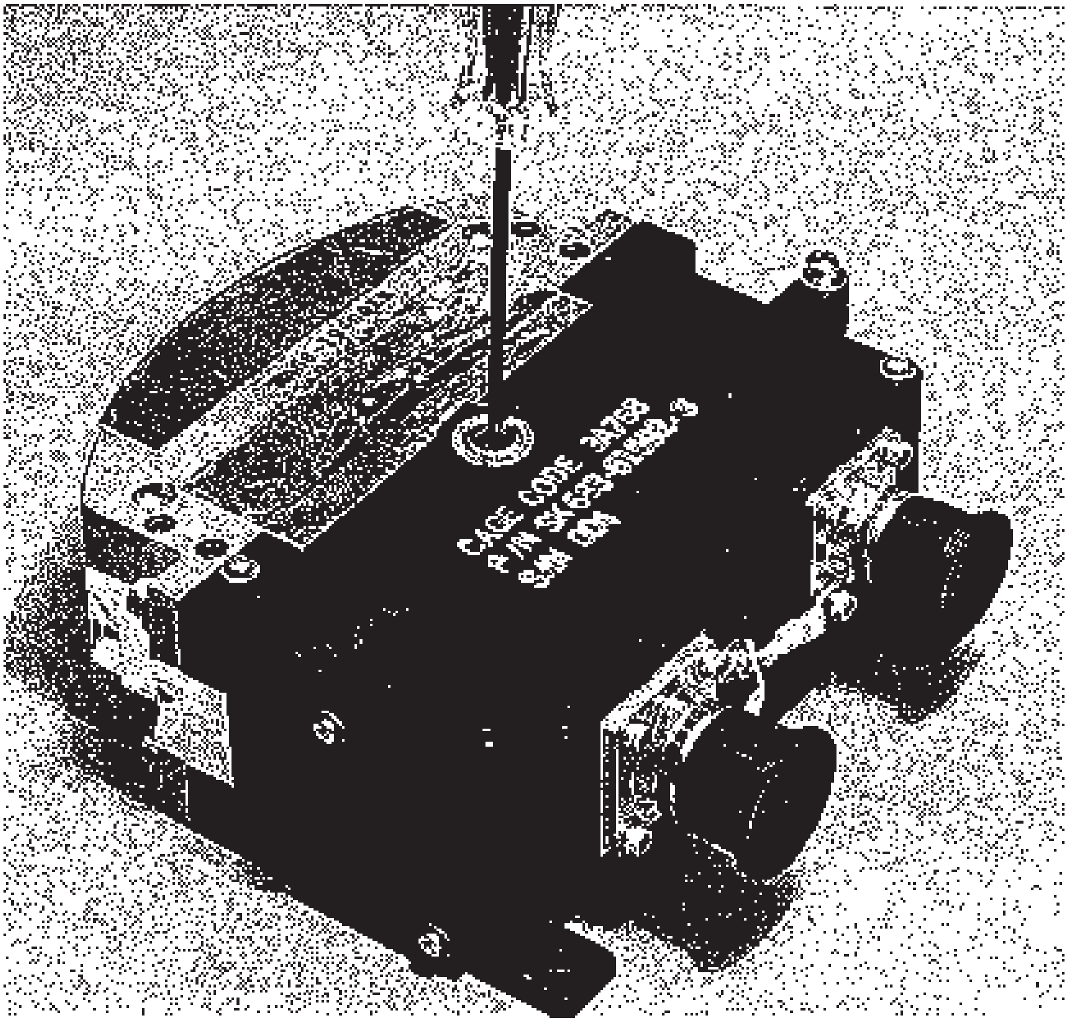
ARIS UNIT FRONT VIEW — ACTUATORS



ARIS Actuators 7 & 8 (Top)



Actuator Assembly



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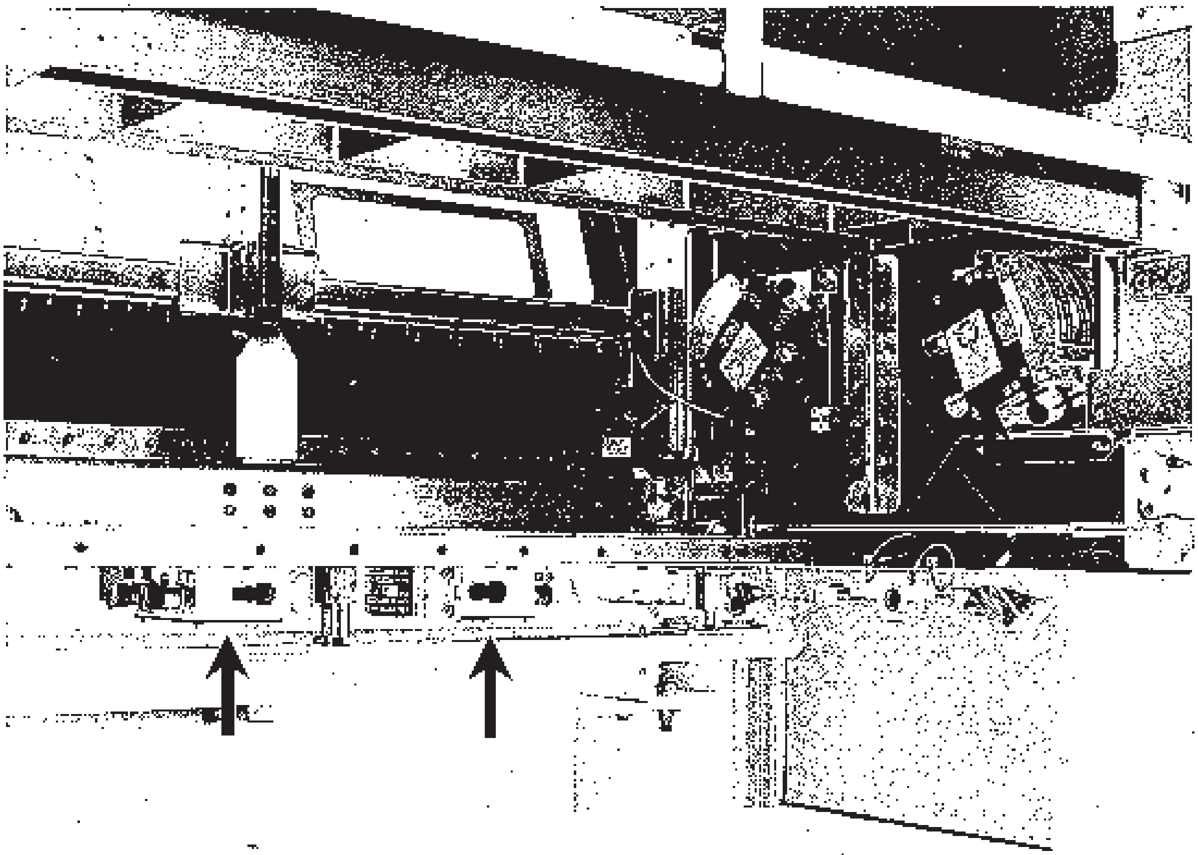
Actuator Assemblies 3, 4, 5 & 6



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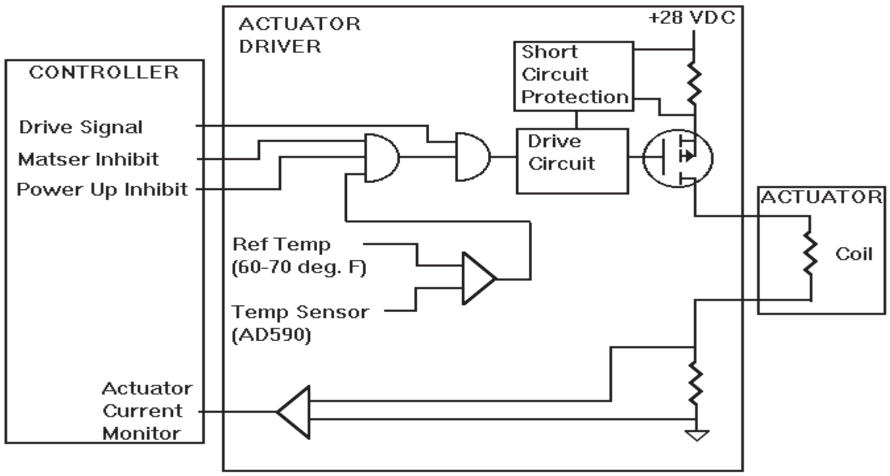
ARIS Actuator Circuit Operation

The Actuator Driver Assembly is a "Class D" amplifier that sends a pulse width modulated 28 VDC "drive" signal to the Actuator(s), proportional to the analog command signal.

The Actuator Driver Assembly (removes power from) or enables (allows power to) the Actuator based on the "inhibit" signal from the Controller. The module sends a differential analog signal back to the Controller that is proportional to the current in the Actuator.

ARIS Actuator Driver Circuits

Controller / Actuator Driver Circuit



Actuator/Pushrod Operation

Each Actuator contains a motor (voice coil), a pushrod and a position sensor. The motor is driven by the Actuator Driver. One end of the pushrod is attached to the motor and the other end is attached to the US Lab through the isolation plate or the standoff.

Commands to the motor, which accelerate the pushrods, are the mechanism by which a rack is ”floated”. The pushrods and the umbilicals cabling are the only mechanical linkages between a rack equipped with ARIS and the US Lab.

The position sensor provides a low–level current to the REU, and then to the Controller, that is proportional to the movement of the pushrod(s).

Other Mechanical Components

Other ARIS mechanical components include the pushrods, the snubbers, the isolation plate and miscellaneous brackets and fittings.

Rack movement is accomplished through pushrods that apply force against the ISS framework itself.

The snubbers are made of machined aluminum and prevent damage to the ARIS actuator pushrods in the event the rack is disturbed or moved by the Crew after the system is activated on–orbit. Once extended into their operating position, the snubbers provide a ”hard stop” that limits rack movement to 0.5 inches maximum. The snubber extension pins can be fully extended to provide a rigid restraint on–orbit when the Crew is accessing the rack. The actuator pushrods and the snubbers are designed to carry on–orbit loads ONLY. Launch and landing loads are carried by the ISPR upper and lower attach fittings similar to other ISPRs.

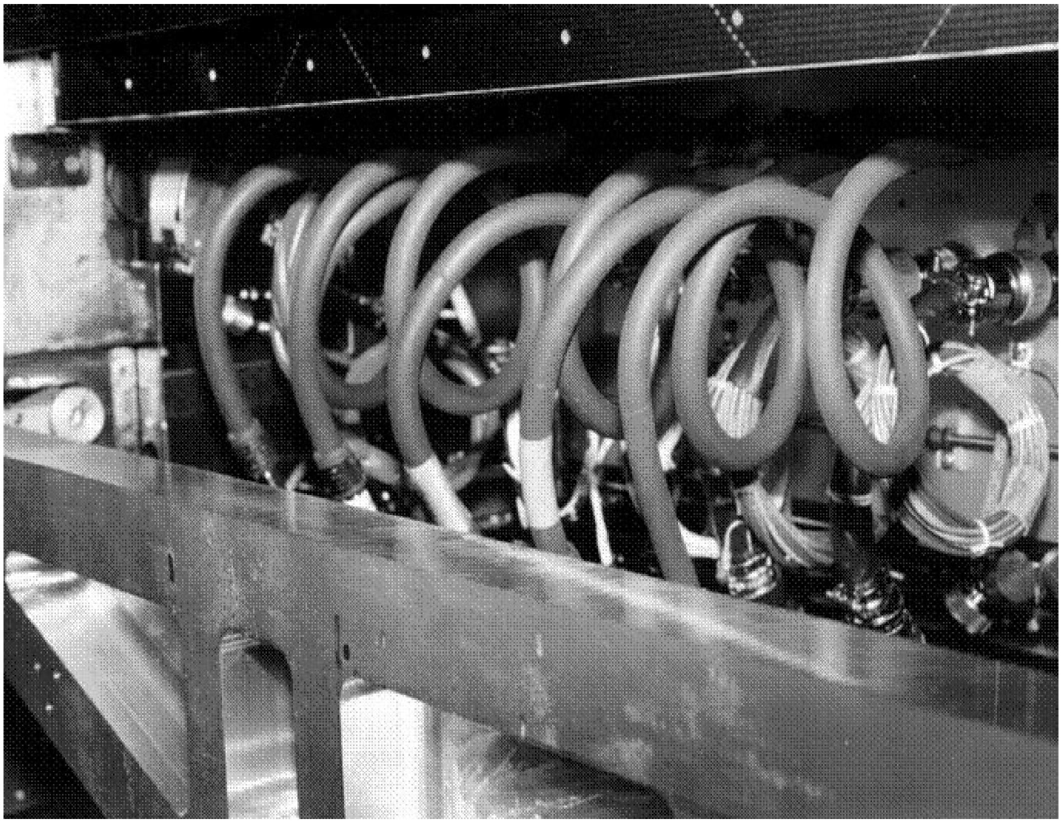
ARIS Umbilical Assembly

The ARIS Umbilical Assembly provides a low bias force and spring rate connection between the United States Laboratory (USL) structure and the payload rack structure for utility pass–through.

When the user payload utilizes an ARIS, the user payload connects to a utility interface panel on the USL structure. The utility interface panel on the payload rack is part of the ARIS Standard Umbilical Assembly.

BOEING

ARIS Umbilicals



ARIS Umbilicals

ARIS Umbilical Cables

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ARIS Umbilical Assembly (Cont.)

ARIS will distribute utilities through payload interfaces between the USL and user payload racks via the ARIS Umbilical Assembly.

The cables within this assembly have a prefabricated stiffness and are looped and arranged such that any vibratory disturbances within the rack are negated. An **isolation plate** located in the bottom of the rack helps negate the transfer of vibration disturbances.

Loss of Internal Thermal Control System (ITCS) cooling to the **ARIS cold plates** is detected at the rack level by the temperature sensor located in the ITCS Rack Flow Control Assembly.

Out of tolerance temperature data is sent to a specified USL MDM depending on the location of the rack. The MDM then issues a Class 3 alarm to the Crew.

Initialize state

Initialize – Upon ”power–on” of ARIS the system is automatically initialized. The ARIS Controller is ”initialized” and communication with the 1553 data bus is established. ”Reset” command button is available if initialization process fails during power–up. Initialization is NOT a mode of operation per se.

ARIS also performs built–in–tests (BIT) to detect, diagnose and/or isolate ARIS failures. Upon completion of ”initialization” and BIT, ARIS then transitions to ”Idle.”

This process is software driven and not commanded by the Crew.

Display Modes of Operation

Idle – ARIS does not attempt to control position or acceleration of the rack. Controller reports status, ”health” of ARIS hardware.

Hold – ARIS centers the rack and holds its position relative to ISS without actively attenuating vibrations. In this state, snubbers can be mechanically locked and unlocked.

Active – ARIS senses and compensates for acceleration to maintain microgravity environment. Rack position is monitored and actuator drive commands are limited to prevent contact with rack mechanical stops.

NOGO – ARIS is in an Idle–like **state** and does not attempt to control position or acceleration. ARIS enters this state upon failure of the active BIT or any error.

ARIS Power OFF – ARIS Power OFF button is for emergency situations where ARIS power must be terminated immediately! Power to ARIS is inhibited by the RIC.

ARIS Operations Functions

ARIS OFF–Nominal Ops Functions **ARIS SATS Document**

	FUNCTION	OPERATOR
14.0	ARIS Over Temperature Recovery	Ground
15.0	ARIS Rack Rotation	Crew only
16.0	Actuator Replacement	Crew only
17.0	Pushrod Realignment	Crew only
18.0	ARIS Over Current Recovery	Ground
19.0	Prep Rack for Rotation of Adjacent Rack	Crew only
20.0	ARIS Reboot (Boot failed)	Ground or Crew
21.0	NOGO Recovery	Ground or Crew
22.0	Pushrod Replacement	Crew only
23.0	Emergency Power Down	Ground or Crew
24.0	Diagnostics	Ground
25.0	Accelerometer Replacement	Crew only
26.0	Isolation Plate Replacement	Crew only
27.0	REU Replacement	Crew only
28.0	Controller Replacement	Crew only

ARIS Rack Installation Summary

ARIS rack installation provisions are installed at 12 US Lab ISPR locations prior to Flight 5A

ARIS racks are flown on MPLM (First flight is 6A)

ARIS rack IVA from MPLM to US Lab similar to standard payload rack

Stowed hardware required to complete installation
– Snubbers, upper actuators, umbilicals

Rack is rotated into selected ISPR location

Isolation plate, snubber and actuator connections are made

Rack is activated and checked out

1.2 ARIS DOCUMENTS

The ARIS documentation as shown in Table 1.2–1 includes:

TABLE 1.2–1 ARIS DOCUMENTATION

SSP 50251, ARIS to Module ICD Part 1	This book provides ARIS to Module interface requirements applicable to the ARIS, US Lab, JEM, and APM.
SSP 50251, ARIS to Module ICD Part 2	This book provides ARIS to Module interface information and drawings applicable to the ARIS, US Lab, JEM, and APM.
SSP 57005 ARIS to Payload ICD	The purpose is to provide the necessary interface information for a payload developer to be able to design their power, data, thermal, and mechanical interfaces to the ARIS equipment.
SSP 57006 ARIS Users Guide	This book provides ARIS information and guidance to payload developers.
SSP 57xx1 ARIS ICE Specification	This specification will identify the design requirements for the ARIS ISS Characterization Experiment, which will be operated on ISS during the 90 days following the 6A flight.
SSP 57xx2 ARIS ICE Specification	This specification will identify the design requirements for the ARIS ISS Characterization Experiment, which will be operated on ISS during the 90 days following the 6A flight.
SSP 57xx3 ARIS ICE Test Report	This report will provide the results of the ARIS ICE operations and subsequent performance analysis.
SSP 57xx4 ARIS ICE Test Plan	This plan will identify the objectives and planning for the ARIS ICE.
S683–10158 ARIS Prime Item Development Specification	This specification identifies the design requirements for the ARIS. It flows down from the US On–orbit Segment Specification, which flows from the ISS System Specification.
S684–10439 ARIS/EXPRESS Installation & Maintenance Trainer Prime Item Development Specification	This specification identifies the design requirements for the AEIMT, which will be installed in JSC Bldg 9 for Crew training.
D683–TBD ARIS Safety Data Pkg	This package identifies the ARIS safety considerations.
D683–29887–1 ARIS ICE Safety Compliance Data Package	This package identifies the ARIS ICE safety considerations.
NAS15–10000 Contract Deliverable Items List (DIL)	The Prime DIL defines the official schedule of ARIS Kit, ARIS Rack, ARIS ICE, AEIMT, ARIS GSE Umbilicals and any other ARIS equipment deliveries.

1.3 ARIS PARTS LIST

The ARIS equipment consists of the following:

TBD

1.4 ARIS DRAWING TREE

The ARIS Drawing Tree follows:

TBD

1.5 ARIS EQUIPMENT DELIVERY SCHEDULES

ARIS Equipment Deliveries are shown in Table 1.5–1.

TABLE 1.5–1 ARIS EQUIPMENT DELIVERIES (Page 1 of 2)

Basis (CR)	DIL Item		Goes to:
958	ARIS ICE Mission Equipment	10/1/99	KSC
967	ARIS/EXPRESS Installation & Maintenance Trainer	3/31/99	JSC
1225	ARIS GSE Umbilical Set	1/12/99	MSFC (EXPRESS)
1225	ARIS GSE Umbilical Set	8/1/99	MSFC (MSRF)
1225	ARIS GSE Umbilical Set	8/1/99	LeRC (FCF)
1225	ARIS GSE Umbilical Set	8/1/99	KSC
1289	ARIS Kit #1	11/18/99	EXPRESS
1289	ARIS Kit #2	12/17/99	EXPRESS
1289	ARIS Kit #3	12/17/99	EXPRESS
1289	ARIS Kit #4	12/17/99	EXPRESS
1289	ARIS Kit #5	1/31/00	FCF (CIR)
1289	ARIS Kit #6	1/31/00	MSRF #1
1289	ARIS Kit #7	2/29/00	MSRF #2
1289	ARIS Kit #8	2/29/00	FCF (FIR)
1289	ARIS Kit #9	3/31/00	MSRF #3
1816	ARIS Kit #10		
1816	ARIS Kit #11		
1289	ARIS Rack #1	11/18/99	EXPRESS
1289	ARIS Rack #2	1/31/00	EXPRESS
1289	ARIS Rack #3	8/28/00	EXPRESS
1289	ARIS Rack #4	12/15/00	EXPRESS
1289	ARIS Rack #5	2/15/01	FCF (CIR)
1289	ARIS Rack #6	3/31/00	MSRF #1
1289	ARIS Rack #7	5/31/00	MSRF #2
1289	ARIS Rack #8	4/27/01	FCF (FIR)
1289	ARIS Rack #9	7/31/00	MSRF #3
1816	ARIS Rack #10		
1816	ARIS Rack #11		

TABLE 1.5–1 ARIS EQUIPMENT DELIVERIES (Page 2 of 2)

Basis (CR)	DIL Item		Goes to:
1289	ARIS Stowed Items	11/18/99	EXPRESS
1289	ARIS Stowed Items	12/17/99	EXPRESS
1289	ARIS Stowed Items	12/17/99	EXPRESS
1289	ARIS Stowed Items	12/17/99	EXPRESS
1289	ARIS Stowed Items	1/31/00	FCF (CIR)
1289	ARIS Stowed Items	1/31/00	MSRF #1
1289	ARIS Stowed Items	2/29/00	MSRF #2
1289	ARIS Stowed Items	2/29/00	FCF (FIR)
1289	ARIS Stowed Items	3/31/00	MSRF #3
1816	ARIS Stowed Items		
1816	ARIS Stowed Items		
1331	P/L Crew Aids Kit	10/1/99	JSC
1331	P/L Crew Aids Kit	10/1/99	JSC

2.0 ARIS SUPPORT

2.1 ARIS DEVELOPMENT SUPPORT

Some development support is available to Facility Payload Projects that are using the ARIS. These Facility Payload Projects currently include: FCF (3 ARIS), EXPRESS (4 ARIS), MSRF (3 ARIS) and SPD (1 ARIS).

The intent of this support is to help the Facility Payload developer in the design, integration, and initial on–orbit setup of their ARIS equipment. Additionally, some simple trades and analyses may be conducted under this task to assist a developer in looking at potential modifications of ARIS in support of Facility Payload PDR and CDR activities. Areas of assistance are anticipated be in the mechanical, electrical, controls, and software disciplines. These personnel are often involved in development of flight hardware, so coordination of requests of support should go through one Facility Payload focal to the person responsible for coordinating this ARIS Core Team support. Currently, this point of contact is Michael Miller, Facility Payloads and Hardware Tracking Manager (michael.miller@sw.boeing.com).

2.2 ARIS ONLINE INFORMATION SUPPORT

ARIS information is currently scattered in a variety of websites. The following list as shown in Table 2.2–1 may be of interest:

TABLE 2.2–1 WEBSITES WITH ARIS INFORMATION

http://iss–www.jsc.nasa.gov/ss/issapt/payofc/oz3/program_hardware.htm	This site is just getting set up and provides information about Boeing provided payload hardware, including ARIS equipment.
http://plato.ds.boeing.com/tma/aris/aris.htm	This site has some information about the STS–79 experiment with ARIS.

<need to add info on cabling model, ISPR model, etc. to websites>

Additional information is available about the ISPR and ARIS structure. The points of contact for ISPR FEM and for support of Facility Payload Structural Analysis Reports for PDR & CDR are Matt Arnold and Steve Kerkhof.

2.3 ARIS ON–ORBIT SUPPORT FROM MGAIT

The MGAIT has tasks to support on–orbit ARIS activities. These include:

A. Analyze attenuation performance prior to rack reconfiguration

B. Provide ARIS Controller gains for major payload reconfiguration

C. Assess payload effects on on–board acceleration levels and sway space constraints

The intent of this support is to help the Facility Payload developer in the initial on–orbit setup of their ARIS equipment and major reconfigurations. Additionally, some simple trades and analyses may be conducted under this task to assist a developer in looking at potential modifications of ARIS in support of Facility Payload PDR and CDR activities. Areas of assistance are anticipated be in the microgravity analysis discipline. These personnel are often involved in verification of flight hardware, so coordination of requests of support should go through one Facility Payload focal to the person responsible for coordinating this ARIS Core Team support. Currently, this point of contact is Michael Miller, Facility Payloads and Hardware Tracking Manager (michael.miller@sw.boeing.com).

3.0 MICROGRAVITY ENVIRONMENT PREDICTIONS

3.1 QUASISTEADY ENVIRONMENT VS ARIS COMPATIBLE LOCATIONS

The following assessment, as shown in Figure 3.1–1, indicates the Design Analysis Cycle 7 (DAC7) analysis results from Michael Laible. The 12 locations in the US Lab are all ARIS compatible, with the nomenclature C1 being ceiling position 1 (aft end, closest to Node 1), S1 being starboard position 1, and so on. In the JEM and APM, positions with A or F denote Aft or Forward, with positions 1 being closest to Node 2 for both modules. In the APM, 4 aft and 4 forward locations will be ARIS compatible; the two overhead ISPR locations will not. In the JEM, positions A1, F1, and A5 will be ARIS compatible. The total of locations that will be ARIS (and also PaRIS) compatible is therefore 23.

DAC7 Nominal Run

DAC7 Nominal Run using Altitude Curve, October Launch date
No change in rack count – 14 of 16 less than 1 μG

Location	μG Vector		Unit Vector			Cone Angle		
	Magnitude (μG)	⊥ Component (μG)	X	Y	Z	Max angle from unit vector (deg)	⊥ Component @ max angle (μG)	Magnitude at max angle (μG)
CG	0.325	0.054	–0.992	–0.069	0.102	14.88	0.036	0.135
USL–C1	0.44	0.1	–0.691	–0.299	–0.658	19.192	0.091	0.262
USL–C2	0.395	0.088	–0.786	–0.31	–0.535	22.304	0.08	0.195
USL–C3	0.36	0.07	–0.888	–0.314	–0.337	24.227	0.061	0.136
USL–C4	0.336	0.057	–0.955	–0.293	–0.042	18.961	0.033	0.095
USL–C5	0.328	0.06	–0.922	–0.235	0.307	15.01	0.023	0.087
USL–S1	0.935	0.125	–0.401	0.094	–0.911	7.828	0.115	0.838
USL–S2	0.872	0.123	–0.421	0.119	–0.899	8.506	0.115	0.77
USL–S3	0.81	0.121	–0.443	0.147	–0.884	9.295	0.115	0.702
USL–S4	0.749	0.118	–0.469	0.181	–0.864	10.22	0.115	0.635
USL–P1	0.944	0.126	–0.352	–0.339	–0.873	7.826	0.126	0.918
USL–P2	0.878	0.124	–0.368	–0.351	–0.861	8.326	0.124	0.847
USL–P4	0.748	0.12	–0.41	–0.384	–0.827	9.666	0.11	0.644
JPM1–A1	1.274	0.133	–0.269	–0.48	–0.835	6.088	0.132	1.242
JPM2–F1	1.482	0.136	–0.254	–0.438	–0.862	5.382	0.136	1.441
JPM3–A2	1.337	0.133	–0.246	–0.563	–0.789	5.833	0.133	1.301
JPM4–F2	1.54	0.136	–0.236	–0.514	–0.825	5.205	0.136	1.494
JPM5–A3	1.411	0.133	–0.223	–0.633	–0.741	5.554	0.133	1.372
JPM6–F3	1.607	0.137	–0.217	–0.581	–0.785	5.008	0.137	1.558
JPM7–A4	1.495	0.134	–0.201	–0.692	–0.694	5.268	0.134	1.453
JPM8–A5	1.586	0.135	–0.18	–0.74	–0.648	4.987	0.135	1.541
JPM9–F5	1.767	0.138	–0.181	–0.687	–0.704	4.592	0.138	1.712
JPM10–F6	1.858	0.138	–0.165	–0.729	–0.665	4.388	0.138	1.8
APM–CLG1	0.842	0.13	–0.435	0.509	–0.742	9.059	0.118	0.737
APM–CLG2	0.938	0.133	–0.402	0.629	–0.666	8.183	0.121	0.842
APM–FWD1	1.458	0.136	–0.326	0.261	–0.909	5.375	0.136	1.445
APM–FWD2	1.518	0.137	–0.323	0.356	–0.877	5.192	0.137	1.506
APM–FWD3	1.591	0.138	–0.317	0.44	–0.84	5.002	0.138	1.582
APM–FWD4	1.676	0.14	–0.31	0.512	–0.801	4.807	0.14	1.667
APM–AFT1	1.278	0.133	–0.348	0.332	–0.876	5.991	0.133	1.264
APM–AFT2	1.349	0.134	–0.341	0.434	–0.834	5.729	0.134	1.338
APM–AFT3	1.433	0.136	–0.331	0.52	–0.788	5.467	0.136	1.423
APM–AFT4	1.528	0.138	–0.319	0.591	–0.741	5.208	0.138	1.519
CAM–MID	0.394	0.105	–0.529	–0.564	0.634	22.788	0.093	0.22
CAM–TOP	0.744	0.132	–0.102	–0.228	0.968	10.473	0.132	0.713

FIGURE 3.1–1 QUASISTEADY MICROGRAVITY PER ISPR LOCATION

DAC6 Quasi–Steady Microgravity Assessment

DAC6 AC MICROGRAVITY CONTOURS (Side)

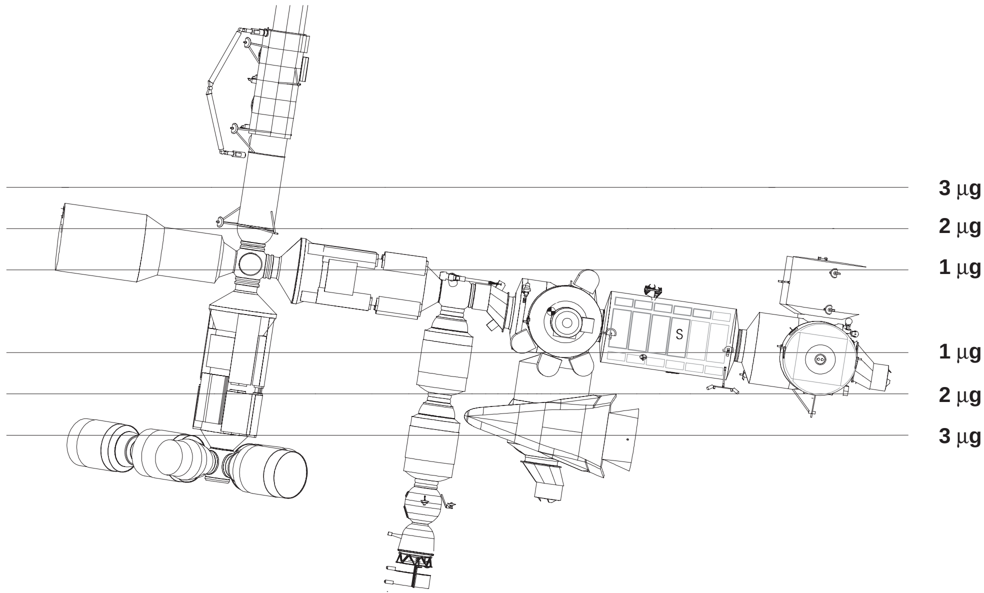


FIGURE 3.1–2 DAC6 QUASISTEADY MICROGRAVITY CONTOURS

3.2 VIBRATORY ENVIRONMENT

The following assessment indicates the Design Analysis Cycle 6 (DAC6) analysis results of the Non–Isolated Research Assessment (NIRA). This is the predicted offboard environment *without* ARIS.

Microgravity Performance Predictions

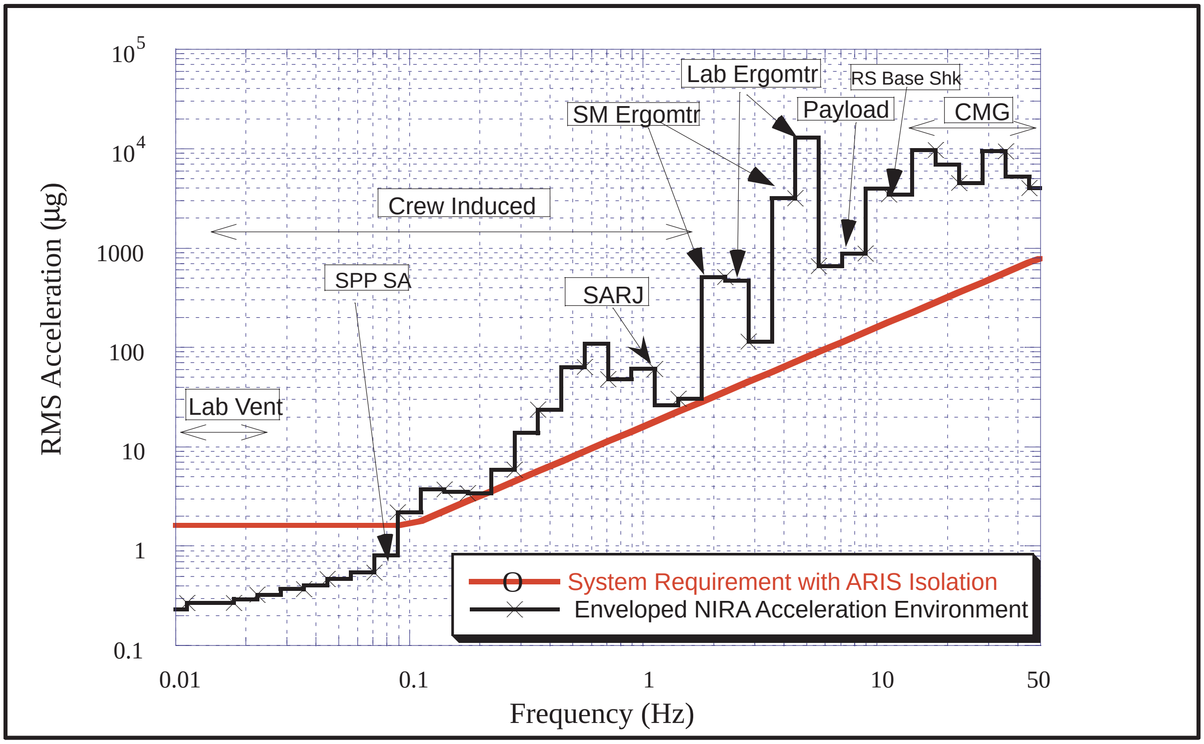


FIGURE 3.2–1 MICROGRAVITY RESPONSE PREDICTION (OVERALL ENVELOPE)

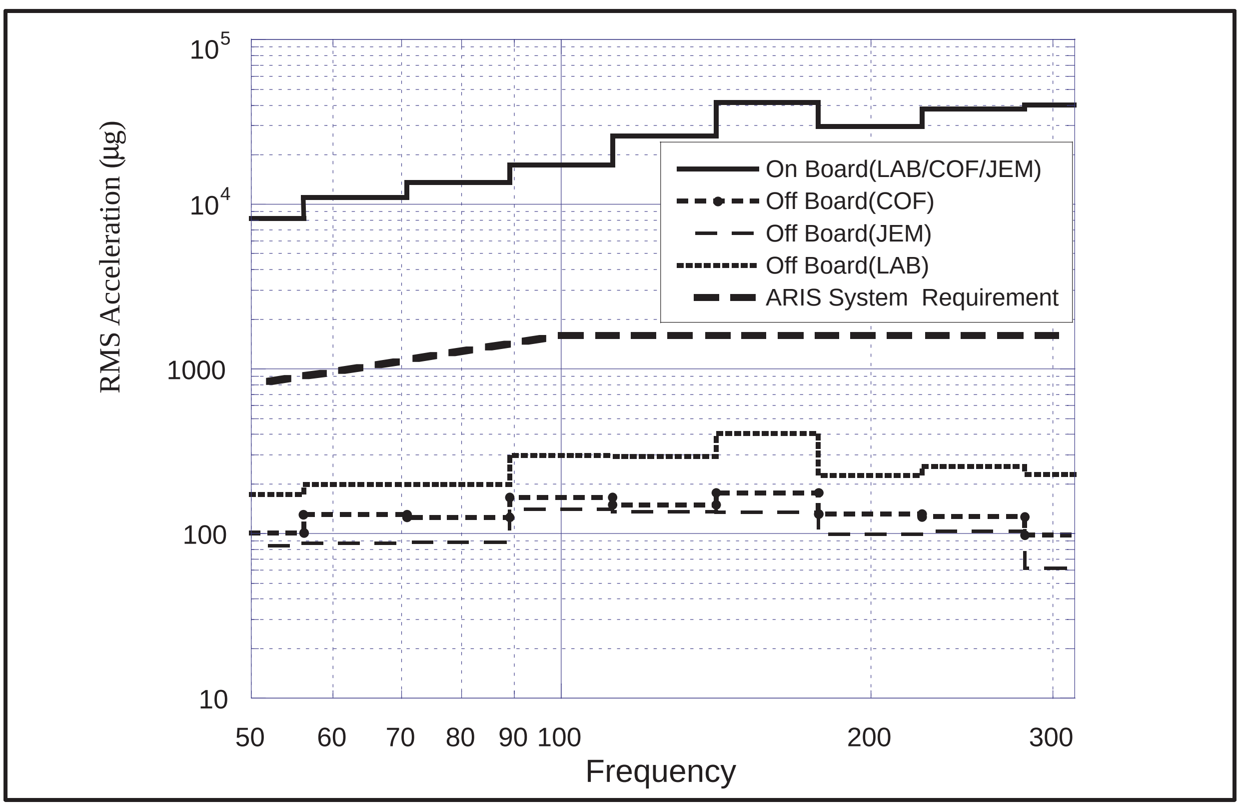


FIGURE 3.2–2 NIRA RESPONSE AT LAB/COF/JEM ISPR DUE TO PAYLOAD DISTURBANCES

4.0 REQUIREMENTS / CAPABILITIES

The Active Rack Isolation System (ARIS) has the following major capabilities. For ARIS–equipped payload racks, the ARIS has the capability to 1) limit the vibratory accelerations, 2) measure the vibratory accelerations, and 3) distribute payload utilities.

The ARIS capability to limit vibratory accelerations depends on the state of the ARIS. In the active isolation state, the ARIS actively performs acceleration attenuation when commanded by the user payload. In its standby state, the ARIS is powered, initialized, and ready to perform active isolation. Normally, the ARIS is place in either the active isolation or standby state when the Space Station is in microgravity mode. In its secured state, the ARIS is unpowered and manually locked down; usually when the Space Station is in a mode other than microgravity mode or the rack is unpowered.

4.1 LIMIT VIBRATORY ACCELERATIONS.

When in the active isolation state, the ARIS has the capability to attenuate vibratory accelerations between the United States Laboratory (USL) and the payload racks according to the minimum attenuation profile as specified in Table 1.2.1–I and shown in Figure 1.2.1–1. This profile applies to the 100–second, root–mean–square, acceleration magnitude evaluated on a one–third–octave–band basis.

Note: This attenuation performance profile applies when the USL acceleration environment is equal to or less than the acceleration environment specified in the ARIS Prime Item Development Specification, section 3.2.1.1.

TABLE 4.1–1 ARIS MINIMUM ACCELERATION ATTENUATION CAPABILITY

Attenuation (dB)	Frequency Range (Hz)
0	Less than 0.00078
13 (log(*f*) + 3.109)	0.00078 to 0.00158
4	0.00158 to 0.00631
–20 (log(*f*) + 2)	0.00631 to 10
–60	10 to 300

When in the secured state, the ARIS is required to not magnify quasi–steady or vibratory accelerations (0.0 to 300 Hz) between the USL and the payload rack other than those resulting from the integrated payload–rack/user–payload structural resonances.

During transition from the standby state to the active isolation state and during transition from the active isolation state to the standby state, the ARIS is required to limit the instantaneous magnitude of transient accelerations transmitted to the payload rack to less than or equal to 1000 microgravities per axis.

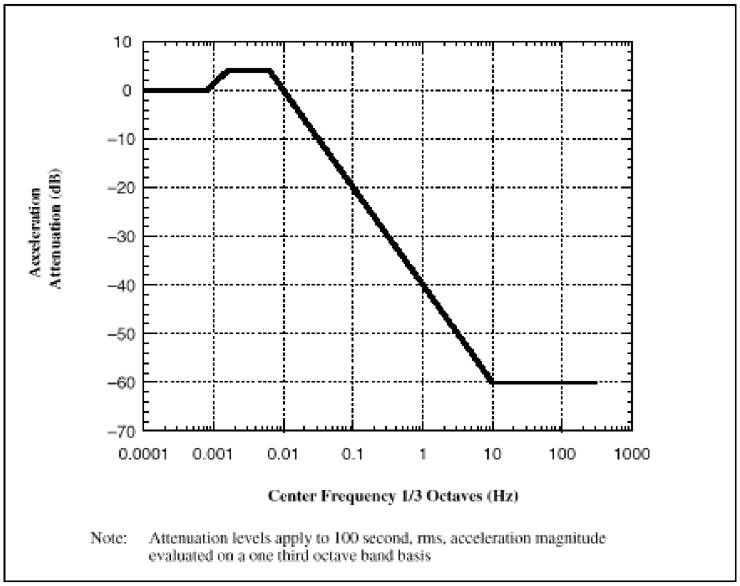


FIGURE 4.1–1 ARIS MINIMUM ACCELERATION ATTENUATION REQUIREMENT

When in the active isolation state, the ARIS has the capability to recover, without human intervention, from a crew pushoff and actively provide the specified vibration attenuation within 5 seconds after being subjected to a crew pushoff on the payload rack of 125 lbf applied for 0.1 second.

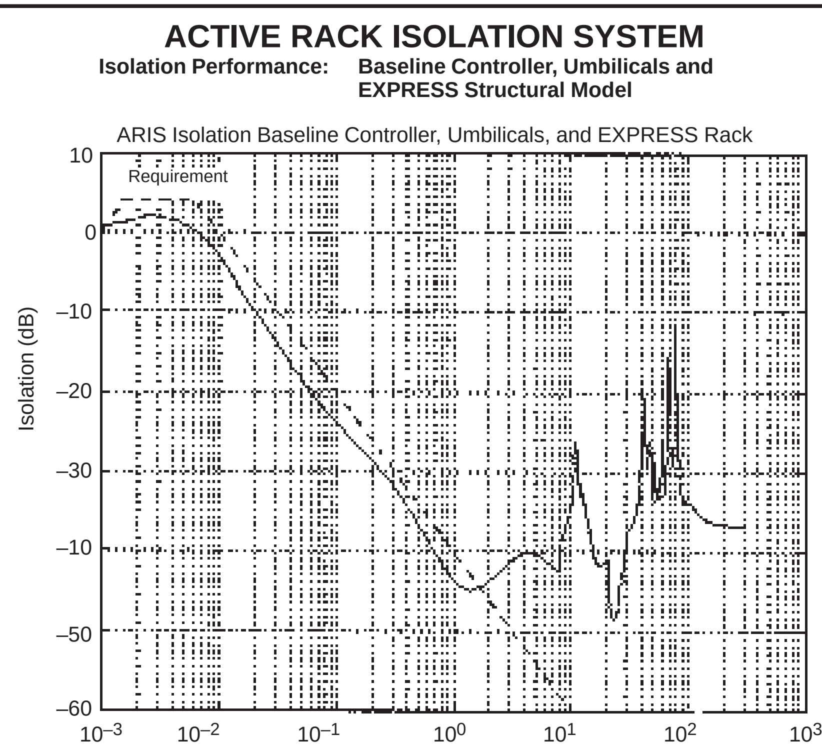


FIGURE 4.1–2 ARIS ACCELERATION ATTENUATION CAPABILITY (W/ 4 GAGE POWER UMBILICALS)

ACTIVE RACK ISOLATION SYSTEM

Onboard Environment: Baseline Controller, Umbilicals and EXPRESS Structural Model

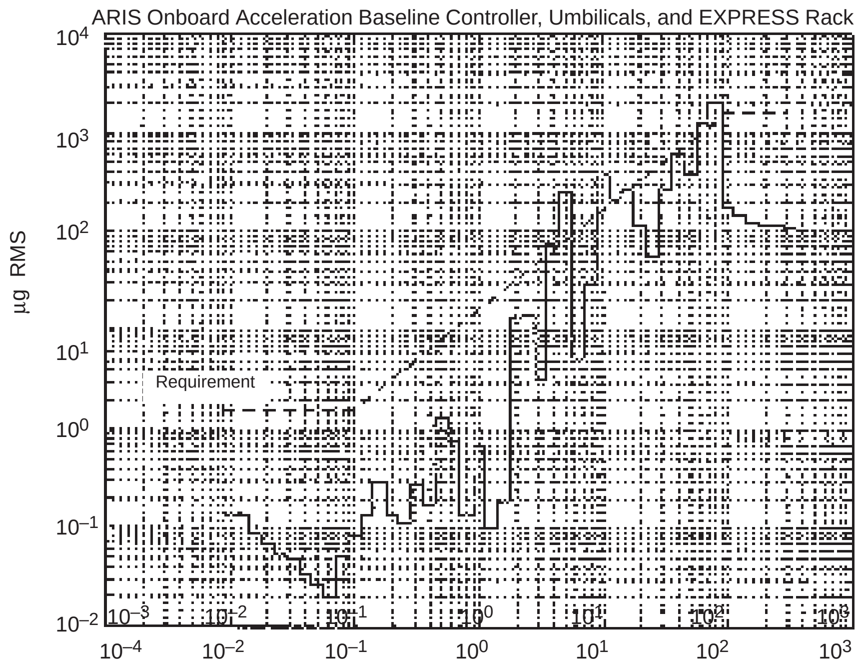


FIGURE 4.1–3 ARIS ACCELERATION PERFORMANCE BASED UPON PREDICTED ON–ORBIT ENVIRONMENT

4.2 MEASURE VIBRATORY ACCELERATIONS.

Upon demand, when in the active isolation or standby state, the ARIS is required to report acceleration data measured in 3 orthogonal axes on the payload rack from 0.01 Hz to 300 Hz with a minimum accuracy as specified in Table 1.2.1–II.

TABLE 4.2–1 ARIS MINIMUM ACCURACY FOR REPORTED VIBRATORY ACCELERATION DATA

Frequency (Hz)	Accuracy (micro–grms, one–third–octave–band analysis)
0.01 - 0.1	Better than 0.16
0.1 - 100	Better than (frequency) x 1.6
100 - 300	Better than 160

4.3 DISTRIBUTE UTILITIES.

The ARIS has the capability to provide distribution capabilities for the following functions:

A. Distribute user payload power

B. Accept user payload waster heat

C. Distribute user payload waste heat

D. Supply user payload vacuum

E. Remove waster gases from user payloads

F. Distribute nitrogen to user payloads

G. Transfer health and status data from user payloads

H. Transfer safety data from user payloads

I. Transfer ancillary data to user payloads

J. Transfer commands to user payloads from ground, crew, and onboard processes

K. Transfer user payload request for services

L. Transfer user payload data

M. Transfer health and status to downlink

N. Transfer safety data to downlink

O. Transfer user payload data to downlink

P. Transfer user payload storage files to downlink

Q. Transfer ancillary data to downlink

R. Transfer user payload video data

S. Transfer interpayload commands

T. Transfer interpayload status

U. Transfer interpayload data

V. Transfer files to/from user payloads

The ARIS is required to distribute the standard interfaces, standard interface options, and USL–specific interfaces between the USL and the user payload as specified in SSP 41152.

<we need to add capabilities based upon test results when we get them>

5.0 RACK PACKAGING CONSIDERATIONS

The ARIS to Pressurized Payload ICD (SSP 57005) identifies the ARIS interfaces applicable to all Facility Payloads that use ARIS, including structural, volumetric, electrical, power, data, and software. The ARIS to Module ICD (SSP 50251) provides the interface information between the ARIS and modules for the locations that accommodate ARIS.

Since the objective of ARIS is to minimize vibrations, it benefits the onboard environment to have an ISPR that has fairly stiff characteristics. One way this can be done is to add significant structural augmentation to stiffen the rack, but this can have a negative effect of increasing the mass. Another way that has been studied for the EXPRESS Rack is the application of damping treatments. Appendix A provides the results of a study conducted to support this activity.

Placement of the internal ARIS components within the ISPR in alternate locations is feasible, and an initial evaluation of this can be conducted to support a PDR or CDR activity. A decision to repackage the ARIS components would result in a change to the configuration and mounting hardware, and may also result in some modifications to the Logistics Support Analysis (LSA) for on–orbit replacement of On–orbit Replaceable Units (ORUs).

5.1 UMBILICAL PERFORMANCE

A. *Description*

B. *Specifications*

C. *Effects on Performance*

(1) Thermal Packaging Considerations

(2) Weight

(3) Waste Gas

(4) Vacuum

(5) N2

5.2 ELECTRICAL/ELECTRONICS INTEGRATION CONSIDERATIONS

A. Cabling Installation for non–EXPRESS Racks

B. Cabling Installation for EXPRESS Racks

C. Power Usage: profiles and predictions

D. EMC considerations

5.3 SOFTWARE INTEGRATION CONSIDERATIONS

A. Software Interfaces: Cross reference to ICD

B. Payload Processor functions to support ARIS

C. Commands And Operational Sequences

D. Health and Status

6.0 ON–ORBIT INSTALLATION AND CALIBRATION

ARIS hardware is both preinstalled in the rack on the ground and installed by the Crew on–orbit. Table 6–1 identifies the Major ARIS Assemblies and if they are installed by the Crew or preinstalled in the rack.

TABLE 6.1–1

Item	Part	Preinstalled or Crew Installed
CONTROLLER ASSY	683–61566–1	Preinstalled
UMBIL ASSY, ELECT	683–61587–1	Crew Installed
UMBIL ASSY, ELECT	683–61587–10	Crew Installed
UMBIL ASSY, ELECT	683–61587–2	Crew Installed
UMBIL ASSY, ELECT	683–61587–3	Crew Installed
UMBIL ASSY, ELECT	683–61587–4	Crew Installed
UMBIL ASSY, ELECT	683–61587–5	Crew Installed
UMBIL ASSY, ELECT	683–61587–6	Crew Installed
UMBIL ASSY, ELECT	683–61587–7	Crew Installed
UMBIL ASSY, ELECT	683–61587–9	Crew Installed
ACTUATOR ASSEMBLY	683–61592–1	Both
ACTUATOR ASSEMBLY	683–61592–2	Both
ACTUATOR ASSEMBLY	683–61592–3	Preinstalled
ACTUATOR ASSEMBLY	683–61592–4	Preinstalled
ACTUATOR ASSEMBLY	683–61592–5	Preinstalled
ACTUATOR ASSEMBLY	683–61592–6	Preinstalled
PUSHROD, ASSEMBLY	683–61599–1	Preinstalled
PUSHROD, ASSEMBLY	683–61599–2	Preinstalled
PUSHROD, ASSEMBLY	683–61599–3	Crew Installed
PUSHROD, ASSEMBLY	683–61599–4	Preinstalled
REM ELECT ASSY	683–61623–1	Preinstalled
ACCELEROMETER ASSY	683–61720–1	Preinstalled
ACTUATOR DRIVER	683–61760–1	Preinstalled

Those items identified as “Preinstalled” do not require installation participation from the user. The items identified as “Crew Installed” require installation by the Crew on–orbit. The items identified as “Both” require some installation participation from the Crew on–orbit. Installation procedures for the items identified as “Crew Installed” and “Both” are contained in Section 6.2.

Some calibration/adjustment of the ARIS is required by the crew on–orbit. The details of the calibration/adjustments are documented Section 6.1.3 and 6.2.

6.1 INSTALLATION PROCESS

Once on–orbit, the ARIS will require installation of some ARIS hardware and subsequent configuration for on–orbit operations. Figure 6–1 illustrates the ARIS installation process at a high level. The details of this installation process is contained in the Installation Instructions in Section 6.2.

6.1.1 ASSEMBLY

ISPR racks that are equiped with some of the ARIS hardware are delivered to the Space Station via the MPLM. The IVA crewmembers will remove the racks from the MPLM and move them to the installation locations per the Resupply Load Plans. The crewmembers will then begin the on–orbit assembly of the integrated ARIS rack.

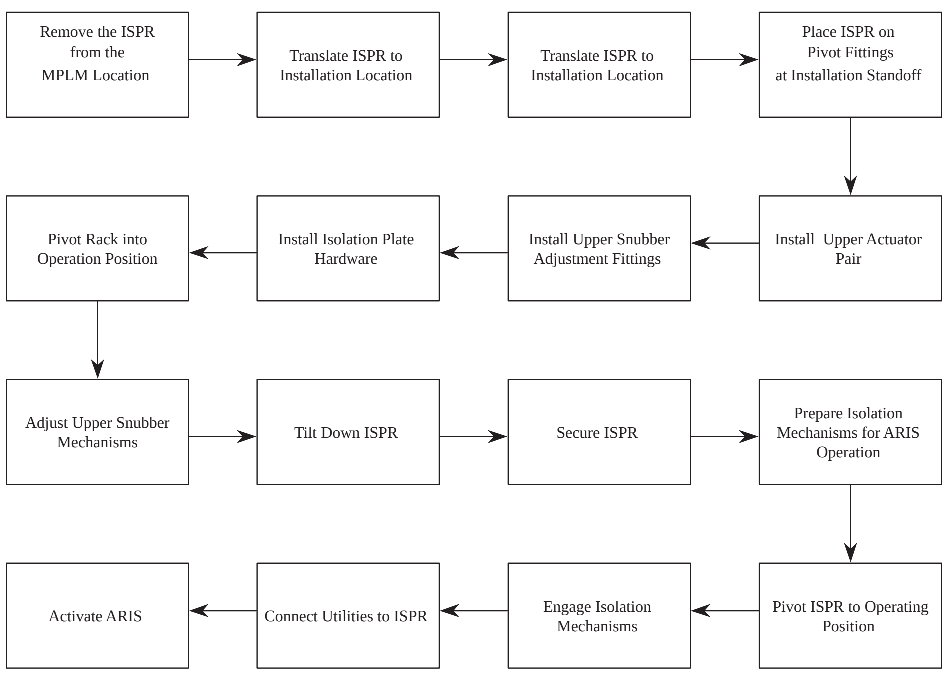


FIGURE 6.1–1

During the Assembly and Initialization of ARIS on–orbit specific tools will be required to perform the tasks. These tools are an intregal part of the ARIS setup. These tools are listed in Table 6.1.1–1.

6.1.2 CALIBRATION

A series of software commands are necessary to calibrate the ARIS to attenuate all vibrations. These commands will be sent to the 1553 user bus. The 1553 user bus will send these to the rack

TABLE 6.1.1–1 ARIS TOOLS

5/32”, 6” Long ball nose hex driver, with a 1/4” drive socket on the end
3/8”, 6” Long ball nose hex driver, with a 3/8” drive socket on the end
3/4”, standard open end wrench
7/64”, standard length hex driver with a 1/4” drive socket on the end
3/32”, 6” Long ball nose hex driver with a 1/4” drive socket on the end
9/16”, standard length internal hex with a 1/4” drive socket on the end
9/64”, 6” Long ball nose hex driver with a 1/4” drive socket on the end

payload controller. The rack controller will send this command to the ARIS controller. A subroutine to measure the ISPR mass, inertia, stiffness, and range will be executed. The results of the calibration are then gathered by the ARIS controller. The results of the calibration will be sent to the ground to update the rack configuration.

6.1.3 INITIALIZATION

Once calibration of ARIS is complete the system will be ready for full operation. The crewmembers must place ARIS in the operational mode. This is accomplished via software. The proper commands to accompish initialization will depend on the software load for the mission..

6.2 ASSEMBLY, CALIBRATION AND INITIALIZATION INSTRUCTIONS

6.3 ASSESSED CREW TIME

7.0 LOGISTICS SUPPORT

Logistics Support includes the acquisition and implementation Logistics Support for ARIS is provided using the repair/maintenance concepts established by the Logistics Support Analysis (LSA). There are two types of Logistics Support provided for the ARIS, on–orbit and ground. The Logistics Support provided for ARIS on–orbit hardware failures is based on the ISS maintenance concept of removing and replacing of ORUs, and repair of ORUs/SRUs on the ground where economically efficient. Table TBD shows the ORUs that have been identified for on–orbit replacement.

7.1 SPARE PARTS AND QUANTITY

The Spares Analysis for the ARIS hardware consisted of review of the ARIS ORUs the associated Mean Time Between Failures (MTBF) and the maintenance concepts. Utilizing the MTBF data a failure rate could be determined. This failure rate was applied to a Possion Distribution model to determine an estimate of the amount of failures that would be experienced during the life of the ARIS hardware (10yrs). The groundrules and assumptions used to derive the spares quantities are listed in Table 7.1–1 (TBD). Table 7.1–1 (TBD) details the parts that are being spared, the quantity of spares, MTBF data, rationale for spares quantity, and on–orbit spares quantity.

TABLE –7.1–1 (TBD) GROUNDRULES AND ASSUMPTIONS

1.	Spares Storage on–orbit is unlimited
2.	ORUs identified can be removed on–orbit
3.	Parts life is 10yrs from time of activation
4.	11 Racks on–orbit at steady state
5.	10/02/98 Assembly Sequence used
6.	Duty Cycle of 0.5 was used
7.	K–factor of 1.3 used for enduced failures
8.	No on–orbit cannibalization used to derive spares quantities
9.	Upmass, downmass, upvolume and downvolume is unlimited
10.	90 day resupply flights

7.2 MAINTENANCE

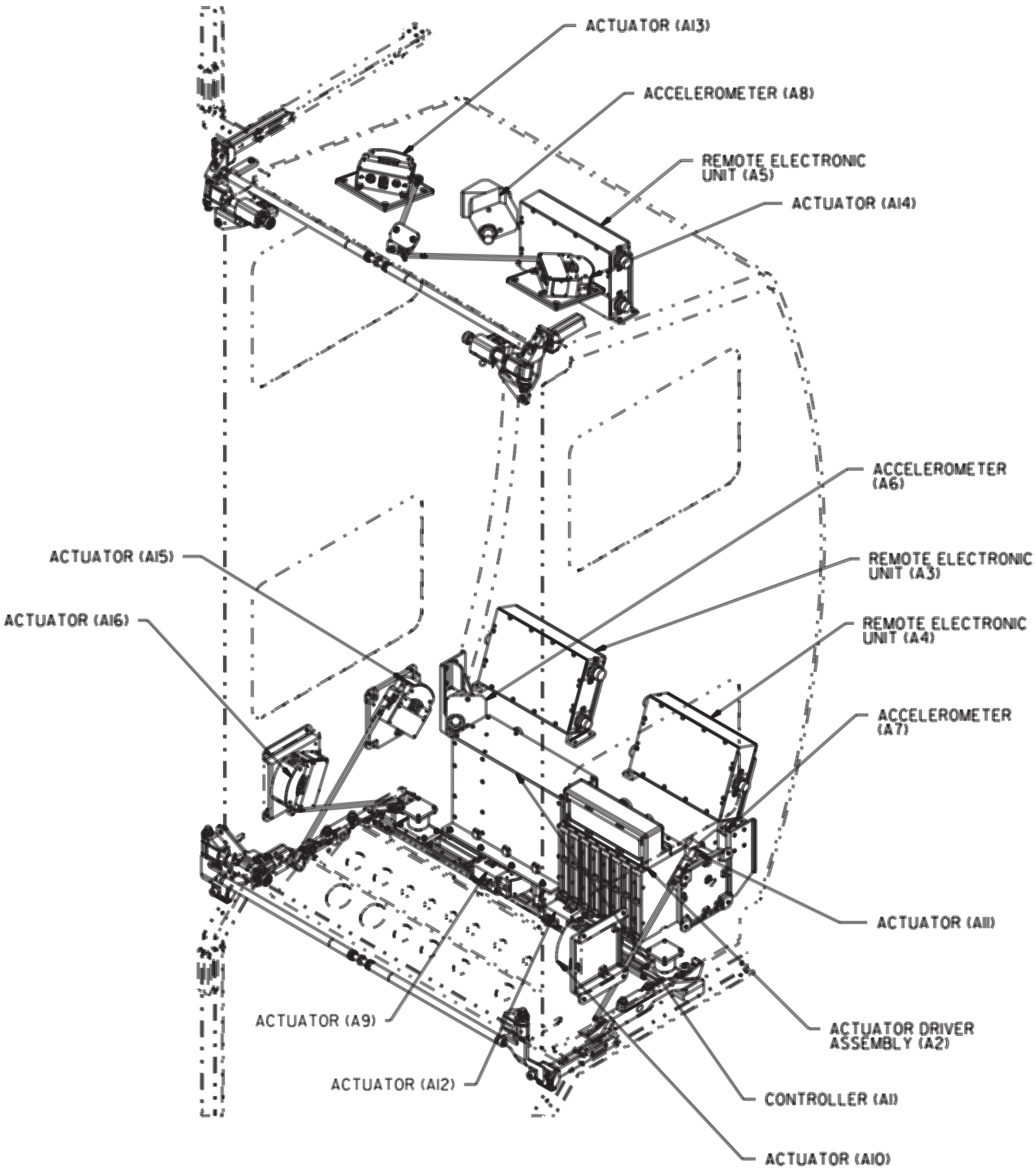
7.3 MAINTENANCE INSTRUCTIONS

All removal or reinstallation procedures assume that the rack has already been prepared for maintenance to begin (i.e. rotated into position such that rear access panel is removed). Therefore, none of the activities described below will include steps for access to rack, retrieval of tools, removal of non–ARIS hardware for access, or limitations placed on the activities as a result of non–ARIS tasks.

Removal/reinstallation steps will identify the reference designator to be removed, tools to be used during the operation, and a sequence of steps necessary to remove the ORU from the ISPR.

Based on Assembly Complete Quantities at 2004; Support to 2010

Item	Part	MTBF	Total Qty on Station	Spare Qtys	On–orbit Spares	Comments
CONTROLLER ASSY	683–61566–1	64800	11	3	1	Backplane likely to have fewer failures Fall backs —Cannibalize failed cards —Use residual parts
. CPU PWA	683–61565	N/A	11	4		
. DAC PWA	683–61696	N/A	11	4		
. Backplane PWA	683–61701	N/A	11	1		
. Power Supply	683–61700	N/A	11	4		
ACTUATOR ASSEMBLY	683–61592–1	508000	22	4	1	Assumes unit cost is approx. $20K. If much more expensive then should repair and take advantage of common parts
ACTUATOR ASSEMBLY	683–61592–2	508000	22	4	1	
ACTUATOR ASSEMBLY	683–61592–3	508000	11	2	1	
ACTUATOR ASSEMBLY	683–61592–4	508000	11	2	1	
ACTUATOR ASSEMBLY	683–61592–5	508000	11	2	1	
ACTUATOR ASSEMBLY	683–61592–6	508000	11	2	1	
PUSHROD, ASSEMBLY	683–61599–1	N/A	22	2	1	Assume can figure how to buy more if necessary
PUSHROD, ASSEMBLY	683–61599–2	N/A	22	2	1	
PUSHROD, ASSEMBLY	683–61599–3	N/A	22	2	1	
PUSHROD, ASSEMBLY	683–61599–4	N/A	22	2	1	
REM ELECT ASSY	683–61623–1	149700	33	3	1	Fallbacks —Cannibalize failed cards —Use residual parts
. Accelerometer Board PWA	683–61622	N/A	33	6		
. Position Board PWA	683–61715	N/A	33	6		
ACCELEROMETER ASSY	683–61720–1	111000	33	15	1	Covers Poisson uncertainty for no repair scenario
ACTUATOR DRIVER	683–61760–1	63100	11	3	1	Fallbacks —Cannibalize failed cards —Use residual parts
. Amplifier Interface PWA	683–61560	N/A	11	3		
. Power Section PWA	683–61609	N/A	11	3		


ACTUATOR (A13)
ACCELEROMETER (A8)
REMOTE ELECTRONIC UNIT (A5)
ACTUATOR (A14)
ACCELEROMETER (A6)
REMOTE ELECTRONIC UNIT (A3)
REMOTE ELECTRONIC UNIT (A4)
ACCELEROMETER (A7)
ACTUATOR (A15)
ACTUATOR (A16)
ACTUATOR (A11)
ACTUATOR DRIVER ASSEMBLY (A2)
ACTUATOR (A9)
ACTUATOR (A12)
CONTROLLER (A1)
ACTUATOR (A10)

7.3.1 CONTROLLER (A1)

Removal of A1

Tools Required:

A. 5/32” Internal hex driver

B. 6” Extension

C. 4” Extension

D. 3/8” Ratchet driver

Removal Steps:

(1) Remove and temporarily stow cable half attached to J1 connector of A1

(2) Remove and temporarily stow cable half attached to J2 connector of A1

(3) Remove and temporarily stow cable half attached to J3 connector of A1

(4) Using ratchet and extensions, disengage the 8 #10 captive bolts (4 each side)

(5) Lift box off of coldplate surface for removal from rack

Note: Controller can not be removed through the rear access panel of the ISPR. Removal must take place through the lower portion of the payload volume or through the utility panel volume.

7.3.2 ACTUATOR DRIVER (A2)

Removal of A2

Tools Required:

A. 5/32” Internal hex driver

B. 6” Extension

C. 4” Extension

D. 3/8” Ratchet driver

Removal Steps:

(1) Remove and temporarily stow cable half attached to J1 connector of A2

(2) Remove and temporarily stow cable half attached to J2 connector of A2

(3) Using ratchet and extensions, disengage the 6 #10 captive bolts (3 each side)

(4) Lift box from cold plate for removal from rack

Note: Actuator driver can not be removed through the rear access panel of the ISPR. Removal must take place through the lower portion of the payload volume or through the utility panel volume.

7.3.3 REMOTE ELECTRONIC UNIT (A3)

Removal of A3

Tools Required:

A. 5/32” Internal hex driver

B. 3/8” Ratchet driver

Removal Steps:

(1) Remove and temporarily stow cable half attached to J1 connector of A3

(2) Remove and temporarily stow cable half attached to J2 connector of A3

(3) Remove and temporarily stow cable half attached to J3 connector of A3

(4) Using ratchet and hex driver, disengage the 4 #10 captive bolts

(5) Lift remote electronics unit off fitting and remove from ISPR

Note: Remote Electronic Unit A3 is mounted on the top surface of the lower rear intercostal of the ISPR and can be easily accessed and removed from the rear access opening of the ISPR.

7.3.4 REMOTE ELECTRONIC UNIT (A4)

Removal of A4

Tools Required:

A. 5/32” Internal hex driver

B. 3/8” Ratchet driver

Removal Steps:

(1) Remove and temporarily stow cable half attached to J1 connector of A4

(2) Remove and temporarily stow cable half attached to J2 connector of A4

(3) Remove and temporarily stow cable half attached to J3 connector of A4

(4) Using ratchet and hex driver, disengage the 4 #10 captive bolts

(5) Lift remote electronics unit off fitting and remove from ISPR

Note: Remote Electronic Unit A4 is mounted on the top surface of the lower rear intercostal of the ISPR and can be easily accessed and removed from the rear access opening of the ISPR.

7.3.5 REMOTE ELECTRONIC UNIT (A5)

Removal of A5

Tools Required:

A. 5/32” Internal hex driver

B. 3/8” Ratchet driver

Removal Steps:

(1) Remove and temporarily stow cable half attached to J1 connector of A5

(2) Remove and temporarily stow cable half attached to J2 connector of A5

(3) Remove and temporarily stow cable half attached to J3 connector of A5

(4) Using ratchet and hex driver, disengage the 4 #10 captive bolts

(5) Lift remote electronic unit off fitting and remove from ISPR

7.3.6 ACCELEROMETER (A6)

Removal of A6

Tools Required:

A. 5/32” Internal hex driver

B. 3/8” Ratchet driver

Removal Steps:

(1) Remove and temporarily stow cable half attached to J1 connector of A6

(2) Using ratchet and hex driver, disengage the 2 #10 captive bolts.

(3) Lift accelerometer off fitting and remove from ISPR

7.3.7 ACCELEROMETER (A7)

Removal of A7

Tools Required:

A. 5/32” Internal hex driver

B. 3/8” Ratchet driver

Removal Steps:

(1) Remove and temporarily stow cable half attached to J1 connector of A7

(2) Using ratchet and hex driver, disengage the 2 #10 captive bolts.

(3) Lift accelerometer off fitting and remove from ISPR

7.3.8 ACCELEROMETER (A8)

Removal of A8

Tools Required:

A. 5/32” Internal hex driver

B. 3/8” Ratchet driver

Removal Steps:

(1) Remove and temporarily stow cable half attached to J1 connector of A8

(2) Using ratchet and hex driver, disengage the 2 #10 captive bolts.

(3) Lift accelerometer off fitting and remove from ISPR

7.3.9 ACTUATOR (A9)

Removal of A9

Tools Required:

A. 5/32” Internal hex driver

B. 3/8” Ratchet driver

C. 7/64” Internal hex driver

D. 3/32” Internal hex driver

Removal Steps:

(1) Remove and temporarily stow cable half attached to J1 connector of A9

(2) Remove and temporarily stow cable half attached to J2 connector of A9

(3) Using the 3/32” hex and ratchet driver turn the locking screw on the actuator body CCW until a hard stop occurs

(4) Using the 5/32” hex and ratchet driver turn the other locking screw on the actuator body CW until a hard stop occurs.

(5) Using the 7/64” internal hex and ratchet driver disengage the 1 #6 captive fastener that attaches the pushrod to the actuator sidearm.

(6) Using the 7/64” internal hex and ratchet driver disengage the 2 #6 captive fasteners that are in the actuator motor housing.

(7) Using the 5/32” internal hex and ratchet driver disengage the 2 #10 captive fasteners located on the front feet of the actuator housing.

Note: Removal of this actuator may require “low profile” tools to provide adequate access for removal. If “low profile” tools are not available, removal of the center section of the isolation plate may be necessary. Further analysis is necessary to varify.

7.3.10 ACTUATOR (A10)

Removal of A10

Tools Required:

A. 5/32” Internal hex driver

B. 3/8” Ratchet driver

C. 7/64” Internal hex driver

D. 3/32” Internal hex driver

Removal Steps:

(1) Remove and temporarily stow cable half attached to J1 connector of A10

(2) Remove and temporarily stow cable half attached to J2 connector of A10

(3) Using the 3/32” hex and ratchet driver turn the locking screw on the actuator body CCW until a hard stop occurs

(4) Using the 5/32” hex and ratchet driver turn the other locking screw on the actuator body CW until a hard stop occurs.

(5) Using the 7/64” internal hex and ratchet driver disengage the 1 #6 captive fastener that attaches the pushrod to the actuator sidearm.

(6) Using the 7/64” internal hex and ratchet driver disengage the 2 #6 captive fasteners that are in the actuator motor housing.

(7) Using the 5/32” internal hex and ratchet driver disengage the 2 #10 captive fasteners located on the front feet of the actuator housing.

7.3.11 ACTUATOR (A11)

Removal of A11

Tools Required:

A. 5/32” Internal hex driver

B. 3/8” Ratchet driver

C. 7/64” Internal hex driver

D. 3/32” Internal hex driver

Removal Steps:

(1) Remove and temporarily stow cable half attached to J1 connector of A11

(2) Remove and temporarily stow cable half attached to J2 connector of A11

(3) Using the 3/32” hex and ratchet driver turn the locking screw on the actuator body CCW until a hard stop occurs

(4) Using the 5/32” hex and ratchet driver turn the other locking screw on the actuator body CW until a hard stop occurs.

(5) Using the 7/64” internal hex and ratchet driver disengage the 1 #6 captive fastener that attaches the pushrod to the actuator sidearm.

(6) Using the 7/64” internal hex and ratchet driver disengage the 2 #6 captive fasteners that are in the actuator motor housing.

(7) Using the 5/32” internal hex and ratchet driver disengage the 2 #10 captive fasteners located on the front feet of the actuator housing.

Note: Removal of this actuator may require “low profile” tools to provide adequate access for removal. If “low profile” tools are not available, removal of the actuator driver (A2) may be necessary. Further analysis is necessary to verify.

7.3.12 ACTUATOR (A12)

Removal of A12

Tools Required

A. 5/32” Internal hex driver

B. 3/8” Ratchet driver

C. 7/64” Internal hex driver

D. 3/32” Internal hex driver

Removal Steps:

(1) Remove and temporarily stow cable half attached to J1 connector of A12

(2) Remove and temporarily stow cable half attached to J2 connector of A12

(3) Using the 3/32” hex and ratchet driver turn the locking screw on the actuator body CCW until a hard stop occurs

(4) Using the 5/32” hex and ratchet driver turn the other locking screw on the actuator body CW until a hard stop occurs.

(5) Using the 7/64” internal hex and ratchet driver disengage the 1 #6 captive fastener that attaches the pushrod to the actuator sidearm.

(6) Using the 7/64” internal hex and ratchet driver disengage the 2 #6 captive fasteners that are in the actuator motor housing.

(7) Using the 5/32” internal hex and ratchet driver disengage the 2 #10 captive fasteners located on the front feet of the actuator housing.

Note: Removal of this actuator may require “low profile” tools to provide adequate access for removal. If “low profile” tools are not available, removal of the center section of the isolation plate may be necessary. Further analysis is necessary to varify.

7.3.13 ACTUATOR (A13)

Removal of A13

Tools Required

A. 5/32” Internal hex driver

B. 3/8” Ratchet driver

C. 7/64” Internal hex driver

D. 3/32” Internal hex driver

Removal Steps:

(1) Remove and temporarily stow cable half attached to J1 connector of A13

(2) Remove and temporarily stow cable half attached to J2 connector of A13

(3) Using the 3/32" hex and ratchet driver turn the locking screw on the actuator body CCW until a hard stop occurs

(4) Using the 5/32" hex and ratchet driver turn the other locking screw on the actuator body CW until a hard stop occurs.

(5) Using the 7/64" internal hex and ratchet driver disengage the 1 #6 captive fastener that attaches the pushrod to the actuator sidearm.

(6) Using the 7/64" internal hex and ratchet driver disengage the 2 #6 captive fasteners that are in the actuator motor housing.

(7) Using the 5/32" internal hex and ratchet driver disengage the 2 #10 captive fasteners located on the front feet of the actuator housing.

7.3.14 ACTUATOR (A14)

Removal of A14

Tools Required

A. 5/32" Internal hex driver

B. 3/8" Ratchet driver

C. 7/64" Internal hex driver

D. 3/32" Internal hex driver

Removal Steps:

(1) Remove and temporarily stow cable half attached to J1 connector of A14

(2) Remove and temporarily stow cable half attached to J2 connector of A14

(3) Using the 3/32" hex and ratchet driver turn the locking screw on the actuator body CCW until a hard stop occurs

(4) Using the 5/32" hex and ratchet driver turn the other locking screw on the actuator body CW until a hard stop occurs.

(5) Using the 7/64" internal hex and ratchet driver disengage the 1 #6 captive fastener that attaches the pushrod to the actuator sidearm.

(6) Using the 7/64" internal hex and ratchet driver disengage the 2 #6 captive fasteners that are in the actuator motor housing.

(7) Using the 5/32” internal hex and ratchet driver disengage the 2 #10 captive fasteners located on the front feet of the actuator housing.

7.3.15 ACTUATOR (A15)

Removal of A15

Tools Required

A. 5/32” Internal hex driver

B. 3/8” Ratchet driver

C. 7/64” Internal hex driver

D. 3/32” Internal hex driver

Removal Steps:

(1) Remove and temporarily stow cable half attached to J1 connector of A15

(2) Remove and temporarily stow cable half attached to J2 connector of A15

(3) Using the 3/32” hex and ratchet driver turn the locking screw on the actuator body CCW until a hard stop occurs

(4) Using the 5/32” hex and ratchet driver turn the other locking screw on the actuator body CW until a hard stop occurs.

(5) Using the 7/64” internal hex and ratchet driver disengage the 1 #6 captive fastener that attaches the pushrod to the actuator sidearm.

(6) Using the 7/64” internal hex and ratchet driver disengage the 2 #6 captive fasteners that are in the actuator motor housing.

(7) Using the 5/32” internal hex and ratchet driver disengage the 2 #10 captive fasteners located on the front feet of the actuator housing.

7.3.16 ACTUATOR (A16)

Removal of A16

Tools Required

A. 5/32” Internal hex driver

B. 3/8” Ratchet driver

C. 7/64” Internal hex driver

D. 3/32” Internal hex driver

Removal Steps:

(1) Remove and temporarily stow cable half attached to J1 connector of A16

(2) Remove and temporarily stow cable half attached to J2 connector of A16

(3) Using the 3/32” hex and ratchet driver turn the locking screw on the actuator body CCW until a hard stop occurs

(4) Using the 5/32” hex and ratchet driver turn the other locking screw on the actuator body CW until a hard stop occurs.

(5) Using the 7/64” internal hex and ratchet driver disengage the 1 #6 captive fastener that attaches the pushrod to the actuator sidearm.

(6) Using the 7/64” internal hex and ratchet driver disengage the 2 #6 captive fasteners that are in the actuator motor housing.

(7) Using the 5/32” internal hex and ratchet driver disengage the 2 #10 captive fasteners located on the front feet of the actuator housing.

8.0 SHIPPING GUIDELINES

8.1 RACK SHIPPING CONTAINER

9.0 PAYLOAD CONSTRAINTS TO ON–BOARD DISTURBANCES

A. Specified Skyline of Payload Constraints

B. 5 Data Points of exceeded skyline vs. Degraded environment and loss of sway space

10.0 SHIPPING GUIDELINES

A. Rack Shipping Container

B. Handling Instructions

C. Who to Contact

D. Provisions for shipping to Storage Sites

E. Provision for Pre–Flight Prep Site

11.0 TRAINING RESOURCES

A. Hardware

B. Software