Window Observational Research Facility
Block I
Project Requirements Document

International Space Station Program

Baseline

January 27, 1999

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INTERNATIONAL SPACE STATION PROGRAM

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PREFACE

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The Window Observational Research Facility (WORF) will provide a stable platform for payloads that will utilize the International Space Station (ISS) United States (U.S.) Laboratory nadir research window. This facility, which will be built around a standard EXpedite the PRocessing of Experiments to the Space Station (EXPRESS) Rack, will include standard mounting interfaces and access to U.S. Laboratory utilities to accommodate up to two payloads. In addition, the facility will support crewmembers conducting Earth observation activities, by providing interfaces for mounting restraints and two adjustable brackets for mounting still cameras and camcorders. Payloads will be able to choose between a number of operational modes, ranging from crew occupied to completely autonomous. The WORF will be launched on Utilization Flight (UF)-1.

Michael Suffredini
Manager
ISS Payloads Office

4-2-99
Date

INTERNATIONAL SPACE STATION PROGRAM

WINDOW OBSERVATIONAL RESEARCH FACILITY
BLOCK I
PROJECT REQUIREMENTS DOCUMENT

CONCURRENCE

JANUARY 27, 1999

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1.0 SCOPE

This specification defines the Window Observational Research Facility (WORF) for the International Space Station (ISS). A definition of the subsystem, operations concept, and interfaces is provided in Section 1.1, WORF Subsystem Definition. Physical requirements and those requirements for performance, reliability, maintainability, availability, and transportability characteristics are provided in Section 3.2. The environmental conditions that the subsystem may encounter are also provided in Section 3.2. Design and construction standards are given in Section 3.3. Logistics and Training requirements are discussed in Sections 3.4 and 3.5 respectively. The purpose, description, and performance and physical characteristics of each component of the WORF subsystem are provided in Section 3.6. Recommended verification requirements are established in Section 4.0.

The following definitions differentiate between requirements and other statements:

Shall: This is the only verb used for the binding requirements.

Should/May: These verbs are used for stating highly desirable but non-mandatory goals.

Will: This verb is used for stating facts or declaration of purpose.

1.1 WORF SUBSYSTEM DEFINITION

Section 1.1 contains a general description of the WORF subsystem, the Lab research window, and WORF operational scenarios. The specific requirements of the WORF Program are provided in later sections.

The objective of the WORF is to provide a facility whereby the U.S. Laboratory (USL) nadir viewing research window can be utilized for Earth and space science research. The WORF includes all support structure, covers, and stowage that will be located behind the window port. The research window has been developed as part of the Lab module and its characteristics are described in Section 1.1.1. The WORF subsystem requirements, as described in this document, refer to all parts of the WORF except the window port structure itself including the glass panes. The optical performance of the window port, however, is included as part of the WORF subsystem since the performance of the facility will depend on maintaining this key parameter.

A. The WORF will:

1. Provide structure for which hardware can be rigidly attached
2. Provide stowage
3. Protect the window port
4. Protect window optical quality

5. Accommodate crew utilization of the WORF
6. Provide window access
7. Provide access to ISS utilities located at the LAB1 D3 position

For all components, wherever possible, the WORF Program will utilize existing common International Space Station Program (ISSP) developed hardware, such as stowage, crew restraints, Portable Computer System (PCS) mounts, and seat track. Unique hardware will be developed only where the Program-developed hardware is inadequate to meet WORF needs. The WORF Program will not be providing any type of optical instrumentation or optical mounting system except where stated otherwise.

The WORF structure will utilize a Boeing International Standard Payload Rack (ISPR) to provide a standardized interface which payloads can utilize to attach payload-developed mounting systems. The WORF will provide two small camera brackets, which will be used for stabilization of crew hand-held photographic equipment. Payloads will be expected to provide mounts for their own hardware. The interface will consist of a standardized mounting configuration, which provides maximum flexibility to accommodate as many types of different payloads as possible. The standardized attachment configuration will also be used to attach payload support instrumentation, stowage, and crew restraints. The WORF will interface with the standard ISPR interfaces available at the LAB1 D3 position. The structure will also be designed to minimize transmission of ISS system-induced vibration and to provide as stable interface as is necessary to meet requirements.

The WORF will provide stowage. The WORF Program will utilize common ISSP developed stowage where possible. WORF stowage will accommodate crew Earth observations equipment, WORF specific tools and supplies, and the scratch pane. The stowage will be removable.

The WORF will provide the capability to protect the window port while installing instrumentation and for supporting crew hand held photography. When installing instrumentation, a window shield will be provided which can withstand crew-induced loads and withstand contact with instruments without exposing window pane coatings to damage. This window shield will be transparent enough that the boundaries of the window port are visible. A subset of this shield (or perhaps the same shield if it meets the optical requirements specified in this document) will be used by the crew to support handheld photography. Specifically, it will allow a crewmember to butt a camera lens up to the shield for stability while protecting the optical quality of the window port for those cameras that have a 10.2 cm (4-in.) diameter aperture or less.

The WORF will protect the integrity and optical quality of the window port. This protection includes maintaining the transmittance of the window port, preventing sources of glare from illuminating the window port, and protecting wavefront quality. The transmittance of the window port can be degraded by contaminants that collect on window panes, by the build-up of condensation, by micrometeoroid and debris impacts, and by scratches in coatings. Glare from cabin lighting can severely affect optical quality by adding an unwanted background signal in radiometric applications and unwanted reflected images that can be seen in photographs taken through the window and therefore must be minimized. A number of components will be developed to protect the optical quality of the research window. A condensation prevention system will be utilized to prevent moisture from condensing on the primary pressure pane when the scratch pane is removed (the scratch pane is heated to prevent condensation when installed). An aisle-side cover and a payload shroud will be developed to provide two ways to eliminate glare sources emanating from the cabin. WORF structure that will be illuminated by external sources transmitted through the window will be coated with low reflectance materials. Internal covers mentioned in the previous section will also be used to minimize debris and contaminants that could collect on window panes. The WORF will also protect the crew from harmful Ultraviolet (UV) and Infrared (IR) radiation when the scratch pane is removed.

The WORF will provide crew restraints to accommodate crew utilization of the WORF. Crew restraints will be available to support crew tasks while located inside and outside the LAB1 D3 volume. Where possible, a standard set of crew restraints will be utilized within the WORF volume. However, there may be unique aspects to the use of optical devices on-orbit that will necessitate the need for unique crew restraints to be developed.

The WORF will provide crew access to the window in a timely manner. This access is required to support short notice Earth observation tasks and in cases of emergency where the window must be safed due to window pane damage. To achieve this objective, the removal of WORF components such as the aisle-side cover and payload mounts will be accomplished without the use of tools and will be achievable in a timely manner.

The ISS utilities located in the LAB1 D3 position include the standard Utility Interface Panel (UIP) interfaces, including but not limited to high, medium, and low data and command link, a moderate temperature cooling loop, fire prevention and detection, and power. WORF will provide displays on payload and WORF status conformal with the ISS Standard for Payload Displays **<TBD #2>**. Payloads will be expected to provide the appropriate cabling to interface with these utilities through the WORF. The WORF, in turn, will provide the necessary access plugs to utilize these ISS utilities. Specific requirements and information for payload developers will be specified in **<TBD #5>**, Window Observational Research Facility Payload Development Guide.

1.1.1 LAB RESEARCH WINDOW DESIGN

The Lab nadir window is the only window port on the United States (U.S.) Segment that provides true nadir viewing. The nominal configuration of the Lab window consists of four window panes which provide a 50.8 cm (20-in.) diameter clear aperture (Figure 1.1.1-1, U.S. Laboratory Research Window Mount/Hull Cross Section). The outboard pane (Figure 1.1.1-2, U.S. Laboratory Research Window and Window Mount Detail) serves as a meteoroid/debris sacrificial pane known as the debris pane. The center two panes are referred to as the primary and redundant pressure panes. The inboard pane is the scratch pane, which serves as a UV and IR filter, and protects the primary pressure pane against internally generated damage. The outer three panes are composed of Corning 7940 fused silica that are coated on all surfaces by a modified anti-reflection MgF_2 coating. The scratch pane is composed of Corning 0313 Chemcor glass that has been chemically tempered and laminated with a silicone laminate. The scratch pane has also been coated with an anti-reflection coating to optimize the transmittance from 450 to 800 nm, and a red-reflector coating which reduces the IR from 850-1000 nm to less than 10%.

The three fused silica panes are fabricated such that the total peak-to-valley wavefront error in transmission through the three panes over any 15.2 cm (6-in.) diameter aperture does not exceed $\lambda/7$ where the reference wavelength is 632.8 nm. In order to utilize fully the high quality windows, the scratch pane will need to be removed.

1.1.2 OPERATIONS CONCEPTS

This section will detail nominal operational concepts for deployment of the WORF and some potential candidate payloads. The specific operation procedures for deployment of payloads will be specified in **<TBD #4>**, Window Observational Research Facility Operational Procedures.

1.1.2.1 PRELAUNCH

The WORF will undergo standard prelaunch processing for International Standard Payload Racks in the Space Station Processing Facility, Building M7-360, at Kennedy Space Center.

1.1.2.2 LAUNCH

The WORF will be launched unpowered in the Space Transportation System orbiter payload bay as part of cargo in the Multi-Purpose Logistics Module (MPLM).

1.1.2.3 DEPLOYMENT

The WORF will be deployed in U.S. Laboratory position LAB1 D3 using WORF-specific deployment procedures developed as part of the WORF Operational Procedures Document.

1.1.2.4 ON-ORBIT OPERATIONAL SCENARIOS

Several operational scenarios have been developed that encompass the types of operations that will need to be supported. All of the functional requirements of the WORF were extracted from these operational scenarios.

NOTE: These scenarios are meant to describe required capabilities of the WORF; as such they are not requirements in themselves, but drive the development of requirements.

For the purposes of brevity, each scenario combined capabilities that would normally be found in a number of different experiments. Hence some of the scenarios below do not necessarily represent actual scenarios that would be pursued by the science community. The cameras and other optical instrumentation described are meant to be examples of the type of instrumentation that would be expected to be used in the WORF by payload providers. The WORF Program will provide mounting interfaces for one large payload or two small payloads in addition to the small camera brackets. The following scenarios do not include actual WORF Program requirements. Specific requirements levied on WORF components are listed later in this document. Hence, any uncertainty on what is meant by “rigid,” “easily accessible,” or other statements are specifically defined in later sections. Descriptions of some systems are intentionally vague to avoid advocating one particular design solution.

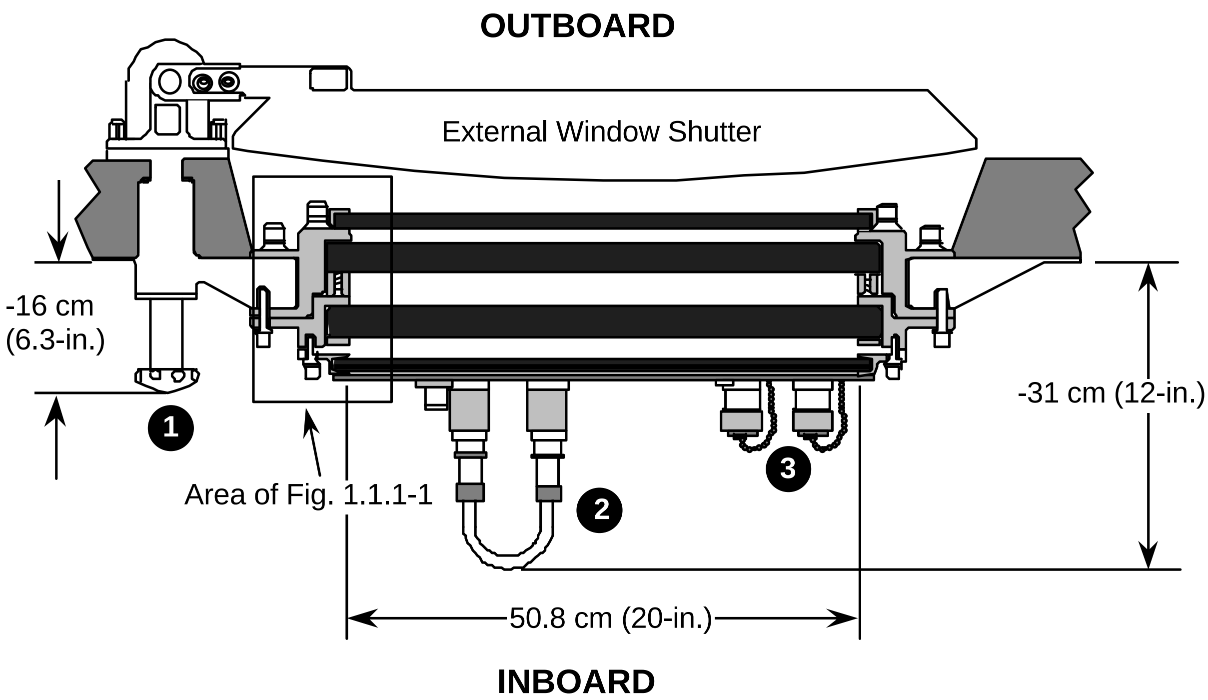

FIGURE 1.1.1-1 U.S. LABORATORY RESEARCH WINDOW MOUNT/HULL CROSS SECTION

NOTE: Reference 1 indicates handwheel that operates the external Window Shutter. Reference 2 indicates hardware to allow equalization of pressure between the Scratch Pane and the Primary Pressure Pane (see Figure 1.1.1-2 for definition of individual panes). Reference 3 indicates electrical connections for the Scratch Pane Heater. The Internal Pressure Cover Assembly is not in place in this diagram.

FIGURE 1.1.1-2 U.S. LABORATORY RESEARCH WINDOW AND WINDOW MOUNT DETAIL

NOTE: Included in the view is the configuration with the Internal Pressure Cover Assembly in place. This assembly will normally be stowed, and will only be installed in the event of damage to the primary or redundant pressure panes.

1.1.2.4.1 SHORT NOTICE EARTH OBSERVATION OPPORTUNITY

An opportunity for a short notice Earth observation task is communicated to the crew 1/2 revolution prior or ~45 minutes prior to overflight of the area. The crewmember first travels to the LAB1 D3 position and removes the LAB1 D3 aisle-side cover without tools. A large payload mounted in the WORF must be removed to allow access to the window. Without tools, the payload is removed and temporarily attached on the neighboring rack with an attachment scheme that is provided within the WORF complement of items located in stowage within the WORF. The crew person then removes a 35mm camera and a 350mm lens from stowage and verifies that the camera is ready for Earth observations photography. A crew restraint system is provided to allow the crew person to work while remaining in the Lab aisle area just outside the LAB1 D3 volume. Next, the crewmember enters the WORF volume. A window shield is moved into place, again without tools, to protect the window while the crewmember sets up the 35mm camera on an easily accessible small camera bracket. Prior to shooting pictures, the LAB1 D3 payload shroud is closed by the crewmember from within the WORF volume to eliminate window glare due to cabin lighting.

1.1.2.4.2 INSTALLATION AND OPERATION OF A LARGE FORMAT CAMERA

A 135 kg large format aerial photo camera is installed on a slide mount that attaches to the WORF structure. During the installation, the WORF stowage units are removed and temporarily stowed on neighboring racks. The mount structure includes a slide mechanism that allows the camera to be repositioned horizontally and vertically into the window field of view, and relocated to the rear of the WORF volume. The payload requires that the scratch pane be removed to take advantage of the high wavefront quality of the research window. Removal of the scratch pane requires removal of ten fasteners and disconnecting the ground strap and window. After removal, the scratch pane is stored in a permanent storage container that is integral to the WORF. While installing the camera, a window shield is utilized to prevent anything from contacting the inner window pane. The window shield is moved away from the window port after the camera is installed and ready to be used. A condensation prevention system is available to prevent condensation from forming on the inner surface of the primary pressure pane.

1.1.2.4.3 OPERATION OF TWO PAYLOADS

Two payloads are located in the WORF and are attached by user-provided mounts to the WORF structure. The two payloads are too large to simultaneously observe through the window. One payload performs daytime observations, while the other performs observations during orbital night. One payload is a 12.7 cm (5-in.) refractive telescope, which is quite long, requiring it be mounted near the aisle-side part of the WORF. The WORF attachment points and payload user-provided mounts are such that one payload can be quickly moved away from the window, and the other quickly moved into position. No tools are required for this operation. Each payload requires power so that the crewmember must also disconnect one payload power plug and connect the other payload to power. Once a given payload is ready for operation, the

WORF volume aisle-side cover is closed to prevent cabin light from entering the volume, especially during the orbital night observations. Manual crew operation of the 12.7 cm (5-in.) refractive telescope is required from time to time.

1.1.2.4.4 OPERATION OF A GROUND-CONTROLLED PAYLOAD

An instrument is mounted to WORF structure utilizing a payload user-provided mount without requiring tools. The window shield is utilized as described in previous scenarios. The instrument mount allows for pointing of an instrument package, which consists of an electronic still camera equipped with a Nikon 350mm lens and a coaxially mounted camcorder. The camcorder allows for monitoring of the scene viewed by both instruments, and is connected to a monitor mounted outside the WORF volume. Pointing of the instrument package can be achieved manually by a crewmember or by ground command using user-provided software. After calibration, autonomous targeting of the camera is achieved using ISS data provided by the appropriate data port available at the LAB1 D3 location. This data is entered into a PCS that provides targeting data to the payload. The PCS laptop and a payload monitor are mounted on the ISPR external seat track to allow viewing of data acquired by the payload without opening the aisle-side cover. All instrumentation is connected to the payload power supply, which is connected to ISS power. The aisle-side cover is utilized to block cabin lighting from entering the WORF volume. All cables are secured to the payload user-provided mount and WORF structure to keep the LAB1 D3 volume clear. A cable access port in the WORF structure allows the monitor to be directly connected to the camcorder without interference with the operation of the aisle-side cover. The condensation prevention system is utilized if necessary to keep the window port clear of condensation. Real-time uplink and downlink capabilities provided by the ISS data port are utilized to allow ground control of the instrument and the real-time transmission of images.

1.1.2.4.5 DEPLOYMENT OF A HYPERSPECTRAL IMAGER

A hyperspectral imager is mounted in the WORF without requiring tools, utilizing a payload-provided mount. The payload consists of a 20.3 cm (8-in.) telescope and a number of charged coupled detectors. The investigator-supplied payload mount provides the necessary vibration isolation to enable use of the 20.3 cm (8-in.) telescope. The payload operates from 400-2000 nm, requiring the scratch pane be removed. Scratch pane removal, and use of the window shield and payload shroud are as described in previous scenarios. One of the Charge-Coupled Devices (CCDs) requires cooling and needs access to the ISS moderate temperature cooling loop. In addition, the payload utilizes the power and data utilities available at the LAB1 D3 position. Payload targeting is achieved by utilizing ISS state vectors provided by utilizing the ISS data port.

1.1.2.4.6 INSTALLATION OF THE INTRAVEHICULAR ACTIVITY WINDOW COVER

<TBD #1>

1.1.2.4.7 REPLACEMENT OF THE WORF AND WORF COMPONENTS

The maintenance concept for the WORF is to “Remove and Replace” to the functional Orbital Replacement Unit (ORU) level. This level will be determined by results of Repair Level Analysis.

1.3 ORDER OF PRECEDENCE

In the event of a conflict between the text of this specification and the references cited herein, the text of this specification takes precedence. Nothing in this specification, however, supersedes applicable laws, regulations, or ISSP requirements unless a specific exemption has been obtained. All specifications, standards, exhibits, drawings, or other documents that are referenced in this specification are incorporated as cited.

2.0 DOCUMENTS

2.1 APPLICABLE DOCUMENTS

The following documents include specifications, models, standards, guidelines, handbooks, and other special publications. The current issue of the following documents is identified in the Program Automated Library System (PALS) (http://issa-www.jsc.nasa.gov/cgi-bin/dsql+/ORAP?-h+palshome). The documents listed in this paragraph are applicable to the extent specified herein. Inclusion of applicable documents herein does not in any way supersede the order of precedence identified in Paragraph 1.3 of this document.

SSP 41000	System Specification for the International Space Station
SSP 41172	Qualification and Acceptance Environmental Test Requirements
SSP 50005	ISS Flight Crew Integration Standards
SSP 52005	ISS Payload Flight Equipment Requirements and Guidelines for Safety Critical Structures
SSP 52057	International Space Station Research Program Plan
SSP 57000	Pressurized Payloads Interface Requirements Document
SSP 57001	Pressurized Payloads Hardware Interface Control Document
SSP 57002	Payload Software Interface Control Document Template
NSTS 1700.7B, ISS Addendum	Safety Policy and Requirements for Payloads Using the International Space Station
ANSI PH3.617	Definitions, Methods of Testing, and Specifications for Appearance Imperfections of Optical Elements and Assemblies
ANSI/IEEE 802.3	10 Base-T Ethernet Services

ASTM 1003-97	Standard Test Method for Haze and Luminous Transmittance of Transparent Plastics
ASTM 1044	Standard Test Method for Resistance of Transparent Plastics to Surface Abrasion
ASTM F-548	Standard Test Method for Intensity of Scratches on Aerospace Transparent Plastics
FED-STD-595B	Colors Used in Government Procurement
MIL-C-675	Coatings of Glass Optical Elements (Anti-reflection)
MIL-PRF-13830B	Optical Components for Fire Control Instruments: General Specification Governing the Manufacture, Assembly, and Inspection of
MIL-STD-1553B	Digital Time Division Command/Response Multiplex Data Bus
NHB 5300.4 (1B)	Quality Provisions for Aerospace Contractors
SN-C-0005	Contamination Control Requirements for the Space Shuttle Program
<TBD #2> Under development	ISS Standard for Payload Displays
<TBD #3> Under development	Care and Cleaning Procedures for Optical Quality Windows
<TBD #4> Under development	Window Observational Research Facility Operational Procedures
<TBD #5> Under development	Window Observational Research Facility Payload Development Guide
<TBD #6> Under development	WORF Interface Control Document

3.0 REQUIREMENTS

3.1 LAB1 D3 VOLUME

The WORF shall conform with the modified ISPR static envelope as defined in Figure 3.1.1.4-1 of SSP 57001, Pressurized Payloads Hardware Interface Control Document.

3.1.1 COORDINATE SYSTEM

The WORF coordinate system shall be defined per SSP 57000, Pressurized Payloads Interface Requirements Document, Section 3, Figure 3-2 (see Figure 3.1.1-1).

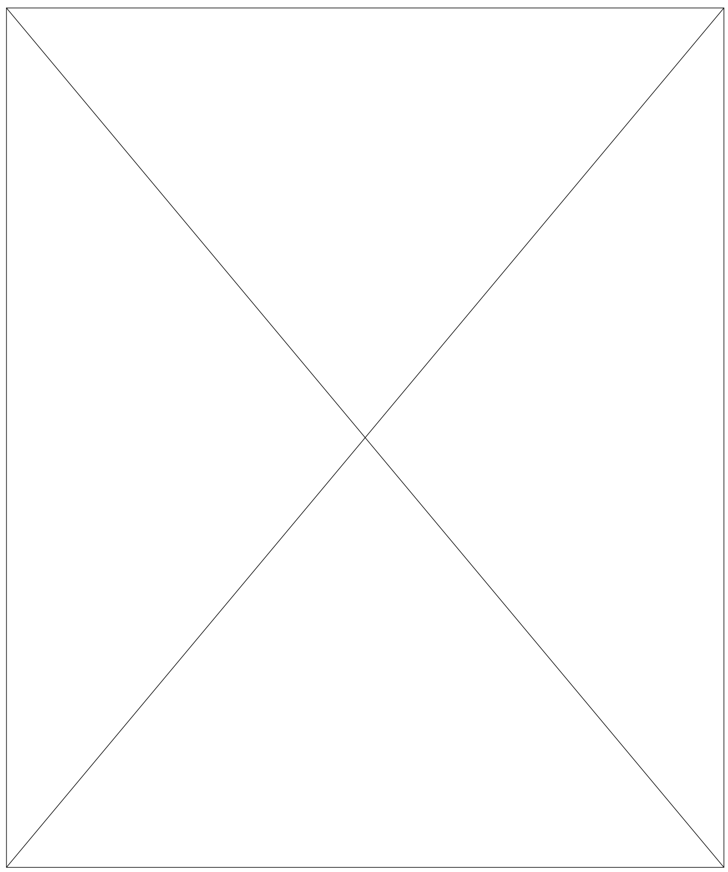

FIGURE 3.1.1-1 WORF COORDINATE SYSTEM

3.1.2 INTERFACE DEFINITION

All WORF-to-ISS Hardware (H/W) interface definitions and requirements shall be controlled by SSP 57000.

3.1.2.1 INTERFACE CONTROL

3.1.2.1.1 HARDWARE INTERFACE CONTROL

All WORF-to-ISS interface controls shall be specified in SSP **<TBD #6>**, WORF Interface Control Document.

3.1.2.1.2 SOFTWARE INTERFACE CONTROL

All WORF-unique software interface controls shall be specified in SSP 57002, Payload Software Interface Control Document Template.

3.1.3 ORGANIZATION AND MANAGEMENT RELATIONSHIPS

The requirements and specifications for development, fabrication, and deployment of the WORF will be managed in the International Space Station Payloads Office as specified in SSP 52057, International Space Station Research Program Plan.

3.2 CHARACTERISTICS

3.2.1 PERFORMANCE

3.2.1.1 CREW ACCESS TO WINDOW PORT FOR EARTH OBSERVATION TASKS

The WORF shall allow crew access to the window port in 45 minutes or less to allow support of short notice Earth observation tasks as generally described in Section 1.1.2. Access in this case is defined as disconnecting from all WORF utilities, removal and safe stowage of ground-controlled or autonomous payloads deployed in the WORF at the time of notification, deployment of the small camera bracket and camera shields described in Section 3.6, securing the desired camera equipment in the small camera bracket, and positioning a crewmember with crew restraints in the WORF ready to complete the data take.

3.2.1.2 CREW ACCESS TIME ALLOCATION FOR EARTH OBSERVATION TASKS

This time period for crew access for Earth observation tasks shall be partitioned to 20 minutes ±2.5 minutes for removal of payloads, and 20 minutes ±2.5 minutes for set-up of the WORF volume for crew Earth observations.

3.2.1.3 CREW ACCESS TO WINDOW PORT FOR EMERGENCY OPERATIONS

The WORF shall allow crew access to the window port to allow inspection and safing of the window port. Access in this case is defined as removal of the active payloads in the quickest manner possible, or rotating the rack away from the window without removing payloads, whichever is shorter, in order to give sufficient volume to install the internal pressure cover assembly.

3.2.1.3.1 REMOVAL OF PAYLOADS

The WORF shall be designed to allow for removal of payloads within 10 minutes without tools.

3.2.1.3.2 RACK ROTATION

The WORF design shall not hinder the capability to rotate the rack away from the nadir window port with payloads installed.

3.2.1.4 UNATTENDED OPERATION

The WORF shall allow unattended operation of payloads.

3.2.1.5 PREVENTION OF STRAY LIGHT SOURCES WITHIN THE WORF PAYLOAD VOLUME

The environment in the WORF will be maintained such that optical instruments can be utilized without degradation. Internal Laboratory module light sources such as cabin lighting, Light Emitting Diode (LED) indicators, and WORF workspace lighting must be eliminated while payloads are operating in all nominal operational configurations of the WORF. Any source of light emanating from within the Laboratory that enters the WORF payload volume, or is located within the WORF payload volume, can degrade the performance of many types of payloads. To this end, the following three requirements have been developed to eliminate stray light sources within the WORF payload volume.

3.2.1.5.1 DETERMINATION OF THE DIFFUSE AMOUNT OF LIGHTING

The diffuse amount of lighting from all light sources within the Laboratory module including LEDs, cabin lighting, and WORF workspace lighting, incident on the window for all WORF nominal operational configurations where the aisle-side cover is closed, shall not exceed 2.8 x 10^{-11} W/cm^2/sr in any wavelength band 10 nm wide between 400 and 700 nm.

3.2.1.5.2 DETERMINATION OF GLARE FEATURES

The WORF shall be capable of passing the glare features optical tests described in Section 4.4.

3.2.1.5.3 LIGHT SOURCES WITHIN THE WORF

The WORF shall contain no internal sources of light that illuminate the WORF payload volume, that cannot be turned off during payload operations in all WORF nominal operational configurations.

3.2.1.6 TEMPORARY STOWAGE RESTRAINT SYSTEM

The WORF shall provide a restraint system where WORF stowage items can be temporarily stowed on neighboring racks on a non-interference basis with other U.S. Laboratory operations.

3.2.1.7 SCRATCH PANE REMOVAL

The WORF shall not interfere with removal of the scratch pane.

3.2.1.8 SCRATCH PANE INSTALLATION

The WORF shall not interfere with installation of the scratch pane.

3.2.1.9 WINDOW SHUTTER OPERATION

The WORF shall not interfere with the crew access to and operation of the mechanism to operate the external window shutter.

3.2.1.10 INSTALLATION OF THE INTRAVEHICULAR ACTIVITY COVER

In the event of damage to any of the window panes, the WORF shall not interfere with installation of the internal pressure cover assembly.

3.2.1.11 REMOVAL OF THE INTRAVEHICULAR ACTIVITY COVER

The WORF shall not interfere with removal of the internal pressure cover assembly.

3.2.1.12 INTRAVEHICULAR ACTIVITY WINDOW CHANGEOUT

The WORF structure shall allow the ability to perform an Intravehicular Activity (IVA) changeout of the window port. The WORF structure may be removed from the LAB1 D3 position to meet this requirement.

3.2.1.13 MINIMUM PAYLOAD VOLUME

The minimum volume available for payloads, including deployment of payload and supporting equipment as defined in Sections 3.6.1.2 and 3.6.3.3 shall be defined by the dimensions of 91.4 cm (36-in.) wide (in the parallel to the x axis of the WORF as defined in Section 3.1.1) by 81.3 cm (32-in.) high (parallel to the z axis of the WORF) by 78.7 cm (31.0-in.) deep (parallel to the y axis of the WORF), with axes defined in Section 3.1.1, Figure 3.1.1-1.

3.2.1.14 DIFFUSE SURFACE REFLECTANCE OF WORF STRUCTURE

All surfaces of the WORF which will be exposed to incoming light **<TBR>** from the window port shall have a diffuse surface reflectance of no more than 12% for a wavelength range between 400 and 700 nm.

3.2.1.14.1 SPECULAR SURFACE REFLECTANCE OF THE AFT (AISLE-SIDE) PART OF THE WORF

The aft surfaces of the WORF, which includes the aisle-side cover, which will be exposed to incoming light **<TBR>** from the window port shall have a specular surface reflectance of no more than 1% for a wavelength range between 400 and 700 nm.

3.2.1.14.2 SPECULAR SURFACE REFLECTANCE OF REMAINING WORF STRUCTURE

The surfaces of the WORF, other than aft surfaces, which will be exposed to incoming light **<TBR>** from the window port shall have specular surface reflectance not to exceed 10% between 400 and 700 nm.

3.2.1.14.3 WORF STRUCTURE FINISH

All externally lighted surfaces **<TBR>** shall have a lusterless black finish such that the black color is visually comparable to any of the following colors: #37030, #37031, #37038, or #37056 per FED-STD-595B, Colors Used in Government Procurement.

3.2.1.15 SUPPORT INSTRUMENTATION VISUAL ACCESS

The WORF shall allow viewing of a monitor or computer screen installed outside the WORF internal volume, such that a crewmember may do so while located in the Lab aisle without violating the requirements in Section 3.2.1.5.1 or Section 3.2.1.5.2.

3.2.1.16 CONDENSATION

The WORF shall prevent condensation from collecting on the internal surface of the primary pressure pane when the scratch pane is removed.

3.2.1.17 LAUNCH AND LANDING CYCLES

The WORF shall be able to withstand a minimum of three launch and landing cycles.

3.2.1.18 PROTECT OPTICAL PERFORMANCE

The environment in the WORF will be maintained such that optical instruments can be utilized without degradation. Stray light, air temperature variations, and turbulence can degrade imagery collected by large and small aperture optics. The following requirements ensure the optical environment is maintained.

3.2.1.18.1 REQUIREMENTS VOLUME

Section 3.2.1.18.2 shall apply to a volume defined by a 40.6 cm (16-in.) diameter area parallel to the primary pressure pane, centered about the center of the primary pressure pane, and extending from the inner surface of the primary pressure pane to a distance of 10.2 cm (4-in.) into the WORF volume along the y-axis, as described in Section 3.1.1.

3.2.1.18.2 CABIN ATMOSPHERE OPTICAL PATH VARIATION

The variation in the optical path across any 15.2 cm (6-in.) aperture perpendicular to the y-axis (as described in Section 3.1.1) within the volume defined in Section 3.2.1.18.1, shall not be more than 0.5×10^{-4} mm as a result of variations in the refractive index of the cabin air caused by variations in temperature or pressure.

3.2.1.18.3 WINDOW THERMAL GRADIENTS

Thermal gradients induced into the primary pressure pane shall not cause a variation in the optical path across any 15.2 cm (6-in.) aperture perpendicular to the y-axis (as described in Section 3.1.1) within the center 40.6 cm (16-in.) diameter of the window of greater than 0.5×10^{-4} mm as a result of thermally induced variations in the refractive index of the glass.

3.2.2 PHYSICAL

3.2.2.1 LAUNCH AND RETURN ENVELOPE

The deployed WORF subsystem shall be contained within the ISPR envelope as defined in SSP 57000.

3.2.2.2 ON-ORBIT DEPLOYMENT ENVELOPE

The deployed WORF subsystem shall be contained within the envelope for the U.S. Laboratory LAB1 D3 position, as modified to conform with the modified ISPR static volume defined in SSP 57001.

3.2.2.2.1 INTERNATIONAL STANDARD PAYLOAD RACK REAR ACCESS PANEL REMOVAL

Due to the intrusion of the window mount into the operational volume of a standard ISPR, the rear access panel of the ISPR based WORF shall be designed such that it may be removed on-orbit prior to the WORF’s actual installation in the LAB1 D3 position as specified in SSP 57000.

3.2.2.2.2 INTERNATIONAL STANDARD PAYLOAD RACK REAR ACCESS PANEL RE-INSTALLATION

After removal of the ISPR rear access panel for installation of the WORF into the LAB1 D3 position, the rear access panel shall be able to be reinstalled prior to removal of the WORF to the MPLM for return to Earth.

3.2.2.2.3 INTERNATIONAL STANDARD PAYLOAD RACK REAR ACCESS PANEL STOWAGE

Upon removal from the WORF during installation, the ISPR rear access panel shall be returned to Earth for ready access storage in the event it is needed for return of the WORF rack to the Earth.

3.2.3 MAINTAINABILITY

The WORF rack and its subsystems shall have periodic inspections, corrective maintenance, restoration, replacement of failed components, and resupply operations.

3.2.3.1 CORRECTIVE MAINTENANCE

The WORF Rack and its subsystems shall allow corrective maintenance.

3.2.3.2 RESTORATION OF PERFORMANCE

The WORF shall be designed that it may be restored to full operation should any component fail.

3.2.3.3 PREVENTATIVE MAINTENANCE

As a design goal, the WORF rack should not require preventative maintenance during its operational lifetime.

3.2.4 ENVIRONMENTAL CONDITIONS

3.2.4.1 SOLAR ULTRAVIOLET AND INFRARED RADIATION

3.2.4.1.1 ULTRAVIOLET/INFRARED RADIATION IN THE LAB1 D3 VOLUME

With the scratch pane removed, the WORF shall provide the capability to prevent UV and IR radiation greater than is allowed in SSP 50005, ISS Flight Crew Integration Standards, Section 11.11.3.1.4, from entering the WORF volume while still allowing a crewmember to view out of the window port from within the LAB1 D3 volume.

3.2.4.1.2 ULTRAVIOLET/INFRARED RADIATION IN THE LAB AISLE AREA

With the scratch pane removed, the WORF shall prevent UV and IR radiation greater than is allowed in SSP 50005 from entering the Lab aisle area while still allowing payloads to view the expanded UV/IR spectrum being transmitted by the window port without the scratch pane installed.

3.2.4.2 CREW-INDUCED LOADS

The WORF subsystems, excluding the small camera shield and small camera bracket, shall meet the performance requirements as specified in Sections 3.2.1, after exposure in its on-orbit configuration to the crew-induced loads defined in SSP 57000, Paragraph 3.1.1.3.

3.2.4.3 INTERIOR WORKSPACE LIGHTING

The interior workspace of the WORF shall meet the applicable interior workspace lighting requirements as specified in SSP 57000, Section 3.12.3.4.

3.2.4.3.1 CAPABILITY TO TURN OFF WORKSPACE LIGHTING

A means shall be provided to turn off interior work space lighting.

3.2.4.3.2 CAPABILITY TO TURN ON WORKSPACE LIGHTING

A means shall be provided to turn on interior work space lighting.

3.2.4.4 INTERIOR WORKSPACE ACOUSTICS LIMIT

The interior workspace of the WORF shall meet the NC50 acoustical limit requirements for crewmembers in closed spaces.

3.2.4.5 HABITABILITY REQUIREMENTS

3.2.4.5.1 CARBON DIOXIDE CONCENTRATION <TBR #1>

The WORF shall have sufficient air exchange with the U.S. Laboratory cabin air to keep the carbon dioxide concentration in the WORF to at or below 7.6 mm Hg when the U.S. Laboratory cabin carbon dioxide concentration is at or below 6 mm Hg.

3.2.4.5.2 TEMPERATURE

The WORF shall maintain the interior WORF temperature when a crewmember is present at 18.3°C-26.7°C ±1.1°C (65°F-80°F ±2°F).

3.2.5 REPLACEMENT

The WORF shall be designed such that components can be on-orbit replaceable, including repair or planned upgrades in WORF capability.

3.3 DESIGN AND CONSTRUCTION

3.3.1 HUMAN ENGINEERING

The WORF shall be designed to meet the human engineering interface requirements of SSP 57000.

3.3.2 WINDOW AND GLASS STRUCTURAL DESIGN

All WORF glass components shall meet NSTS 1700.7B, ISS Addendum, Safety Policy and Requirements for Payloads Using the International Space Station, Paragraph 208.1, and SSP 52005, ISS Payload Flight Equipment Requirements and Guidelines for Safety Critical Structures, Paragraph 3.1.2 and Appendix F.

3.3.3 FRACTURE CONTROL

WORF hardware shall be designed for fracture control in accordance with all applicable paragraphs of NSTS 1700.7B, Paragraph 208.1.

3.3.4 OPERATIONAL LIFETIME

The WORF rack shall have an operational lifetime of 10 years beginning with its initial launch.

3.4 LOGISTICS/MAINTENANCE

3.4.1 MAINTENANCE

The maintenance concept for the WORF rack will be to “Remove and Replace” to the functional ORU level. This level will be determined by results of Repair Level Analysis.

3.4.1.1 ACCESSIBILITY FOR MAINTENANCE

All equipment predicted to require on-orbit servicing or replacement shall be accessible to crewmembers.

3.4.1.2 MAINTENANCE TOOLS

The WORF rack shall be designed to be maintained and serviced on-orbit using standard tools as specified in Table XXIV, Standard IVA Tool List, and Table XXV, IVA Diagnostic Equipment List of SSP 41000, System Specification for the International Space Station.

3.5 PERSONNEL AND TRAINING

3.5.1 LOCATION

Training shall be conducted at the Johnson Space Center (JSC) for all nominal and contingency operations of the WORF.

3.5.1.1 ON-ORBIT TRAINING

Training materials shall be developed to support on-orbit training on WORF components, maintenance, and payloads.

3.5.2 TRAINING CONTENT

Each crewmember will be trained in operating the WORF rack and in the maintenance of the window port. This training will include both generic operations of the WORF rack and the installation and operation of payloads in the rack. Training on operations of the window port will cover nominal operations, contingency operations, removal and care of the scratch pane, and in maintenance and cleaning of the interior side of the primary pressure pane.

3.5.2.1 WINDOW PROTECTION

3.5.2.1.1 INTERNAL WINDOW SHIELDS

Each crewmember shall be trained in the nominal and contingency operations of the internal window shields.

3.5.2.1.1.1 BUMP SHIELD

Each crewmember shall be trained in the nominal and contingency operations of the window bump shield.

3.5.2.1.1.2 CAMERA SHIELD TRAINING

Each crewmember shall be trained in the nominal and contingency operations of the camera shield. If this shield interfaces directly with the U.S. Laboratory nadir window, and is not an integral part of the WORF trainer, training will be accomplished using a NASA-provided mockup of the U.S. Laboratory window port.

3.5.2.1.2 EXTERNAL WINDOW SHUTTER TRAINING

Each crewmember shall be trained in the operation of the external window shutter. As the external window shutter is not part of the WORF hardware, this training will be accomplished using a NASA-provided mockup of the U.S. Laboratory window port.

3.5.2.2 RESEARCH WINDOW MAINTENANCE

3.5.2.2.1 REMOVAL OF THE SCRATCH PANE

Each crewmember shall be trained in the removal of the scratch pane. As the scratch pane is not part of the WORF hardware, this training will be accomplished using a NASA-provided mockup of the U.S. Laboratory window port.

3.5.2.2.2 INSTALLATION OF THE SCRATCH PANE

Each crewmember shall be trained in the installation of the scratch pane. As the scratch pane is not part of the WORF hardware, this training will be accomplished using a NASA-provided mockup of the U.S. Laboratory window port.

3.5.2.2.3 STOWAGE OF THE SCRATCH PANE

Each crewmember shall be trained in the stowage of the scratch pane. As the scratch pane is not part of the WORF hardware, a dimensionally accurate facsimile of the scratch pane can be used for training.

3.5.2.2.4 REPLACEMENT OF PANES IN THE BUMP SHIELD

Each crewmember shall be trained in replacement of panes in the bump shield.

3.5.2.2.5 MAINTENANCE OF THE U.S. LABORATORY RESEARCH WINDOW

Each crewmember shall be trained in the care and maintenance of the research window as specified in **<TBD #3>** Care and Cleaning Procedures for Optical Quality Windows. As the window port is not part of the WORF hardware, this training will be accomplished using a NASA-provided mockup of the U.S. Laboratory window port.

3.5.2.3 CONDENSATION PREVENTION SYSTEM

Each crewmember shall be trained in the operation of the condensation prevention system. As the window port is not part of the WORF hardware, this training will be accomplished using a NASA-provided mockup of the U.S. Laboratory window port.

3.5.2.4 SMALL CAMERA BRACKET TRAINING

Each crewmember shall be trained in the operation of the small camera bracket.

3.5.2.5 OPERATION OF PAYLOAD SHROUDS

Each crewmember shall be trained in the operation of the payload shrouds.

3.5.2.6 OPERATION OF THE AISLE-SIDE COVER

Each crewmember shall be trained in the operation of the aisle-side cover.

3.5.2.7 CREW RESTRAINT SYSTEMS

Each crewmember shall be trained in the use of all WORF crew restraint systems.

3.5.2.8 CONTINGENCY OPERATIONS

Each crewmember shall be trained in WORF and window-related contingency operations. As the window port is not part of the WORF hardware, training involving the window port will be accomplished using a NASA-provided mockup of the U.S. Laboratory window port.

3.5.2.8.1 FIRE SUPPRESSION

Each crewmember shall be trained in fire suppression in the WORF volume.

3.5.2.8.2 SAFING THE WINDOW PORT

Each crewmember shall be trained in the safing of the window port. As the window port is not part of the WORF hardware, this training will be accomplished using a NASA-provided mockup of the U.S. Laboratory window port.

3.5.3 TRAINER

A Class II rack trainer shall be provided to train crewmembers on the functionality of the WORF.

3.5.3.1 TRAINER FEATURES

3.5.3.1.1 PHYSICAL REPRESENTATION

The WORF Trainer shall be an accurate physical representation of the WORF.

3.5.3.1.2 PAYLOAD ATTACH POINTS

The WORF Trainer shall include all payload attach points.

3.5.3.1.3 WINDOW SHIELDS

The WORF Trainer shall include all window shields.

3.5.3.1.3.1 FIDELITY OF WINDOW SHIELDS

The WORF window shields shall have the same form, fit, and function with the exception that the shields need not meet the wavefront and transmittance requirements.

3.5.3.1.4 LIGHT SHIELDS

The WORF Trainer shall include all light shields.

3.5.3.1.5 SOFTWARE SIMULATIONS OF RACK AVIONICS

The WORF Trainer shall provide for software simulation of rack avionics adequate to conduct crew training.

3.5.3.1.6 INTERFACES FOR PAYLOAD TRAINING CAPABILITY HOST SYSTEMS

The WORF Trainer shall include interfaces for all Payload Training Capability Host Systems.

3.6 MAJOR COMPONENT CHARACTERISTICS

3.6.1 WORF STRUCTURE

3.6.1.1 PURPOSE OF WORF STRUCTURE

A variety of instruments with stability requirements ranging from 2.5-250 μrad will be used in the WORF facility. As a variety of different instruments will be using the window port, the primary function of the WORF structure is to provide attachment points into which payload-provided mounts can be easily installed, configured, positioned near the window, and removed without the use of tools. The WORF structure system dynamic response and stiffness will be such that payload mounts can be easily developed to support instruments with the range of stability requirements mentioned.

3.6.1.2 WORF PAYLOAD VOLUME ACCOMMODATION

The WORF shall provide the capability, including volume, mounting hardware, and ISPR utility connections, to either mount two small payloads simultaneously or one large payload.

3.6.1.2.1 SMALL PAYLOAD VOLUMETRIC ESTIMATION

For design purposes, small payloads shall be volumetrically estimated, based on Shuttle experience, as having an equivalent volume of two middeck lockers each and include both the imaging device, secondary electronics box, and a laptop computer interface. (This volumetric estimate is based on the payload complement flown on the Department of Defense Space Shuttle WINDEX payload.)

3.6.1.2.2 LARGE PAYLOAD VOLUME AND MASS ESTIMATION

For design purposes, a large payload shall be volumetrically estimated as having the maximum dimensions of 53.3 cm (21-in.) wide by 50.8 cm (20-in.) deep by 76.2 cm (30-in.) long and a maximum mass of 136 kg (299 pounds) (based upon the dimensions and weight of a Leica-Heerbrug RC-30 aerial photography camera), with the 76.2 cm dimension oriented along the X-axis as specified in Section 3.1.1.

3.6.1.3 STIFFNESS

The stiffness of the WORF structure, in its launch configuration, shall be consistent with the minimum frequency requirements imposed by SSP 57000.

3.6.1.4 STABILITY <TBR #5>

The RSS of the X and Z line-of-sight rotations of large sensors, defined in the following cases, shall be less than 7.5 μrad RMS.

A. Case 1 **<TBD>**

1. 15 lb sensor with $I_x = I_z = 1700$ lb-in^2, $I_y = 850$ lb-in^2
2. Payload mounted on 55 Hz shelf via three point mount, looking out the center of the window
3. Shelf interfaces with WORF side rails at four standardized interface points

B. Case 2 **<TBD>**

1. 25 lb sensor with $I_x = I_z = 1500$ lb-in^2, $I_y = 500$ lb-in^2
2. Payload mounted via a 50 Hz tripod, which positions the sensor in the center of the WORF volume
3. Tripod interfaces with the WORF floor at three standardized interface points

C. Case 3 **<TBD>**

3.6.1.5 LAB DISTORTION

The WORF performance as specified in Sections 3.2.1 and 3.6 shall not be affected by distortion of the Lab module due to pressure and temperature changes under nominal conditions.

3.6.1.6 ATTACHMENT POINTS

The WORF structure shall provide attachment points such that payloads, the payload slide mount, camera brackets, and WORF stowage can be mounted without the use of tools. The goal should be to maximize surface area that is available to attach instrumentation, support equipment, crew restraints, and stowage. The attachment points should provide a standard interface for which payloads can be easily designed.

3.6.1.6.1 WORF PAYLOAD SLIDE MOUNT ACCOMMODATION

The WORF structure shall provide the capability to accommodate a sliding mount such that a range of payloads, as per Section 3.6.1.2, can be positioned in the window and moved from the window-side portion (a minimum of **<TBD #13>** cm (-in.) from the window) of the WORF to the aisle-side portion of the WORF (a minimum of **<TBD #13a>** cm (-in.) from the aisle) in order to facilitate the change of lenses or film by a crewmember located in the Lab aisle.

3.6.1.7 ATTACHMENT POINTS FOR SUPPORT INSTRUMENTATION

The WORF structure shall provide attachment points so that monitors, computers, and other instrumentation can be mounted such that a crewmember located in the aisle can operate them.

3.6.1.8 CABLE RESTRAINTS

The WORF structure shall provide constraints for payload cables to keep the LAB1 D3 volume clear of cables regardless of where the instrumentation is mounted.

3.6.2 AISLE-SIDE COVER

3.6.2.1 PURPOSE OF AISLE-SIDE COVER

An aisle-side cover is required to close out the LAB1 D3 volume so that installed instrumentation can not be disturbed by passing crewmembers and to prevent cabin lighting from entering the volume. Most WORF payloads will require that nearly all cabin lighting be prevented from entering the volume so that window glare and internal reflections are minimized. However, some payloads will require that cabin lighting entering the WORF operational volume be kept to a minimum because nighttime observations are being made or because precise radiometric measurements are being performed.

3.6.2.2 PREVENT ACCESS TO LAB1 D3 VOLUME

3.6.2.2.1 PREVENT LAB DEBRIS

The WORF shall provide an aisle-side cover that prevents Lab debris from entering the LAB1 D3 volume.

3.6.2.2.2 WITHSTAND CREW-INDUCED LOADS

The WORF aisle-side cover shall be able to withstand crew-induced loads as defined in SSP 57000.

3.6.2.3 OPENING OF THE AISLE-SIDE COVER

The aisle-side cover shall be designed such that it can be opened in less than 30 seconds without the use of tools.

3.6.2.4 CLOSING

The aisle-side cover shall be designed such that it can be closed in less than 30 seconds without the use of tools.

3.6.2.5 PROTRUSION OF THE AISLE-SIDE COVER INTO AISLE

The aisle-side cover shall not extend into the aisle during unattended operations.

3.6.3 WORF PROVIDED STOWAGE

3.6.3.1 PURPOSE OF STOWAGE

WORF payloads will require temporary and permanent storage facilities. During installation and removal of instruments and various components, it will be necessary to store these components. Some payloads will require removal of the scratch pane and hence a storage location will be required that will simultaneously accommodate the scratch pane and the camera shield. WORF payloads will need stowage in some location other than the WORF volume.

3.6.3.2 STOWAGE ATTACHMENT POINTS

The WORF shall provide attachment points for WORF and user-provided stowage.

3.6.3.3 WORF EQUIPMENT STOWAGE

The WORF shall provide a stowage volume equivalent to two Shuttle middeck lockers. This stowage may be accommodated within the WORF operational volume.

3.6.3.4 SCRATCH PANE STOWAGE

The WORF shall provide a permanent, integral, non-removable stowage location for both the scratch pane and the camera shield. Since these items are similar in size and shape, it is highly desirable that the stowage volume for both of these items be within one volume.

3.6.3.4.1 PREVENTION OF DAMAGE

The scratch pane stowage shall prevent damage to both the camera shield and scratch pane during normal operations in and around the WORF.

3.6.3.5 TEMPORARY STOWING

The WORF shall provide the means to temporarily stow lenses and other equipment when lenses and film are exchanged.

3.6.3.6 REMOVABILITY OF WORF STOWAGE

WORF stowage, with the exception of the stowage volume for the scratch pane and camera shield, shall be removable from the WORF volume and temporarily stowable on neighboring racks.

3.6.4 WINDOW SHIELD

3.6.4.1 PURPOSE OF WINDOW SHIELD

The WORF will provide the capability to protect the window port when instrumentation is being installed or utilized by crewmembers. The WORF will provide a window shield to protect the primary pressure pane from scratches when instrumentation is being installed. The WORF will provide a shield to allow observations with small cameras (7.62 cm (3-in.) diameter apertures) without introducing noticeable optical degradation. The following requirements may be functionally met with either one or two shields. To differentiate between the requirements of the functions required of the two shields, the shield required to protect the window during instrument installation will be referred to as the bump shield. The other shield that will be used to accommodate small cameras will be referred to as the camera shield.

3.6.4.2 REQUIREMENTS FOR THE BUMP SHIELD

3.6.4.2.1 WINDOW PROTECTION

The WORF shall protect the surface of the primary pressure pane when instrumentation is being installed.

3.6.4.2.2 CREW-INDUCED LOADS FOR THE BUMP SHIELD

The window bump shield shall be able to withstand crew-induced loads as specified in Section 3.2.4.2.

3.6.4.2.3 BUMP SHIELD OPTICAL REQUIREMENTS

All transparent parts of the bump shield shall meet the optical requirements for the nine items in this subsection.

3.6.4.2.3.1 BUMP SHIELD MINIMUM VISUAL AREA

A minimum area, uninterrupted by structure, of 305 cm^2 (120-$in.^2$) shall be provided for viewing. The remaining part of the bump shield need not be transparent.

3.6.4.2.3.2 BUMP SHIELD DEPLOYMENT

When the bump shield is deployed, the center of the optical viewing area shall be nominally centered on the window port such that if a line is drawn nominally perpendicular to the center of the window port, it would pass within ±3.8 cm (±1.5-in.) of the center of the bump shield.

3.6.4.2.3.3 BUMP SHIELD WAVEFRONT QUALITY

The bump shield shall have a peak-to-valley wavefront quality in transmission of no worse than 15 waves (with a reference wavelength of 632.8 nm) over any

10.2 cm (4-in.) diameter area within the 305 cm^2 (120-$in.^2$) area of the bump shield referred to in Section 3.6.4.2.3.1.

3.6.4.2.3.4 BUMP SHIELD SCRATCH REQUIREMENT

The bump shield shall have no scratches as severe as F-548-12 as defined in ASTM F-548, Standard Test Method for Intensity of Scratches on Aerospace Transparent Plastics.

3.6.4.2.3.5 BUMP SHIELD SCRATCH LIMITS

The sum of the lengths of all F-548-11 scratches as defined in ASTM F-548 shall be less than 12.7 cm (5-in.).

3.6.4.2.3.6 BUMP SHIELD ROUND IMPERFECTIONS

The bump shield shall have no round imperfections as specified in ANSI PH3.617, Definitions, Methods of Testing, and Specifications for Appearance Imperfections of Optical Elements and Assemblies, greater than 0.1 cm (0.04-in.).

3.6.4.2.3.7 BUMP SHIELD DURABILITY

If the optical surfaces of the bump shield material are composed of plastic, the durability of the bump shield shall have a Taber resistance for 100 cycles using a 500 gm load of no greater than 5% in accordance with ASTM 1044, Standard Test Method for Resistance of Transparent Plastics to Surface Abrasion.

3.6.4.2.3.8 BUMP SHIELD TRANSMITTANCE

The bump shield shall have an average transmittance of 75% from 400-700 nm. An average transmittance of greater than 85% is desirable and should be achievable with the use of an anti-reflection coating.

3.6.4.2.3.9 BUMP SHIELD HAZE

The haze of the bump shield shall be less than 10% at normal angles of incident per ASTM 1003-97, Standard Test Method for Haze and Luminous Transmittance of Transparent Plastics.

3.6.4.2.4 RETRACTABILITY OF THE BUMP SHIELD FROM THE AISLE

The bump shield shall be retractable by a crewmember located in the Lab aisle. This will eliminate the need for a crewmember to reach past a payload to retract the bump shield.

3.6.4.2.5 DEPLOYABILITY OF THE BUMP SHIELD FROM THE AISLE

The bump shield shall be deployable by a crewmember located in the Lab aisle. This will eliminate the need for a crewmember to reach past a payload to retract the bump shield.

3.6.4.3 CAMERA SHIELD REQUIREMENTS

3.6.4.3.1 CAMERA SHIELD TRANSMITTANCE

The camera shield utilized for observations with small cameras shall have a minimum transmittance of 85% from 400-700 nm. A transmittance of greater than 90% is desirable and should be achievable with the use of an anti-reflection coating.

3.6.4.3.2 CAMERA SHIELD HAZE

The haze of the camera shield shall not exceed 3% at normal angles of incidence per ASTM 1003-97.

3.6.4.3.3 CAMERA SHIELD BEAUTY/AESTHETIC REQUIREMENT

The operating zones of the camera shield are defined in Appendix B, Glossary of Terms.

3.6.4.3.3.1 CAMERA SHIELD SCRATCH REQUIREMENTS FOR ZONE I

In Zone I of the camera shield, there shall be no scratches as severe as F-548-11 as defined in ASTM F-548.

3.6.4.3.3.2 CAMERA SHIELD SCRATCH REQUIREMENTS FOR ZONE II

In Zone II of the camera shield, there shall be no scratches as severe as F-548-12 as defined in ASTM F-548.

3.6.4.3.3.3 CAMERA SHIELD SCRATCH LIMITS FOR ZONE II

In Zone II of the camera shield, the sum of the lengths of all F-548-11 scratches shall be less than 10.2 cm (4-in.).

3.6.4.3.3.4 SCRATCH REQUIREMENTS FOR CAMERA SHIELDS COMPOSED OF GLASS

A camera shield composed of glass shall meet a scratch requirement of 80 or better per MIL-PRF-13830B, Optical Components for Fire Control Instruments: General Specification Governing the Manufacture, Assembly, and inspection of, in Zone I and II.

3.6.4.3.3.5 CAMERA SHIELD ROUND IMPERFECTIONS FOR ZONE I

In Zone I of the camera shield there shall be no round imperfections as defined in ANSI PH3.617 greater than 0.05 cm (0.02-in.).

3.6.4.3.3.6 CAMERA SHIELD ROUND IMPERFECTIONS FOR ZONE II

In Zone II of the camera shield there shall be no round imperfections as defined in ANSI PH3.617 greater than 0.1 cm (0.04-in.).

3.6.4.3.3.7 CAMERA SHIELD AREA IMPERFECTIONS FOR ZONE I

In Zone I of the camera shield there shall be no area imperfections as defined in ANSI PH3.617 visible at a 30 cm (11.8-in.) viewing distance using a Direct Light, Transmitted (DLT) source as defined in ANSI PH3.617.

3.6.4.3.4 CAMERA SHIELD WAVEFRONT QUALITY

The camera shield shall have a peak-to-valley wavefront quality in transmission of no worse than 4 waves (with a reference wavelength of 632.8 nm) over any 10.2 cm (4-in.) diameter area within Zone I.

3.6.4.3.4.1 CAMERA SHIELD WAVEFRONT QUALITY UNDER LOAD

The camera shield wavefront quality as specified in Section 3.6.4.3.4 shall be maintained while a 12 lbf load is induced in a direction nominally perpendicular to the camera shield.

3.6.4.3.5 CAMERA SHIELD DURABILITY

3.6.4.3.5.1 CAMERA SHIELD DURABILITY FOR COATED GLASS

The camera shield shall pass the severe abrasion requirement per MIL-C-675, Coatings of Glass Optical Elements (Anti-reflection).

3.6.4.3.5.2 CAMERA SHIELD DURABILITY FOR PLASTIC

If the exterior surfaces of the camera shield material are composed of plastic, the durability of the camera shield shall have a Taber resistance for 100 cycles using a 500 gm load of no greater than 3% in accordance with ASTM 1044.

3.6.4.3.6 CAMERA SHIELD STABILITY

The camera shield shall not move more than 0.64 cm (0.25-in) under the simultaneous application of the load conditions described in Sections 3.6.4.3.6.1 and 3.6.4.3.6.2.

3.6.4.3.6.1 CAMERA SHIELD CENTER LOAD

A 12 lbf load shall be applied to the center of the camera shield in a direction nominally perpendicular to the camera shield surface.

3.6.4.3.6.2 CAMERA SHIELD SIDE LOAD

A 5 lbf load shall be applied to the side of the camera shield in a direction nominally parallel to the camera shield surface.

3.6.4.3.7 CAMERA SHIELD LOCATION

The camera shield shall be located no more than 3.8 cm (1.5-in.) away from the inner surface of the primary pressure pane.

3.6.4.3.8 WINDOW ACCESS TO THE CONDENSATION PREVENTION SYSTEM

The WORF camera shield shall not prevent the operation of the condensation prevention system described in Section 3.6.8.

3.6.4.4 REQUIREMENTS FOR BOTH SHIELDS

3.6.4.4.1 RETRACTABILITY

The WORF shields shall be retractable away from the window port in a maximum of 30 seconds without the use of tools.

3.6.4.4.2 OBSCURATION BY SHIELDS

The WORF shields when retracted shall not be located within the line-of-sight of the window when viewing in a direction normal to the plane of the window panes.

3.6.4.4.3 DEPLOYMENT OF SHIELDS

The WORF shields shall be deployable in a maximum of 30 seconds without the use of tools.

3.6.4.4.4 REPLACEABILITY OF SHIELDS

The WORF shields shall be removable from the WORF volume and replaceable.

3.6.5 WORF UTILITIES

3.6.5.1 DESCRIPTION

The LAB1 D3 position accommodates interfaces to standard Station utilities in addition to moderate temperature cooling and medium and high rate data network.

3.6.5.2 ACCESS TO ISS PORTABLE COMPUTER SYSTEM

The WORF shall allow physical and functional interface to an ISS-approved laptop computer outside the LAB1 D3 position regardless of the position of the aisle-side cover.

3.6.5.3 NUMBER OF SIMULTANEOUS PAYLOADS TO SUPPORT

The WORF shall provide active utility support to one payload at a time. Concurrent support of two small payloads compatible with the available WORF resources should not be precluded.

3.6.5.4 ELECTRICAL POWER SUPPORT

The WORF shall provide electrical power for payload use as per SSP 57000.

3.6.5.4.1 28 VOLTS DIRECT CURRENT

The WORF shall provide a minimum of two 28 Vdc **<TBD #19>** amp power outlets for each of two payloads mounted in the WORF.

3.6.5.5 THERMAL CONTROL

The WORF shall provide payload interface to the moderate temperature cooling loops for cooling of payloads and WORF equipment as per SSP 57000.

3.6.5.6 WORF COMMAND AND DATA INTERFACE

3.6.5.6.1 MIL-STD-1553B

The WORF shall provide an interface to the ISS standard payload MIL-STD-1553B, Digital Time Division Command Response Multiplex Data Bus, bus interface as specified by SSP 57000.

3.6.5.6.2 ETHERNET

The WORF shall provide an interface to the ISS payload ANSI/IEEE 802.3, 10 Base-T Ethernet Services, as specified in SSP 57000.

3.6.5.6.3 HIGH RATE DATA LINK

The WORF shall provide an interface to the ISS High Rate Data Link (HRDL) services as specified by SSP 57000.

3.6.5.6.4 VIDEO LINK

The WORF shall provide pulse frequency modulation video output signals as specified in SSP 57000 from a selected payload video source to the ISS Internal Video Subsystem (IVS).

3.6.5.7 PAYLOAD COMMAND AND DATA INTERFACES

The WORF shall provide pulse frequency modulation video output signals as specified by SSP 57000.

3.6.5.7.1 PAYLOAD ETHERNET COMMUNICATIONS

The WORF shall provide ANSI/IEEE 802.3 communications at each experiment data connector.

3.6.5.7.2 PAYLOAD TIA/EIA-422 COMMUNICATIONS

The WORF shall access the complement of payloads via TIA/EIA-422 communications at each experiment data connector.

3.6.5.7.3 PAYLOAD BI-DIRECTIONAL DISCRETE COMMUNICATIONS

The WORF shall provide three bi-directional differential discrete signal interfaces with selectable sampling rates at each experiment data connector.

3.6.5.7.4 PAYLOAD ANALOG INPUTS

The WORF shall provide a single EIA-RS-170A format balanced differential video signal interface at each experiment data connector.

3.6.5.7.5 PAYLOAD POINT-TO-POINT COMMUNICATIONS

The WORF shall have the capability for Point-to-Point Communication (PPC) between payload locations with the rack.

3.6.5.7.6 VIDEO DISPLAY INTERFACE

The WORF shall provide a balanced differential video signal to a laptop or monitor interface from a selected video source in EIA-RS-170A format.

3.6.5.7.7 DIRECT INTERFACE TO AISLE-MOUNTED HARDWARE

The WORF shall provide a direct connection interface between payloads mounted in the WORF and laptop and monitor mounted in the U.S. Lab aisle, including a coaxially-mounted camcorder utilizing a camcorder Liquid Crystal Diode (LCD) cable and an Ethernet connector between a payload and the WORF laptop.

3.6.5.7.7.1 PAYLOAD DATA OUTPUT

The WORF shall provide the ability for a payload to simultaneously communicate between a payload in the payload volume and a recording device in the aisle using Ethernet, SCCI-II, S-Video and RS-232/422.

3.6.5.7.7.2 CROSS TALK

The WORF shall prevent cross talk between data communication lines.

3.6.6 SMALL CAMERA BRACKET

3.6.6.1 PURPOSE OF SMALL CAMERA BRACKET

Two small camera brackets will be provided that will be installed in the WORF and easily accessible to crewmembers. These brackets should be easy to use by a crewmember performing standard Earth observation tasks. These brackets will accommodate a variety of camera types and lens lengths and enable the instruments to be moved different distances away from the window to accommodate different length lenses, while maintaining the location of the camera generally in the center of the window. The brackets are meant to stabilize cameras being used by the crew for Earth observations. Crewmembers will normally install a camera on a bracket and then place the camera against the window camera shield to begin observations. The small camera brackets will typically be mounted in the WORF, but will be removable to allow installation of large payloads that will take up the entire WORF volume.

3.6.6.2 DEPLOYMENT REQUIREMENT

The small camera brackets shall be deployable and retractable by crewmembers in less than one minute without the use of tools.

3.6.6.3 INTERFACE

The small camera brackets shall allow installation of a camera or camcorder with a standard 1/4-20-bolt interface without the use of tools.

3.6.6.4 NUMBER OF BRACKETS SUPPLIED

Two small camera brackets shall be supplied in order to be able to use two cameras with different focal length lenses during crew Earth observations activities **<TBR #4>**.

3.6.6.5 CAMERA WEIGHT

Each small camera bracket shall accommodate cameras with a maximum weight of 10 kg.

3.6.6.6 SMALL CAMERA MOUNT STABILITY <TBR #6>

The RSS of the X and Z rotations of the tip of the small camera mount, while supporting cameras with 1-10 lb mass and 1-100 lb-in^2 inertia, shall be less than 25 μrad RMS under all nominal operational configurations.

3.6.6.7 CAMERA SIZES

Each small camera bracket shall accommodate cameras that are from 10.2 cm (4-in.) to 53.3 cm (21-in.) (based on Hasselblad 203FE body with 500mm CF Zeiss lens) in length.

3.6.6.8 REMOVABLE

Each small camera bracket shall be removable from the WORF volume.

3.6.6.9 POSITIONING REQUIREMENT

Each small camera bracket shall be able to be positioned such that an instrument can be moved so that it can contact the camera shield while it is located at its closest position to the primary pressure pane.

3.6.6.10 DEGREES OF FREEDOM

Each small camera bracket shall provide six degrees of freedom for a mounted camera.

3.6.6.11 LOCK DOWN CAPABILITY

Each small camera bracket shall have a lock down capability once the desired position is found.

3.6.6.12 MAINTAINABILITY OF LOCKING MECHANISM

Each small camera bracket locking mechanism shall not fail during repositioning instruments while subjected to a torsional force of 17.4 N (154 lb. in) (based on SSP 50005, Rev. B, Figure 4.9.3-8, Maximum Bare-handed Torque) for a total of 400 cycles.

3.6.7 PAYLOAD SLIDE MOUNT <TBR #3>

3.6.7.1 DESCRIPTION OF THE PAYLOAD SLIDE MOUNT

The payload slide mount will provide a means for the crew to install, position, and maintain payloads while located in the U.S. Laboratory aisle and then permit the payload to be moved into position within the WORF volume. The primary objective of the mount is to simplify crew access to payloads and to provide the means to adjust the position of a payload horizontally and vertically in the window field of view. These capabilities can be met by a separate mount or integrated into the WORF design.

3.6.7.2 SMALL PAYLOAD ACCOMMODATION

The payload slide mount shall accommodate the mounting of two small payloads the sizes of which are defined in Appendix B such that the optical axes of either payload can be mounted within the center 40.6 cm (16-in.) of the window port.

3.6.7.3 LARGE PAYLOAD ACCOMMODATION

The payload slide mount shall accommodate one large payload as defined in Section 3.6.1.2.2, Large Payload Volume and Mass Estimation, such that the camera optical axis falls within the center 15.2 cm (6-in.) diameter of the window port.

3.6.7.4 PAYLOAD SLIDE MOUNT STIFFNESS

The payload slide mount shall meet the stiffness requirements as defined in Section 3.6.6.6, Small Camera Mount Stability.

3.6.7.5 REMOVABLE

The payload slide mount shall be removable from the WORF volume.

3.6.7.6 PERFORMANCE

The payload slide mount performance shall not be affected by distortion of the U.S. Laboratory module due to pressure and temperature changes under nominal conditions.

3.6.7.7 PAYLOAD SLIDE MOUNT ACCESS

The payload slide mount shall be temporarily extendable at least 50.8 cm (20-in.) into the aisle area to allow for easy access by crewmembers located in the aisle area.

3.6.7.8 PAYLOAD SLIDE MOUNT TRAVEL ALONG AXIS NORMAL TO THE WINDOW

The payload slide mount shall allow payloads a range of continuous travel from 50.8 cm (20-in.) into the aisle area, as measured from the front of the WORF rack, to within 1.0 cm (0.4-in.) of the primary pressure pane surface.

3.6.7.9 PAYLOAD SLIDE MOUNT ADJUSTMENT TIME ALONG THE NORMAL TO THE WINDOW

The payload slide mount shall be adjustable in its full range of motion along the axis normal to the window port in less than one minute.

3.6.7.10 PAYLOAD SLIDE MOUNT ATTACHMENT DESIGN

The payload slide mount shall provide a means to attach payloads without the use of tools.

3.6.7.11 PAYLOAD SLIDE MOUNT STOP

An adjustable means to limit travel **<TBD #21>** cm (-in.) towards the window shall be provided to prevent contact of instrumentation with the primary pressure pane.

3.6.7.12 PAYLOAD SLIDE MOUNT STOP SCALE

A scale with a resolution of 1 cm (0.4-in.) shall be provided such that the mount travel limits to the window can be precisely set.

3.6.7.13 PAYLOAD SLIDE MOUNT TRAVEL IN THE AXES PERPENDICULAR TO THE NORMAL OF THE WINDOW PORT

The payload slide mount shall provide a means to adjust or reposition a payload in a direction horizontally or vertically approximately 15.25 cm (6-in.) from the center of the window along any direction perpendicular to the normal with the window port.

3.6.7.14 PAYLOAD SLIDE MOUNT POSITION LOCK

A means to lock down the position of the payload slide mount in all axes without tools shall be provided.

3.6.8 CONDENSATION PREVENTION SYSTEM

3.6.8.1 PURPOSE OF THE CONDENSATION PREVENTION SYSTEM

The WORF requires a condensation prevention system for a number of reasons. When the window port is configured with the scratch pane installed, it serves as a passive heater of the primary pressure pane to prevent condensation. Hence, when the scratch pane is removed to allow utilization of the high optical quality windows, this heating function is no longer available. ISSP thermal analyses indicate that the inner pressure pane could become cold enough that condensation would collect on the window. Hence, a condensation prevention system is required to prevent moisture from condensing on the primary pressure pane. A condensation prevention system is also required when crewmembers are working close to the window. It has been reported on other programs that crewmembers working in close proximity to windows or underneath shrouds can cause condensation to form on the windows with their breath.

3.6.8.2 PREVENTION OF CONDENSATION

The WORF shall provide a condensation prevention system to prevent condensation from forming on the inner surface of the primary pressure pane in all nominal operational configurations.

3.6.8.3 OPERATIONAL VOLUME LIMITATIONS

The condensation prevention system shall not extend into the payload user volume as defined in Section 3.2.1.13.

3.6.8.4 MAINTENANCE OF WINDOW OPTICAL PERFORMANCE

The condensation prevention system shall not degrade the optical performance below that described in Section 1.1.1 and meets the requirements of Section 3.2.1.18.2.

3.6.9 PAYLOAD SHROUD

3.6.9.1 PURPOSE OF PAYLOAD SHROUD

A payload shroud will be available to accommodate crewmembers during payload operations and Earth observation activities. The purpose of the shroud is to prevent cabin lighting from reaching the window while crewmembers are operating different size payloads from within the LAB1 D3 volume. This shroud will accommodate crewmembers that are using payloads mounted on the small camera brackets, accommodate setting up and sighting long instruments that occupy most of the interior space of the WORF, or allow shrouding of a payload during operations that require the aisle-side cover to remain open. One of more shrouds may be required to meet the following requirements, depending on potential payload size. The payload shroud needs to be able to allow a crewmember to work on a 76.2 cm (30-in.) length optical system while still preventing light from entering the volume. In addition, the payload shroud will also allow a crewmember to view directly through the window while it is deployed.

3.6.9.2 PAYLOAD SHROUD FUNCTION

The WORF shall provide a payload shroud to prevent glare during crew use of the window.

3.6.9.3 DEPLOYMENT OF PAYLOAD SHROUD

The payload shroud shall take no more than five minutes to deploy.

3.6.9.3.1 EGRESS TIME

Crewmembers shall be able to egress from the payload shroud in less than 30 seconds.

3.6.9.4 CAMERA SIZES

The payload shroud shall accommodate cameras up to 53.3 cm (21-in.) (based on Hasselblad 203FE body with 500mm CF Zeiss lens) in length.

3.6.9.5 CREW USAGE OPTIONS FOR THE PAYLOAD SHROUD

<TBD #22>

3.6.9.6 CREWMEMBER USE OF THE WINDOW

The payload shroud shall allow a crewmember to directly view through the window while still maintaining the environment specified in all sub-sections of Section 3.2.1.5.1 and 3.2.1.5.2.

3.6.9.7 ACCOMMODATION OF LONG PAYLOADS

The payload shroud shall allow a crewmember to utilize a 76.2 cm (30-in.) long instrument while located in the Lab aisle while still maintaining the environment as specified in all sub-sections of Section 3.2.1.5 and 3.2.1.5.1.

3.6.10 RESTRAINTS

3.6.10.1 PURPOSE OF CREW RESTRAINTS

Crew restraints will be provided. Since the kinds and sizes of optical instruments used will vary considerably, the crew restraints need to be flexible and varied as well. One possibility in providing this flexibility could be to provide many attachment points in the WORF design where any number and type of crew restraints can be accommodated.

3.6.10.2 CREW RESTRAINTS IN THE AISLE

A crew restraint system shall be provided that will allow crewmembers to work in the aisle area and access the WORF volume.

3.6.10.3 CREW RESTRAINTS FOR USE INSIDE THE WORF

Crew restraints shall be provided inside the WORF to accommodate crewmembers using small camera brackets, setting up instrumentation, accessing stowage provisions, and for crewmembers using the types and sizes of instrumentation described in the operational scenarios.

4.0 VERIFICATION

This section contains the formal qualification requirements that are necessary to show compliance with each “shall” statement of Section 3. Non “shall” statements will not and are not required to be quality assurance checked for compliance. This qualification consists of:

A. Data for the reliability analysis which will be collected and recorded during qualification.

B. Engineering (development) evaluation and tests which may be required for analyzing design approaches to ensure that requirements encompassing material selection, tolerances, and operational characteristics are satisfied. If development test data is intended to be used to qualify hardware, this should be declared prior to the test.

C. Qualification requirements are specified in Section 4.3. Qualification represents the broadest scope of verification within design tolerances to which a configuration/end item is subjected. It encompasses the entire range of activity to verify that the design conforms to requirements when subjected to environmental life-cycle conditions. Flight-like hardware is normally used for qualification testing. If actual flight hardware is used for qualification testing, it shall be in accordance with SSP 41172, Qualification and Acceptance Environmental Test Requirements. Environmental models shall be used to represent environments that cannot be achieved under the conditions of ground testing. Simulators, used for verifying requirements, require validation so that the item undergoing qualification cannot distinguish between the simulator and actual operation hardware.

D. Integration testing and checkout shall be conducted during end item buildup. Activities such as continuity checking and interface mating will be performed. Activities such as major component operation in the installed environment, support equipment compatibility, and documentation verification will be proven during qualification.

E. Formal verification of performance characteristics occurs for the full range of performance requirements during qualification.

4.1 GENERAL

Compliance with the requirements, stated in Section 3, shall be proven using one or more of the following methods.

A. Inspection (I): Inspection is a method that determines conformance to requirements by the review of drawings, data, or by visual examination of the item using standard quality control methods, without the use of special laboratory procedures.

B. Analysis (A): Analysis is a process used in lieu of, or in addition to, other methods to ensure compliance to specification requirements. The selected techniques may include, but not be limited to, engineering analysis, statistics and qualitative analysis, computer and hardware simulations, and analog modeling. Analysis may also include assessing the results of lower level qualification activity.

C. Similarity (S): Verification by similarity is the process of analyzing the specification criteria for hardware configuration and application for an article to determine if it is similar or identical in design, manufacturing process, and quality control to an existing article that has previously been qualified to equivalent or more stringent specification criteria. Special effort will be made to avoid duplication of previous tests from this or similar programs. If the previous application is considered to be similar, but not equal to or greater in severity, additional qualification tests shall concentrate on the areas of new or increased requirements.

D. Demonstration (D): Demonstration consists of a qualitative determination of the properties of a test article. This qualitative determination is made through observation, with or without special test equipment or instrumentation, which verifies characteristics such as human engineering features, services, access features, and transportability. Demonstration requirements are normally implemented within a test plan, operations plan, or test procedures.

E. Test (T): Test is a method in which technical means, such as the use of special equipment, instrumentation, simulation techniques, and the application of established principles and procedures are used for the evaluation of components, subsystems, and systems to determine compliance with requirements. Test shall be selected as the primary method when analytical techniques do not produce adequate results; failure modes exist which could compromise personnel safety, adversely affect flight systems or payload operation, or result in a loss of mission objectives; or for any components directly associated with Space Station and Orbiter interfaces. The analysis of data derived from tests is an integral part of the test program and should not be confused with analysis as defined above. Tests shall be used to determine quantitative compliance to requirements and produce quantitative results.

4.1.1 CONTRACTOR RESPONSIBILITY

Unless otherwise specified in the contract, the supplier is responsible for the performance of verification activities as specified herein. Except as otherwise specified in the contract, the supplier may use his own or any other facility suitable for the performance of the verification activities specified herein, unless disapproved by the United States Government. The United States Government reserves the right to perform any of the verifications set forth in this specification.

4.2 VERIFICATION INSPECTIONS

Qualification test procedures are outlined in SSP 41172. Demonstrations, analyses, inspections, and any additional test requirements are specified herein. Individual verification requirements do not require a stand-alone verification to be performed but may be combined with satisfying other verification requirements to prevent redundancy and optimize commonality.

4.3 QUALITY ASSURANCE PROVISIONS

A quality assurance system shall be established that complies with the provisions of NHB 5300.4 (1B), Quality Provisions for Aerospace Contractors. Table 4.3-1, Proposed Verification Methods, lists the recommended one-to-one verification procedures for the requirements in Section 3. These procedures shall be reviewed and baselined as part of the WORF Verification Plan submitted at the Preliminary Design Review. In summary, Inspection (I) will be used to verify physical characteristics such as dimensions, color etc.; Analysis (A) will be used to verify conformance with requirements based on studies, calculations, and modeling; Demonstration (D) will represent dynamic items that need to be shown compliant like installation of the IVA cover; Test (T) will be used for those functions that are fundamental to the WORF and for which there is no confidence in analysis.

TABLE 4.3-1 PROPOSED VERIFICATION METHODS (PAGE 1 OF 6)

Paragraph Number	Requirement	Verification Method
3.1	LAB1 D3 Volume	I
3.1.1	Coordinate System	I
3.1.2	Interface Definition	I
3.1.2.1	Interface Control	I
3.1.2.1.1	Hardware Interface Control	I
3.1.2.1.2	Software Interface Control	I
3.2.1.1	Crew Access to Window Port for Earth Observations Tasks	D
3.2.1.2	Crew Access Time Allocation for Earth Observations Tasks	I
3.2.1.3	3.2.1.3 Crew Access to Window Port for Emergency Operations	D
3.2.1.3.1	Removal of Payloads	D
3.2.1.3.2	Rack Rotation	I
3.2.1.4	Unattended Operation	A, D
3.2.1.5	Prevention of Stray Light Sources Within the WORF Payload Volume	A, T
3.2.1.5.1	Determination of the Diffuse Amount of Lighting	T
3.2.1.5.2	Determination of Glare Features	T
3.2.1.5.3	Light Sources from Within the WORF	I, D

TABLE 4.3-1 PROPOSED VERIFICATION METHODS (PAGE 2 OF 6)

Paragraph Number	Requirement	Verification Method
3.2.1.6	Temporary Stowage Restraint System	A, D
3.2.1.7	Scratch Pane Removal	I
3.2.1.8	Scratch Pane Installation	I
3.2.1.9	Window Shutter Operation	I
3.2.1.10	Installation of the Intravehicular Activity Cover	I
3.2.1.11	Removal of the Intravehicular Activity Cover	I
3.2.1.12	Intravehicular Activity Window Changeout	D
3.2.1.13	Minimum Payload Volume	I, A
3.2.1.14	Diffuse Surface Reflectance of WORF Structure	A
3.2.1.14.1	Specular Surface Reflectance of the Aft (Aisle-Side) Part of the WORF	A
3.2.1.14.2	Specular Surface Reflectance of the Remaining WORF Structure	A
3.2.1.14.3	WORF Structure Finish	D
3.2.1.15	Support Instrumentation Visual Access	I, D
3.2.1.16	Condensation	A
3.2.1.17	Launch and Landing Cycles	A, S
3.2.1.18	Protect Optical Performance	**<TBD>**
3.2.1.18.1	Requirements Volume	I
3.2.1.18.2	Cabin Atmosphere Optical Path Variation	A
3.2.2.1	Launch and Return Envelope	A, D
3.2.2.2	On-Orbit Deployment Envelope	A, D
3.2.2.2.1	International Standard Payload Rack Rear Access Panel Removal	D
3.2.2.2.2	International Standard Payload Rack Rear Access Panel Re-installation	D
3.2.2.2.3	International Standard Payload Rack Rear Access Panel Stowage	**<TBD>**
3.2.3	Maintainability	I
3.2.3.1	Corrective Maintenance	A
3.2.3.2	Restoration of Performance	A
3.2.3.3	Preventative Maintenance	N/A
3.2.4.1.1	Ultraviolet/Infrared Radiation in the LAB1 D3 Volume	T
3.2.4.1.2	Ultraviolet/Infrared Radiation in the Lab Aisle Area	A, T
3.2.4.2	Crew-induced Loads	A
3.2.4.3	Interior Workspace Lighting	D
3.2.4.3.1	Capability to Turn Off Workspace Lighting	D
3.2.4.3.2	Capability to Turn On Workspace Lighting	D
3.2.4.4	Interior Workspace Acoustics Limit	A

TABLE 4.3-1 PROPOSED VERIFICATION METHODS (PAGE 3 OF 6)

Paragraph Number	Requirement	Verification Method
3.2.4.5.1	Carbon Dioxide Concentration **<TBR #1>**	A
3.2.4.5.2	Temperature	I
3.2.5	Replacement	A
3.3.1	Human Engineering	A
3.3.2	Window and Glass Structural Design	A
3.3.3	Fracture Control	A
3.3.4	Operational Lifetime	A
3.4.1	Maintenance	A, D, S
3.4.1.1	Accessibility for Maintenance	I
3.4.1.2	Maintenance Tools	I
3.5.1	Location	I
3.5.1.1	On-Orbit Training	I
3.5.2.1.1	Internal Window Shields	I
3.5.2.1.1.1	Bump Shield	I
3.5.2.1.1.2	Camera Shield Training	I
3.5.2.1.2	External Window Shutter Training	I
3.5.2.2.1	Removal of the Scratch Pane	I
3.5.2.2.2	Installation of the Scratch Pane	I
3.5.2.2.3	Stowage of the Scratch Pane	I
3.5.2.2.4	Replacement of Panes in the Bump Shield	I
3.5.2.2.5	Maintenance of U.S. Laboratory Research Window	I
3.5.2.3	Condensation Prevention System	I
3.5.2.4	Small Camera Bracket Training	I
3.5.2.5	Operation of Payload Shrouds	I
3.5.2.6	Operation of the Aisle-Side Cover	I
3.5.2.7	Crew Restraint Systems	I
3.5.2.8	Contingency Operations	I
3.5.2.8.1	Fire Suppression	I
3.5.2.8.2	Safing the Window Port	I
3.5.3	Trainer	I
3.5.3.1.1	Physical Representation	I
3.5.3.1.2	Payload Attach Points	I
3.5.3.1.3	Window Shields	I
3.5.3.1.3.1	Fidelity of Window Shields	I
3.5.3.1.4	Light Shields	I
3.5.3.1.5	Software Simulations of Rack Avionics	D
3.5.3.1.6	Interfaces for Payload Training Capability Host Systems	D

TABLE 4.3-1 PROPOSED VERIFICATION METHODS (PAGE 4 OF 6)

Paragraph Number	Requirement	Verification Method
3.6.1.2	WORF Payload Volume Accommodation	I
3.6.1.2.1	Small Payload Volumetric Estimation	N/A
3.6.1.2.2	Large Payload Volume and Mass Estimation	N/A
3.6.1.3	Stiffness	A
3.6.1.4	Stability **<TBR #5>**	A
3.6.1.5	Lab Distortion	A
3.6.1.6	Attachment Points	D
3.6.1.6.1	WORF Payload Slide Mount Accommodation	**<TBD>**
3.6.1.7	Attachment Points for Support Instrumentation	D
3.6.1.8	Cable Restraints	D
3.6.2.2.1	Prevent Lab Debris	I
3.6.2.2.2	Withstand Crew-induced Loads	A
3.6.2.3	Opening of the Aisle-Side Cover	D
3.6.2.4	Closing	D
3.6.2.5	Protrusion of the Aisle-Side Cover into Aisle	I
3.6.3.2	Stowage Attachment Points	D
3.6.3.3	WORF Equipment Stowage	D
3.6.3.4	Scratch Pane Stowage	D
3.6.3.5	Temporary Stowing	D
3.6.3.6	Removability of WORF Stowage	A, D
3.6.4.2.1	Window Protection	D
3.6.4.2.2	Crew-Induced Loads for the Bump Shield	A
3.6.4.2.3	Bump Shield Optical Requirements	T
3.6.4.2.3.1	Bump Shield Minimum Visual Area	I
3.6.4.2.3.2	Bump Shield Deployment	D
3.6.4.2.3.3	Bump Shield Wavefront Quality	T
3.6.4.2.3.4	Bump Shield Scratch Requirement	T
3.6.4.2.3.5	Bump Shield Scratch Limits	T
3.6.4.2.3.6	Bump Shield Round Imperfections	T
3.6.4.2.3.7	Bump Shield Durability	A
3.6.4.2.3.8	Bump Shield Transmittance	A
3.6.4.2.3.9	Bump Shield Haze	A
3.6.4.2.4	Retractability of the Bump Shield from the Aisle	D
3.6.4.2.5	Deployability of the Bump Shield from the Aisle	D
3.6.4.3.1	Camera Shield Transmittance	T
3.6.4.3.2	Camera Shield Haze	T
3.6.4.3.3.1	Camera Shield Scratch Requirement for Zone I	T
3.6.4.3.3.2	Camera Shield Scratch Requirement for Zone II	T

TABLE 4.3-1 PROPOSED VERIFICATION METHODS (PAGE 5 OF 6)

Paragraph Number	Requirement	Verification Method
3.6.4.3.3.3	Camera Shield Scratch Limits for Zone II	T
3.6.4.3.3.4	Scratch Requirements for Camera Shields Composed of Glass	T
3.6.4.3.3.5	Camera Shield Round Imperfections for Zone I	T
3.6.4.3.3.6	Camera Shield Round Imperfections for Zone II	T
3.6.4.3.3.7	Camera Shield Area Imperfections for Zone I	T
3.6.4.3.4	Camera Shield Wavefront Quality	T
3.6.4.3.4.1	Camera Shield Wavefront Quality Under Load	A
3.6.4.3.5	Camera Shield Durability	I
3.6.4.3.5.1	Camera Shield Durability for Coated Glass	A
3.6.4.3.5.2	Camera Shield Durability for Plastic	A
3.6.4.3.6	Camera Shield Stability	D
3.6.4.3.6.1	Camera Shield Center Load	I
3.6.4.3.6.2	Camera Shield Side Load	I
3.6.4.3.7	Camera Shield Location	I
3.6.4.3.8	Window Access to the Condensation Prevention System	I, A
3.6.4.4.1	Retractability	D
3.6.4.4.2	Obscuration by Shields	D
3.6.4.4.3	Deployment of Shields	D
3.6.4.4.4	Replaceability of Shields	D
3.6.5.2	Access to ISS Portable Computer System	D
3.6.5.3	Number of Simultaneous Payloads to Support	I, D
3.6.5.4	Electrical Power Support	I, D
3.6.5.4.1	28 Volts Direct Current	I, D
3.6.5.5	Thermal Control	I
3.6.5.6.1	MIL-STD-1553B	I
3.6.5.6.2	Ethernet	I
3.6.5.6.3	High Rate Data Link	I
3.6.5.6.4	Video Link	I
3.6.5.7	Payload Command and Data Interfaces	I
3.6.5.7.1	Payload Ethernet Communications	I
3.6.5.7.2	Payload TIA/EIA-422 Communications	I
3.6.5.7.3	Payload Bi-Directional Discrete Communications	I
3.6.5.7.4	Payload Analog Inputs	I
3.6.5.7.5	Payload Point-to-Point Communications	I
3.6.5.7.6	Video Display Interface	I
3.6.5.7.7	Direct Interface to Aisle-Mounted Hardware	D
3.6.6.2	Deployment Requirement	D

TABLE 4.3-1 PROPOSED VERIFICATION METHODS (PAGE 6 OF 6)

Paragraph Number	Requirement	Verification Method
3.6.6.3	Interface	D
3.6.6.4	Number of Brackets Supplied	I
3.6.6.5	Camera Weight	D
3.6.6.6	Small Camera Mount Stability **<TBR #6>**	A
3.6.6.7	Camera Sizes	D
3.6.6.8	Removable	D
3.6.6.9	Positioning Requirement	D
3.6.6.10	Degrees of Freedom	D
3.6.6.11	Lock Down Capability	D
3.6.6.12	Maintainability of Locking Mechanism	T
3.6.7.2	Small Payload Accommodation	**<TBR>**
3.6.7.3	Large Payload Accommodation	**<TBR>**
3.6.7.4	Payload Slide Mount Stiffness	**<TBR>**
3.6.7.5	Removable	**<TBR>**
3.6.7.6	Performance	**<TBR>**
3.6.7.7	Payload Slide Mount Access	**<TBR>**
3.6.7.8	Payload Slide Mount Travel Along Axis Normal to the Window	**<TBR>**
3.6.7.9	Payload Slide Mount Adjustment Time Along the Normal to the Window	**<TBR>**
3.6.7.10	Payload Slide Mount Attachment Design	**<TBR>**
3.6.7.11	Payload Slide Mount Stop	**<TBR>**
3.6.7.12	Payload Slide Mount Stop Scale	**<TBR>**
3.6.7.13	Payload Slide Mount Travel in the Axes Perpendicular to the Normal to the Window Port	**<TBR>**
3.6.7.14	Payload Slide Mount Position Lock	**<TBR>**
3.6.8.2	Prevention of Condensation	A, D
3.6.8.3	Operational Volume Limitations	I
3.6.8.4	Maintenance of Window Optical Performance	**<TBD>**
3.6.9.2	Payload Shroud Function	D
3.6.9.3	Deployment of Payload Shroud	D
3.6.9.3.1	Egress Time	D
3.6.9.4	Camera Sizes	D
3.6.9.5	Crew Usage Options for the Payload Shroud	A, T
3.6.9.6	Crewmember Use of the Window	D
3.6.9.7	Accommodation of Long Payloads	D
3.6.10.2	Crew Restraints in the Aisle	D
3.6.10.3	Crew Restraints for use Inside the WORF	D

4.4 GLARE FEATURE OPTICAL TEST

The purpose of this test is to ensure that no glare features will be visible after reflection off the window port panes in all WORF nominal operational configurations. A glare feature is defined as any reflected image that has sufficient radiance such that it is visible in photographs or to a crewmember's eye.

4.4.1 WORF CONFIGURATION FOR ALL GLARE FEATURE TESTS

4.4.1.1 CONFIGURATION SCOPE

The following configuration shall be followed for tests described in Sections 4.4.2 and 4.4.3.

4.4.1.2 WORF CONFIGURATION

The WORF shall be configured to prevent cabin lighting as it will be during nominal on-orbit operations.

4.4.1.3 CABIN LIGHTING SIMULATION

The cabin lighting environment of the Laboratory module shall be simulated in location and brightness that is greater than or equal to the maximum total cabin lighting environment such that all internal light paths that would be present on-orbit will be simulated in this test.

4.4.1.4 WINDOW MOCKUP

A mockup of a single window pane shall be installed and configured nominally at a location in the WORF as the primary pressure pane would be located on-orbit.

4.4.1.5 WINDOW MOCKUP SURFACE REFLECTANCE

The window pane mockup inboard surface shall have a surface reflectance between the wavelength range of 400-700 nm of no less than that of the flight Laboratory primary pressure pane.

4.4.1.6 PREVENTION OF TRANSMITTED LIGHT DURING TEST

The window pane mockup shall be configured such that it does not transmit light sources located on the outboard side of the window.

4.4.2 GLARE FEATURE PHOTOGRAPHIC TEST

4.4.2.1 CAMERA TYPE

A 35mm camera equipped with an f/2 or faster camera lens shall be set up within the WORF volume such that the entire window can be imaged within the field of view and such that the aisle-side cover can be closed.

4.4.2.2 CAMERA F-STOP

The camera lens aperture shall be set at f/2.

4.4.2.3 FILM TYPE

TMAX 100 film shall be loaded into the camera and used to photograph features reflected by the window pane mockup.

4.4.2.4 TEST EXPOSURE TIME

The exposure time for each photograph taken shall be 20 seconds.

4.4.2.5 CAMERA FOCUS SETTING

The camera focus setting shall be set at infinity and five feet.

4.4.2.6 TESTS WITH CABIN LIGHTING ON

One or more exposures shall be made with the cabin lighting on for each focus setting.

4.4.2.7 TESTS WITH CABIN LIGHTING OFF

One or more exposures shall be made with the cabin lighting off for each focus setting.

4.4.2.8 FILM DEVELOPMENT PROCEDURES

The film shall be developed in TMAX developer diluted 1:4 with water, developed for 7 minutes at 75°F and rinsed per manufacturer’s recommendations.

4.4.2.9 TEST CRITERION

The glare feature test shall be satisfied if there is no more than 3% density variation in any part of the image between the exposures made with the cabin lights on and those made with the cabin lights off.

4.4.3 CREWMEMBER VISUAL GLARE FEATURE TESTS

In no case shall glare features be visible by crewmembers. In order to ensure this, the following two visual tests will also be performed as specified in the following two sections.

4.4.3.1 CREWMEMBER VISUAL GLARE FEATURE TEST WITH AISLE-SIDE COVER CLOSED

4.4.3.1.1 CREWMEMBER DARK ADAPTION

A small crewmember (height less than 5’7”) shall be prepared for the test by becoming fully dark adapted.

4.4.3.1.2 TEST LOCATION OF CREWMEMBER

A crewmember shall enter the WORF and have the aisle-side cover closed while maintaining full dark adaption.

4.4.3.1.3 CREWMEMBER EVALUATION

The crewmember shall view the window pane and determine whether any glare features are visible when the cabin lights are on.

4.4.3.2 CREWMEMBER VISUAL GLARE FEATURE TEST USING THE PAYLOAD SHROUD

4.4.3.2.1 PAYLOAD SHROUD DEPLOYMENT

The WORF shall be configured such that payload shroud is deployed.

4.4.3.2.2 CREWMEMBER DARK ADAPTION FOR PAYLOAD SHROUD TEST

A small crewmember shall be prepared for the test by becoming fully dark adapted.

4.4.3.2.3 TEST LOCATION OF CREWMEMBER FOR PAYLOAD SHROUD TEST

A crewmember shall enter the WORF and close the payload shroud while maintaining full dark adaption.

4.4.3.2.4 CREWMEMBER EVALUATION WITH PAYLOAD SHROUD DEPLOYED

The crewmember shall view the window pane and determine whether any glare features are visible when the cabin lights are on.

5.0 PREPARATION FOR DELIVERY TO LAUNCH SITE

5.1 PAYLOAD CLEANING FOR PREPARATION FOR DELIVERY TO LAUNCH SITE

All WORF hardware shall be cleaned to Visibly Clean Sensitive as defined in SN-C-0005, Contamination Control Requirements for the Space Shuttle Program.

5.2 TRANSPORT PACKAGING

All WORF hardware shall be delivered in cases that are designed to protect the equipment during transport operations.

APPENDIX A

ABBREVIATIONS AND ACRONYMS

APPENDIX A - ABBREVIATIONS AND ACRONYMS

λ	lambda
˜	Angstrom
°C	degrees celsius
CCD	Charge-Coupled Device
CDR	Critical Design Review
cm	centimeter
DLT	Direct Light, Transmitted
DQA	Document Quality Assurance
EEE	Electrical, Electronic, and Electromechanical
EXPRESS	EXpedite the PRocessing of Experiments to the Space Station
°F	degrees fahrenheit
gm	gram
H/W	Hardware
Hg	Mercury
HRDL	High Rate Data Link
HSV	Huntsville
in.	inch
IR	Infrared
ISPR	International Standard Payload Rack
ISS	International Space Station
ISSP	International Space Station Program
IVA	Intravehicular Activity
IVS	Internal Video Subsystem
JSC	Johnson Space Center
kg	kilogram
Lab	Laboratory
lb.in	pound inches
lbf	pound-force
LCD	Liquid Crystal Diode
LED	Light Emitting Diode
MgF_2	Magnesium Fluoride
mm	millimeter
MPLM	Multi-Purpose Logistics Module
NASA	National Aeronautics and Space Administration
nm	nanometer(s)

ORG	Organization
ORU	Orbital Replacement Unit
PCS	Portable Computer System
PDR	Preliminary Design Review
PPC	Point-to-Point Communication
RMS	Root Mean Square
SSP	Space Station Program (for use in document numbers only)
TBD	To Be Determined
TBR	To Be Resolved
U.S.	United States
U.S. Lab	U.S. Laboratory
UF	Utilization Flight
UIP	Utility Interface Panel
urad	micro radians
USL	U.S. Laboratory (module)
UV	Ultraviolet
Vdc	Volts Direct Current
$W/cm^2/sr$	Watts/square centimeter/steradian
WORF	Window Observational Research Facility

APPENDIX B

GLOSSARY OF TERMS

APPENDIX B - GLOSSARY OF TERMS

AISLE-SIDE

Section of the WORF nearer to the U.S. Lab aisle and farther from the window.

AUTONOMOUS INSTRUMENT

Any payload that is operated by preprogrammed commands.

AUTONOMOUS OPERATION

Operation of a payload without a crewmember present full time. Intermittent crewmember monitoring or adjustment of the payload during autonomous operation may occur.

CAMERA SHIELD ZONES

Zone I of the camera shield is defined as nominally the area located within the center 35.6 cm (14-in.) diameter. Zone II of the camera shield is defined as nominally the area located within the center 45.7 cm (18-in.) diameter.

GROUND-CONTROLLED INSTRUMENT

Any payload that is operated by commands uplinked from a ground station.

HAZARD

The presence of a potential risk situation caused by an unsafe act or condition. A condition or changing set of circumstances that presents a potential for adverse or harmful consequences; or the inherent characteristics of any activity, condition or circumstance, which can produce adverse or harmful consequences.

INBOARD

Side of the WORF nearer to the U.S. Lab aisle.

LARGE CAMERA

Camera and support equipment 75 kg (165 pounds) or greater in weight and/or 53.3 cm (21-in.) wide by 50.8 cm (20-in.) deep by 76.2 cm (30-in.) long in maximum dimensions.

OUTBOARD

Side of the WORF nearer to the window.

SMALL CAMERA

Camera with a lens diameter of 7.6 cm (3-in.) or less and/or **<TBD #23>** in maximum volume.

USER-PROVIDED

Any payload or support equipment not provided by the WORF.

WINDOW-SIDE

Section of the WORF nearer to the window and farther from the U.S. Lab aisle.

APPENDIX C

OPEN WORK

APPENDIX C - OPEN WORK

Table C-1 lists the specific To Be Determined (TBD) items in the document that are not yet known. The TBD is inserted as a placeholder wherever the required data is needed and is formatted in bold type within brackets. As each TBD is solved, the updated text is inserted in each place where that TBD appears in the document and the item is removed from this table. As new TBD items are assigned or existing TBD items are completed/deleted, they will be added to this list. Original TBDs will not be renumbered.

TABLE C-1 TO BE DETERMINED ITEMS

TBD	Section	Description	Date Completed	Responsible Party
1	1.1.2.4.6	Development of operational scenario for installation of the IVA window cover	No later than 5A launch	JSC Mission Operations Directorate
2	1.1, 2.1	Development of ISS Standard for Payloads and Displays	CDR	Boeing Prime
3	2.1, 3.5.2.2.5	Development of Care and Cleaning Procedures for Optical Quality Windows	CDR	Aerospace
4	1.1.2, 2.1	Development of Window Observational Research Facility Operational Procedures	No later than UF-1	JSC Mission Ops Direct.
5	1.1, 2.1	Window Observational Research Facility Payload Development Guide	CDR	Boeing HSV/ Payloads OZ4
6	2.1, 3.1.2.1.1	Assignation of SSP for WORF Interface Control Document	PDR	Boeing Prime
13	3.6.1.6.1	Development of the translation limits of the payload slide mount	CDR	Boeing HSV
13a	3.6.1.6.1	Development of the translation limits of the payload slide mount	CDR	Boeing HSV
19	3.6.5.4.1	Determination of the amperage of the 28 Vdc power in the WORF	PDR	Boeing HSV
21	3.6.7.11	Determination of the aft limit of travel of the WORF payload slide mount	CDR	Boeing HSV
22	3.6.9.5	Determination of crew usage options for the payload shroud	PDR	Boeing HSV and JSC/CB Payloads & Habitability Branch (CA)
23	Appendix B	Determination of the volume of an example small camera	PDR	JSC Payloads (OZ4)

Table C-2 lists unresolved issues within the document. The (TBR) issue is inserted as a placeholder at the points within the document that are affected by the unresolved issue and is formatted in bold type within brackets. As each TBR is resolved, the updated text is inserted and the issue is removed from this table. As new TBR items are assigned or existing TBRs are resolved, original TBRs will not be renumbered.

TABLE C-2 TO BE RESOLVED ISSUES

TBR	Section	Description	Date Completed	Responsible Party
1	3.2.4.5.1, Table 4.3-1	Determination of a minimum air volume moved through the WORF that will achieve the CO_2 level proscribed in Section 3.2.4.5.1	CDR	Wright/Boeing Prime
3	3.6.7	ISSP buy-in to development of the payload slide mount	CDR	Suffredini/OZ
4	3.6.6.4	Determination of the number of Small Camera Mounts to be supplied.	CDR	Suffredini/OZ
5	3.6.1.4	ISSP direction and resources required to proceed with meeting requirement	3/99	Suffredini/OZ
6	3.6.6.6	ISSP direction and resources required to proceed with meeting requirement	3/99	Suffredini/OZ