Cargo Systems Manual (CSM): IMAX Cargo Bay Camera 3D (ICBC 3D)

STS-125

Mission Operations Directorate

Basic
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Lyndon B. Johnson Space Center
Houston, Texas

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Basic

Cargo Systems Manual (CSM):
IMAX Cargo Bay Camera 3D (ICBC 3D)

Space Program Operations Contract
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ICD-A-21417, June 5, 2000

Phase II/III Safety Data Package, November 28, 2007

Customer Drawings, September 21, 1999

LIST OF EFFECTIVE PAGES

The current status of all pages in this document is as shown below:

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PREFACE

The Cargo Systems Manual (CSM): IMAX Cargo Bay Camera 3D (ICBC 3D), was prepared by the United Space Alliance (USA), under contract to Cargo Integration and Operations Branch (CIOB), Operations Division, Mission Operations Directorate (MOD), NASA, Lyndon B. Johnson Space Center, Houston, Texas, with editorial support from Integrated Document Services, Bastion Technologies, Inc., and technical support from the Space Shuttle Program.

Comments concerning the general contents of this manual should be directed to DO52/Jeremy Owen, 281-244-7455.

PURPOSE

The purpose of the Cargo Systems Manual (CSM) is to provide a payload reference document for payload and shuttle flight operations personnel during shuttle mission planning, training, and flight operations. The CSM will include orbiter-to-payload interface information and payload system information (including operationally pertinent payload safety data) that is directly applicable to the MOD role in the payload mission. The CSM is an accurate source of this information for use by flight operations personnel.

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1.0 INTRODUCTION

1.1 BACKGROUND

The IMAX Cargo Bay Camera 3D (ICBC 3D) is a 70mm three-dimensional (3D) motion picture camera system designed for use in the orbiter payload bay. It is used to produce high resolution, large format, color motion pictures of orbiter flight operations suitable for viewing in IMAX® and OMNIMAX® equipped theaters promoting the educational program goals of the National Aeronautics and Space Administration (NASA).

The 2D ICBC has previously flown on eight shuttle flights; STS-61B, -31, -46, and -51 as the Remote IMAX Camera System (RICS) and on STS-61, -63, -74, and -88 as ICBC. ICBC 3D has flown on STS-92/3A, STS-97/4A, STS-100/6A, and STS-104/7A. ICBC 3D is scheduled to fly on the STS-125 Hubble Space Telescope (HST) Servicing Mission 4 (SM4).

1.2 PAYLOAD OVERVIEW

The ICBC 3D consists of an IMAX 70mm three-dimensional motion picture camera and a film magazine. The camera and film magazine are placed inside two specially designed containers, the camera container and the magazine container, that allow camera operation in the vacuum environment of the orbiter cargo bay. Running at a nominal frame rate of 24 frame pairs (right eye and left eye) per second (fps), the ICBC 3D camera will simultaneously expose two film frames on a single strip of film stock to provide the 3D effect. The film magazine contains approximately 5400 ft of film to provide 8 minutes of filming.

Figure 1-1 shows a view of the ICBC 3D camera mounted to the Orbital Replacement Unit Carrier (ORUC) on the port side of the payload bay.

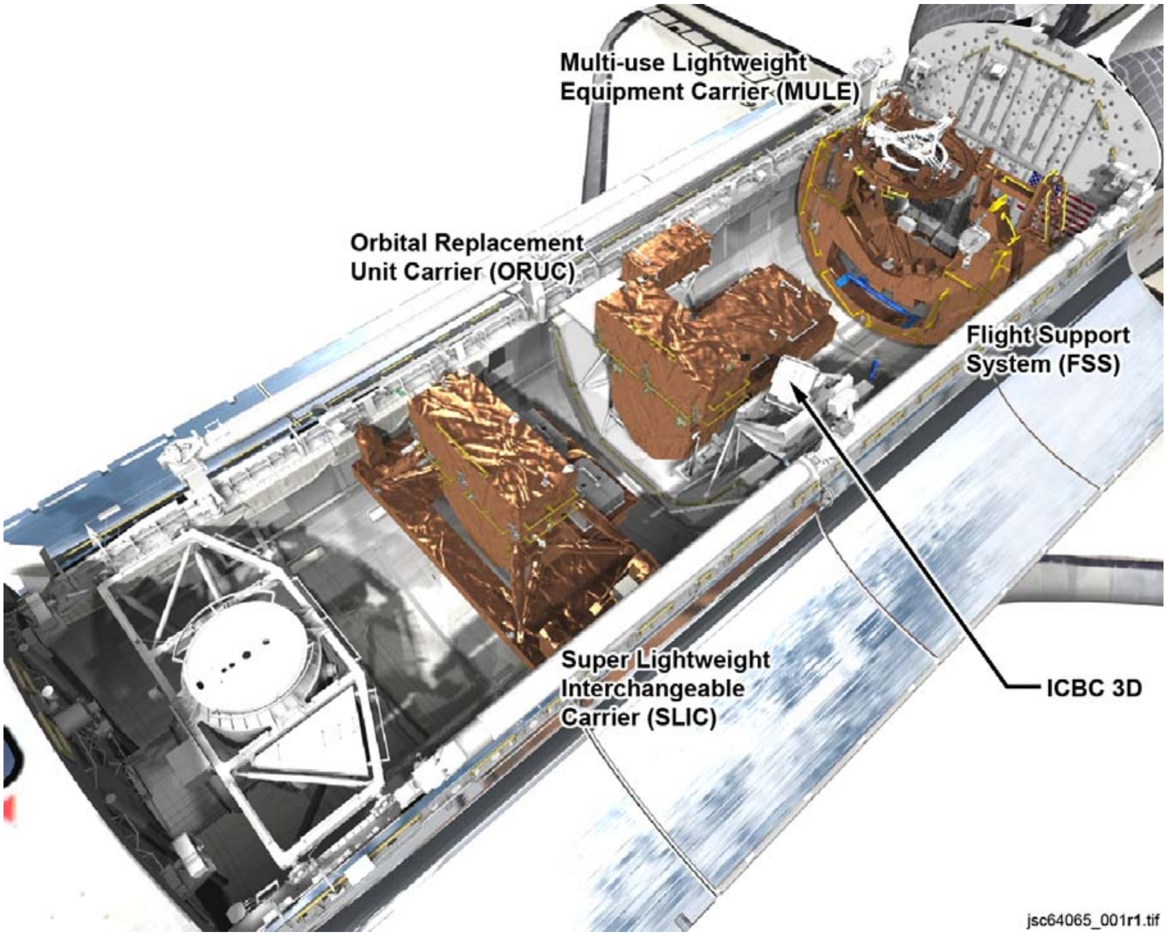

Figure 1-1. ICBC 3D camera system

The ICBC 3D camera uses various lens assemblies. Each lens assembly consists of two identical lenses that act as the camera's right and left eyes and simultaneously exposes two adjacent film frames. Three lens assemblies are selected prior to the flight from a group of 30mm, 40mm, 60mm, and 100mm lens assemblies. These are mounted on the camera turret. Depending on the scene, one of the three lens pairs can be selected by rotating the turret to provide an optimum focal length. The 30mm lenses are "fisheye" type lenses that are typically used for wide-angle or close-range scenes. The other lenses are applicable for longer-range scenes. For STS-125, the camera turret will be outfitted with the 30mm, 40mm, and 60mm lens assemblies. The respective field of view of each lens pair is shown in Figure 1-2 and Figure 1-3.

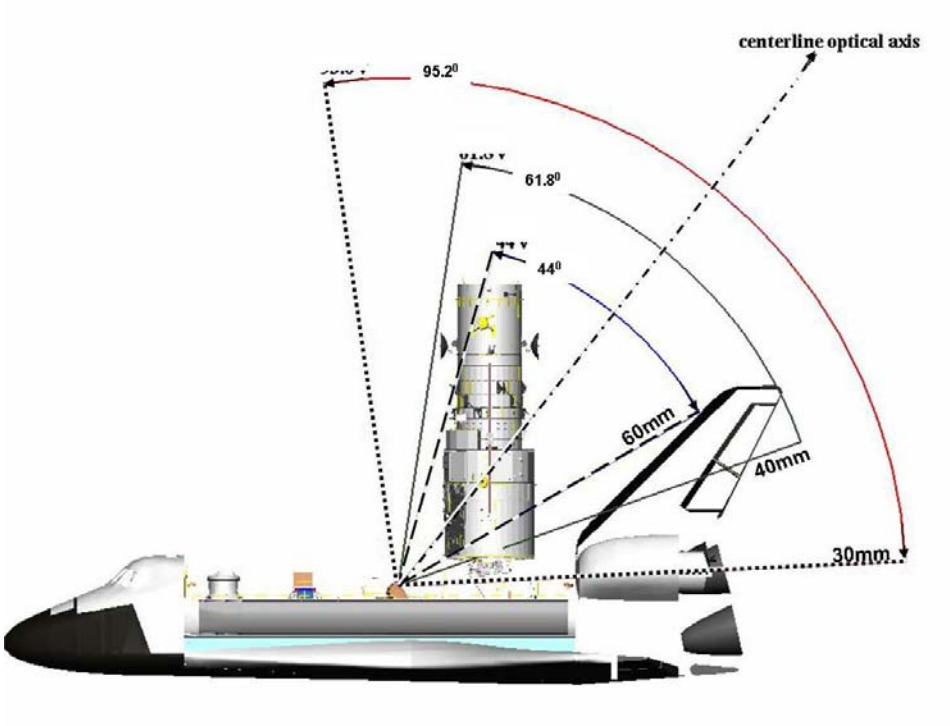

Figure 1-2. ICBC 3D lens pair field of view (-Y view)

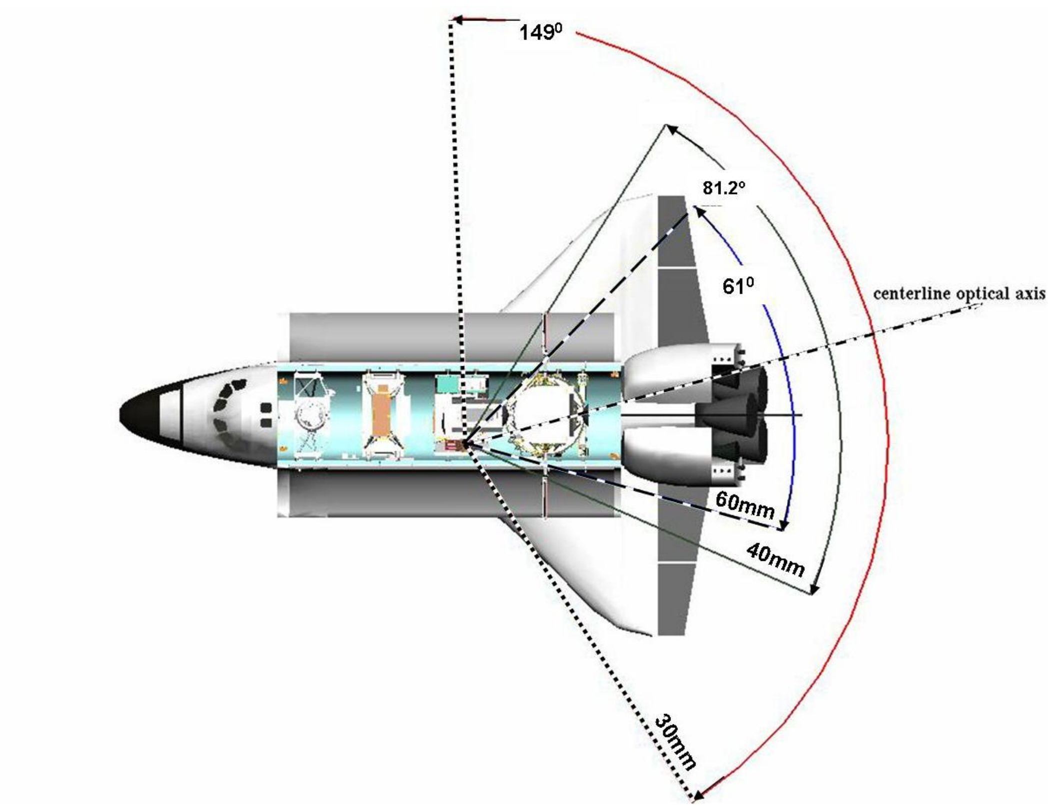

Figure 1-3. ICBC 3D lens pair field of view (-Z view)

The camera will be controlled from the Aft Flight Deck (AFD) using a Payload General Support Computer (PGSC). A glass window on the camera container will provide visibility for the camera. A power door will protect the window and provide thermal isolation when the camera is not in use. A digital audio recorder is used in the crew compartment to record crew comments and ambient on-orbit sounds. When not in use, the recorder, compact flash cards, microphones, PGSC and associated cables, spare batteries, and a spotmeter are stowed in the crew compartment.

1.3 MISSION OVERVIEW

The ICBC 3D will be used to film the repair of the HST. Within 7 hours of payload bay door opening, the ICBC 3D system will be powered on using the ICBC 3D power switch on Standard Switch Panel 2 (SSP2). This will supply power to the camera container and to heaters that are required to maintain the camera and associated elements at proper operating temperatures. Nominally, the system will remain powered until shortly before deorbit prep activities.

The crew will conduct filming operations using a scene list and controlling the camera via a PGSC. The PGSC software interface is discussed in Section 6.0. On the PGSC display, the crew selects various parameters such as lens choice, f-stop, frame rate, and focus, as shown in the scene list. The crew commands the window door to open in preparation for filming. The crew is able to use the PGSC to see what the camera is viewing through the glass window. When the camera is viewing the correct scene, the crew will command the camera to run using the PGSC. Once the scene is shot, the crew will command the camera to stop and command the window door closed. The crew will leave the PGSC powered on to support other shots, or turn it off if it is not needed at that time. At 24 fps, there are 8 minutes of film in the camera.

2.0 STRUCTURES AND MECHANISMS

The structural and mechanical systems of ICBC 3D consist of several components. Except for the PGSC and audio recorder related equipment and supplies, most of ICBC 3D is located in the payload bay. Details of the structures and mechanisms are discussed as follows.

2.1 MOUNTING CONFIGURATION

The camera and its container are installed on the top side of an interface plate, and the film magazine and its container are installed on the bottom side of the plate, as shown in Figure 2-1. The Pickup Plate (7075 Al) is connected to the side of the magazine carrier by 14 bolts. Two thermal isolators, fiberglass G10, are placed between them. The Mounting Plate Assembly (MPA, 7075 Al) is connected to the other side of the pickup plate using 16 bolts.

On all previous flights, the entire assembly was mounted to a Get-Away-Special (GAS) beam. However, for STS-125, it is mounted directly to the ORUC, which is designed to emulate the mounting of a GAS beam, at the MPA using 16 lock-wired bolts. Four fiberglass G10 thermal isolators are placed between the ORUC beam and MPA.

The ORUC is flown in bays 6-8 of the payload bay, while the ICBC 3D assembly is mounted on the port side of the ORUC (Figure 2-2). The MPA, the pickup plate, and the interface plate are used to define the camera pitch, yaw, and roll positions. This adjustment is made preflight and cannot be changed once on orbit.

The interface plate has the following provisions:

a. Two attach points for hermetically sealed feed through connectors for power.

b. Three attach points for hermetically sealed feed through connectors for control signals.

c. Three holes to maintain the pressure equilibrium between the camera and the magazine containers. An additional hole, which allows passage of the film between the magazine and the camera, also helps in maintaining pressure equilibrium.

d. Ground Handling Equipment (GHE) connections for lifting and installation during ground operations.

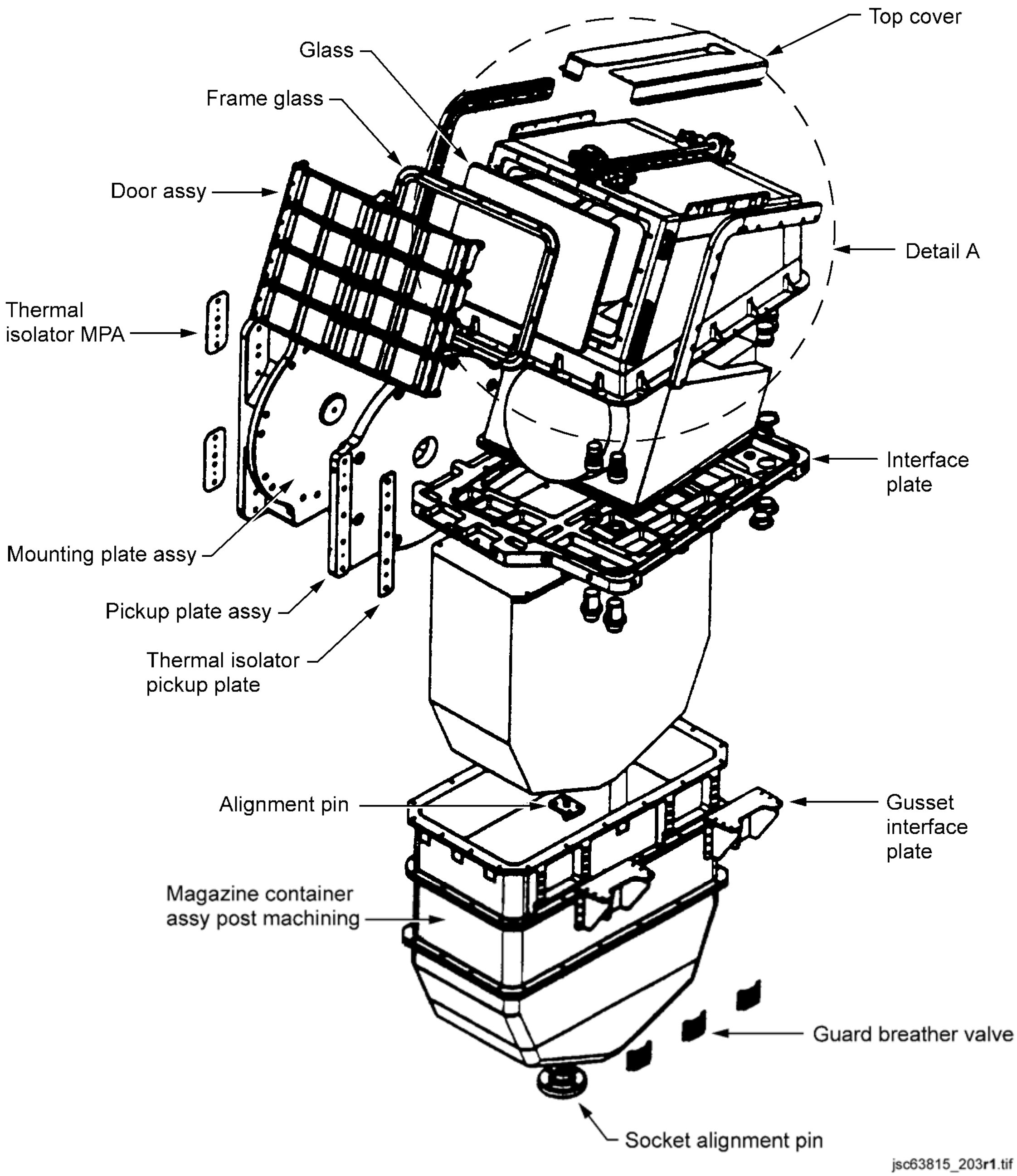

Figure 2-1. ICBC 3D assembly

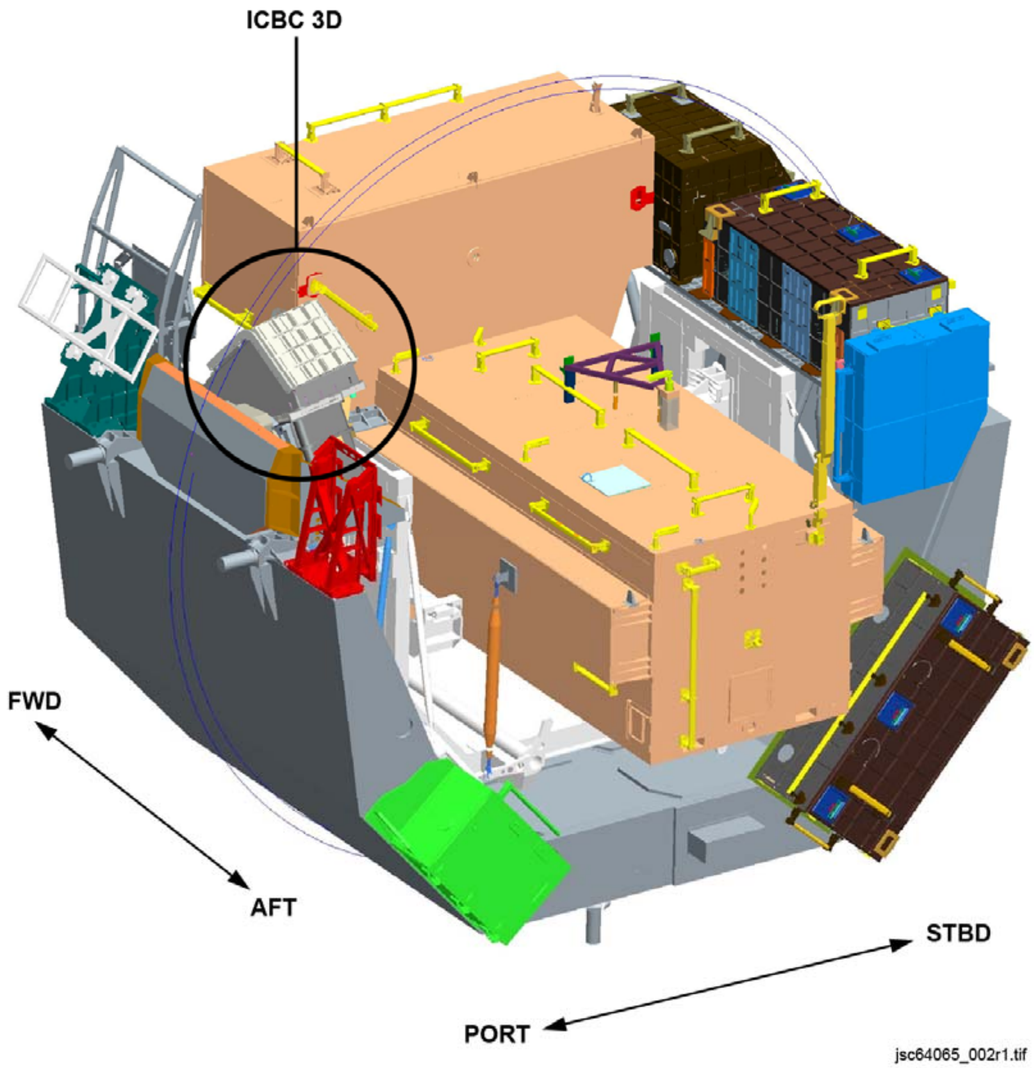

Figure 2-2. ICBC 3D mounting location on ORUC

2.2 MAGAZINE CONTAINER

The magazine container accommodates the film magazine and maintains the necessary thermal and pressure environment for the operation of the camera system. The container is made of four different sections. The upper two sections are machined from 7050 Al and have flanges that are bolted together. The third and fourth sections are machined from 6061 Al and are welded together. The second and the third sections are also flange connected. A silicone O-ring is placed between every flange connection.

To maintain the necessary pressure inside the containers for ICBC 3D operation (the film requires positive pressure to remain flat during exposure), four two-way breather valves are mounted on the third section of the magazine container. The container is pressurized before launch, and the breather valves release the N_2 gas during ascent. Once on orbit, the valves maintain an internal pressure of 5 psid. Failure of a valve to close prevents camera operation but does not endanger structural integrity. However, failure of all four valves to open would exceed the 8 psid maximum pressure for the container. For STS-125, the four existing breather valves were replaced with units identical to the previous flights. Four guards are installed in front of these valves to prevent them from any accidental damage. These valves are set such that the pressure is maintained at 5 psid during the flight and within 1 psi of ambient pressure during reentry. This pressure profile is shown in Figure 2-3.

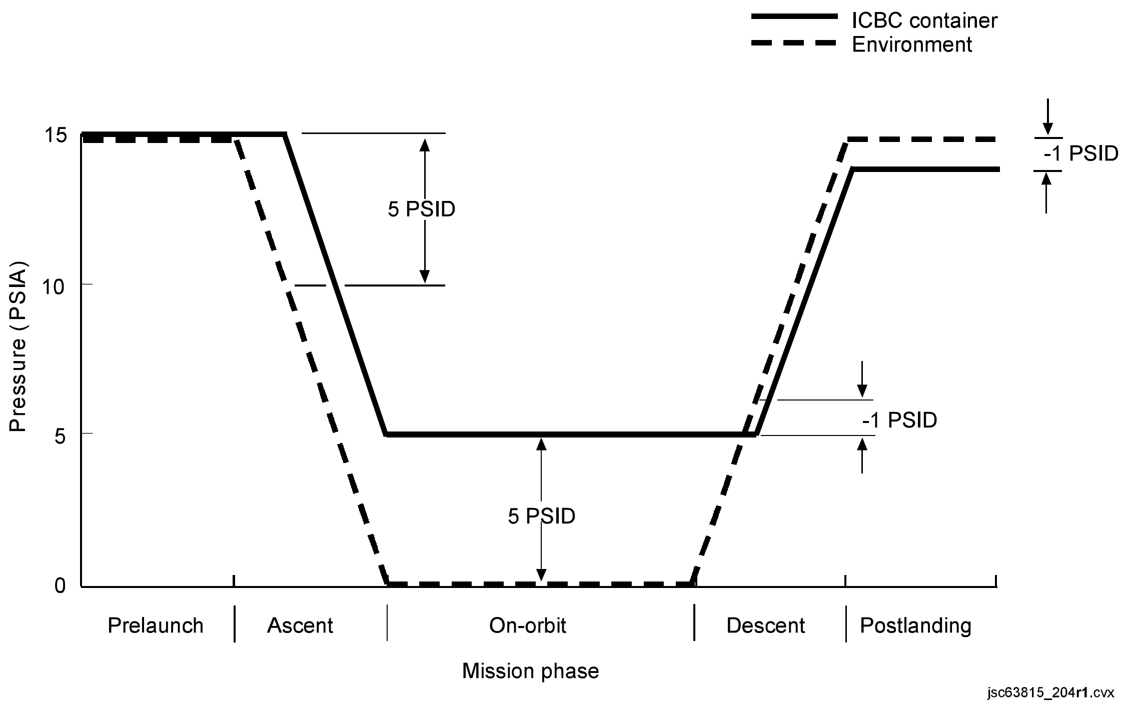

Figure 2-3. ICBC 3D container pressure profile

An alignment socket is provided at the bottom of the magazine container to retain an alignment pin located at the bottom of the film magazine. This design not only facilitates installation of the film magazine into the container, but it also provides support by restricting its movement inside the container.

Two additional fixed lifting attach points, provided at the bottom of the magazine container, can be used during lifting and installation of the assembly in the cargo bay when the orbiter is in the vertical position.

2.3 CAMERA CONTAINER

The camera container (6061 Al) houses the 3D camera and is used to maintain thermal and pressure conditions necessary for camera operation. It is a six-piece weld assembly consisting of a base, front, top, rear, and two side plates. The full assembly is shown in Figure 2-4.

A fused silica glass window is mounted on the front face of the camera container. It consists of 0.665-in-thick optical quality fused silica with an aluminum fluoride or magnesium fluoride anti-reflective coating. The window shape is rectangular (17.2 in x 12.8 in x 0.63 in) and is recessed. The glass is held in place using a window frame attached to the front of the container by 18 bolts. A silicone O-ring is placed between the glass and the container, and a silicone gasket is placed between the glass and the window frame.

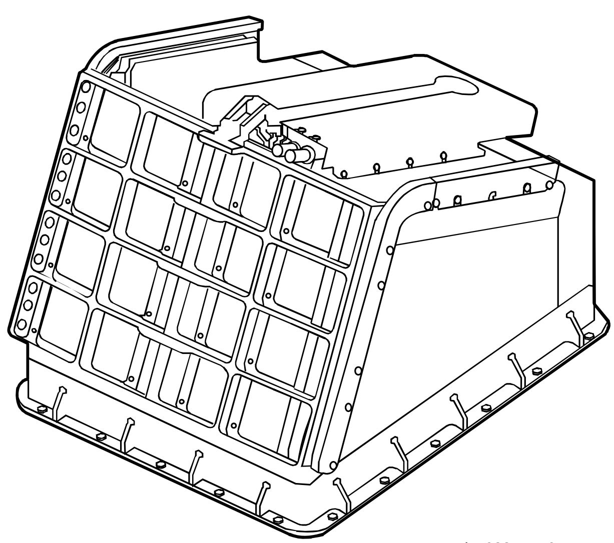

Figure 2-4. Camera container

2.4 WINDOW DOOR ASSEMBLY

A door assembly in front of the camera protects the glass window from accidental damage and provides thermal isolation when the camera is not being operated. It is a four-panel door (7075 Al) with three hinged connections. The rollers mounted on both sides of each panel traverse within the guide rails mounted on both sides of the container.

The door assembly consists mainly of a lead screw drive system on top of the container, a drive motor at the back of the container, and a set of bevel gears to transfer the torque motion from the motor to the screw. The lead screw drive system drives the door assembly. The drive screw has 3/8 in quad-lead stub Acme thread with 0.5 in lead. A linear rail bearing block assembly converts the rotational motion of the lead screw into the linear motion necessary to open and close the door. The linear rail bearing block assembly moves within its linear rail guide mounted beneath the lead screw. A clevis mounted on the top door panel connects to an Acme drive nut on the block assembly via two links. The drive motor is geared at a 27:1 ratio. It takes approximately 6 to 8 seconds to open or close the door. Two pairs of hermetically sealed limit switches, a pair at the front and a pair at the back, terminate power to the motor when the door is fully closed and open, respectively. Both ends of the linear rail guide provide hard mechanical stops should the door over-travel.

A 7/16 in socket interface is provided at the back of the container to manually operate the door by an Extravehicular Activity (EVA) crewmember, if needed. An additional cover (5052 Al) is placed on top of the container to protect the drive mechanism, as shown in Figure 2-5.

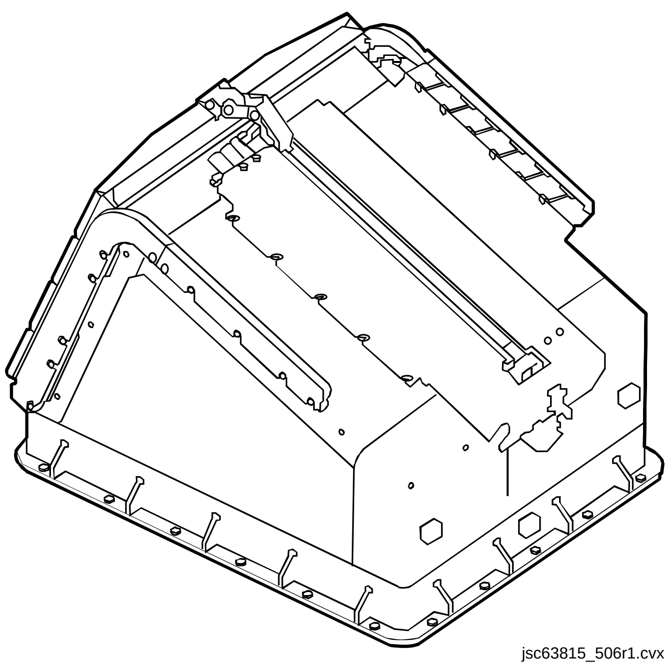

Figure 2-5. Camera container with drive protective cover

3.0 ELECTRICAL POWER DISTRIBUTION

The camera will be powered from orbiter-provided 28 VDC via the Aft Payload B bus routed through the Payload Accommodation Terminal (PAT) Box 1. Four harnesses running from a dedicated ICBC3D Standard Interface Panel (SIP) will supply power, control, and data interfaces to the camera and film magazine components through connectors J101 through J104 (a fifth connector provides power and control from the Top Lid Assembly to other camera components). These connectors are detailed as follows:

a. J101 – Provides switched camera power

b. J102 – Provides switched power to heaters on the camera and magazine

c. J103 – Accepts commands and status signals from camera components and routes them to the orbiter SSP interface connector on the Interface Plate

d. J104 – Provides an RS-422 and video interface between the PGSC in the orbiter middeck and a video camera located inside the ICBC 3D camera assembly

e. J105 – Provides power and control from the Top Lid Assembly to the heater components on the window, as well as to the door motor and limit switches

The ICBC 3D electrical block diagram is shown in Figure 3-1. The power is supplied by orbiter payload primary through two 8-gauge wires fused at 25 amps each. This power is activated via a switch on SSP2. The power is then routed through a power control switching circuit, which supplies power to the camera electronics, the camera door motor, and various heater and control lines. The primary purpose of the switching circuit is to supply power to the heaters when the camera is not in use and to cut power to the heaters while the camera is in use. A secondary use of the switching circuit is to switch power routed to the door motor to the open-door circuit when the closed-door limit switch is engaged and to the closed-door circuit when the open-door limit switch is engaged.

The door motor and the camera control lines are fused to 5 amps, and the heaters are fused to 8 amps. Power to the remaining camera electronics is supplied through two 20-amp fuses. Before the 20-amp fusing, the camera power is filtered to eliminate Radio Frequency (RF) noise and low frequency spikes both into the camera and the orbiter electrical system. After 5-amp fusing, 22-gauge wire is used and 12-gauge wire is used after the 20-amp fusing.

The PGSC receives 28 VDC power from the Payload Data Interface Panel (PDIP) through a standard PGSC power cable. Power conditioning for the PGSC is accomplished within the PGSC unit.

In case of any failure that would preclude the use of PGSC control, the ICBC 3D can be operated from an additional switch provided on SSP2. Using this switch, the operator can open the ICBC 3D door and run the camera for a set period of 30 seconds. The SSP interface is discussed in more detail in Section 5.0.

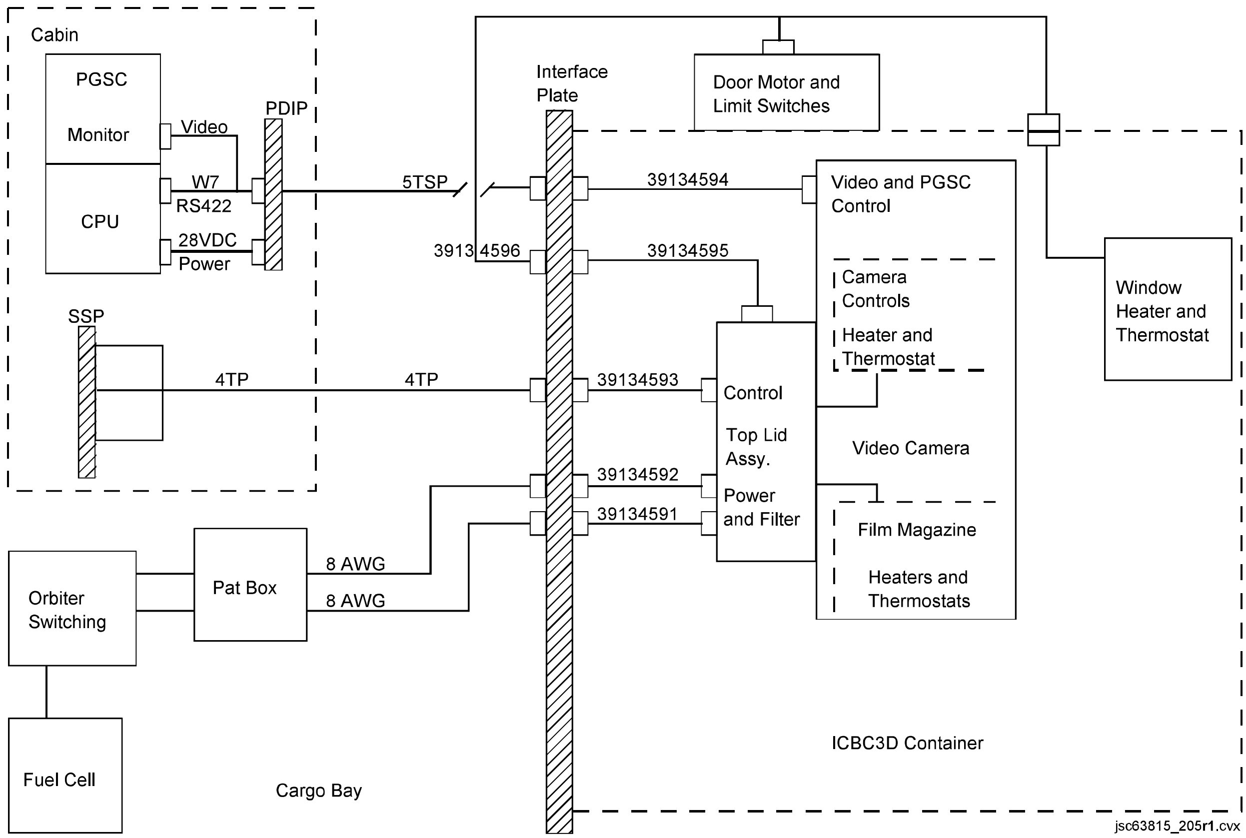

Figure 3-1. ICBC 3D electrical block diagram

4.0 THERMAL CONTROL

The ICBC 3D camera system uses both active and passive thermal control systems to maintain the necessary thermal environment inside the containers during and before camera operation. These systems are described as follows.

4.1 ACTIVE THERMAL CONTROL

Various heaters are used for the ICBC 3D active thermal control system. Eight Kapton insulated heaters (188 watts total) are placed on the film magazine. Four similar heaters, 14 watts each (56 watts total), are placed on the camera. Twelve Kapton insulated strip heaters (246 watts total) are placed on the window frame to prevent fogging.

These heaters are grouped, depending upon their placement to form different temperature controlling zones and also to limit electrical load to 112 watts on the power cables. There are seven heater groups: three on the magazines, three on the window, and one on the camera. Each heater group is controlled by two thermostats placed in series (for a total of 14 thermostats). The thermostats are set such that the temperature of the window is maintained above 45° F, and the temperature inside the containers above 50° F.

4.2 PASSIVE THERMAL CONTROL

The window door and the top surface of the camera container are covered by Kapton VDA tape. Multilayer Insulation (MLI) blankets cover the rest of the ICBC 3D. The MLI blanket is made of seven layers of reinforced aluminized Mylar sandwiched between layers of beta cloth. A layer of silver Teflon is sewn onto the outside surface of the beta cloth. In addition, the blanket is grounded and has vent holes.

4.3 THERMAL OPERATIONS

The ICBC 3D system should be powered up as soon as possible after reaching orbit. This could be within 30 minutes of the first filming opportunity or a maximum of 7 hours after the payload bay doors are opened. Activating main power via SSP2 provides power to the heaters, which, in turn, maintain the appropriate thermal environment for the camera and film.

If power to the ICBC 3D is lost, it should be restored as soon as possible. For every 6 hours it is without main power, 1 hour with power (up to a maximum of 4 hours) is required before shooting film. Even if power is lost for several days, 4 hours is sufficient to restore operating temperatures. Nominal operating temperature is between 50° and 80° F and can be seen on the Current Camera Status display on the ICBC 3D PGSC.

In the event heater power cannot be restored, analysis has concluded that ICBC 3D will be structurally stable for landing; however, heaters are required for filming operations to continue.

5.0 DISPLAYS, CONTROLS, AND VISUALS

Crew interface to the ICBC 3D is via SSP2 and the ICBC 3D software on a PGSC. These interfaces provide nominal crew commanding and operation as well as off-nominal operation. It should be noted that no ICBC 3D-specific telemetry is downlinked; however, Shot and Event logs are downlinked via OCA each day of filming operations. Primary insight to the system is available only to the crew by way of the SSP and PGSC. The interfaces are described as follows.

5.1 STANDARD SWITCH PANEL

The SSP is used to provide main power to the ICBC 3D camera and allow for emergency operation if connection to the PGSC is lost (Figure 5-1). Main power is applied by taking the ICBC3D PWR switch to ON (up position). The accompanying talkback (tb) will show gray (gr) when the power is on. Barberpole (bp) indicates the power is off. Emergency operation of the camera is accomplished by taking ICBC3D EMER RUN switch to ON (up position). The accompanying tb will show gray. Taking this switch to ON will open the door and begin filming. The lens setup will default to the settings contained in the camera firmware. These settings are the 30mm lens pair, f/stop of 8.5, and a focus distance of 25 ft. Taking the switch to OFF will stop filming and close the door.

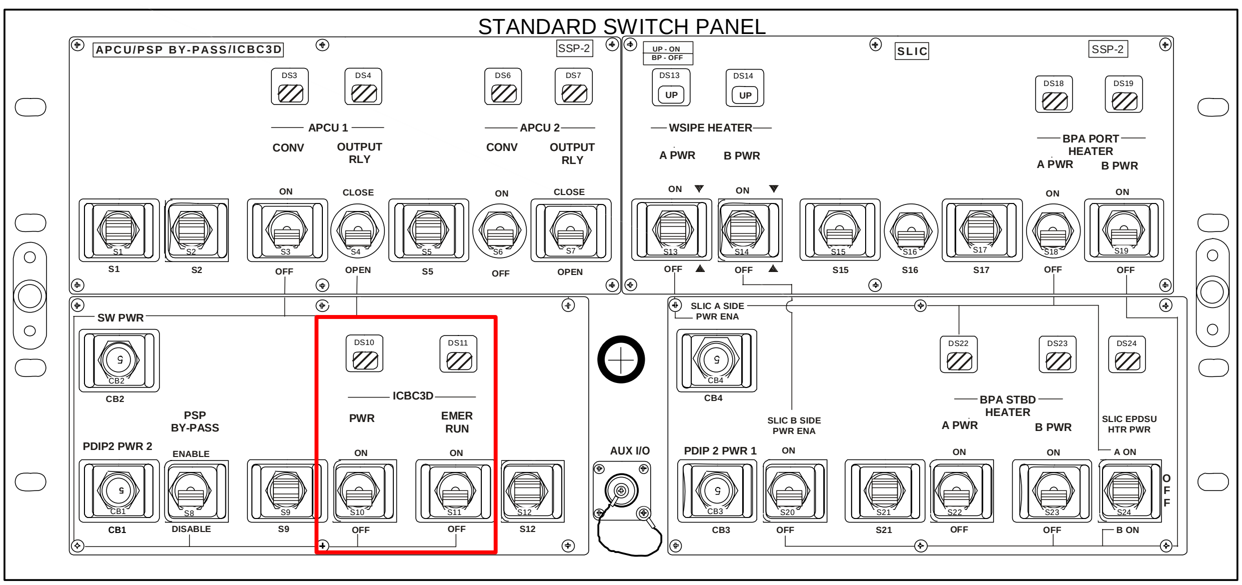

Figure 5-1. ICBC 3D controls on Standard Switch Panel 2

5.2 PGSC

The PGSC is the primary crew interface to ICBC 3D. The ICBC 3D software will be loaded on all PGSCs, since there will not be a dedicated machine manifested for IMAX operations. The PGSC allows the crew to control the various lens settings and film scenes. It also provides the crew with the status of the ICBC 3D system. The commands and controls are described as follows.

5.2.1 PGSC Connection

When the PGSC is powered on and connected to the PDIP (Figure 5-2), it establishes an RS422 link between the PGSC and the ICBC 3D. When the connection is made, the ICBC 3D Mission Elapsed Time (MET) is displayed (Figure 5-3). The MET is used as the reference base for the data stored in the log. For accurate reference data, the MET must be correctly set. Thus, the MET may have to be reset several times during the mission to achieve synchronization between the PGSC and the actual MET. Furthermore, if more than one PGSC is used during the flight, the MET must be edited for each PGSC.

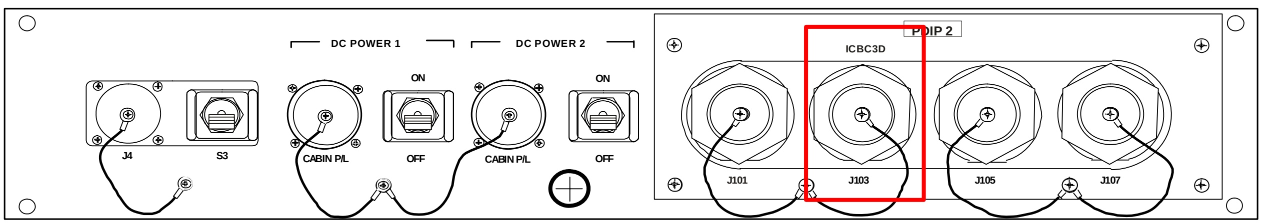

Figure 5-2. ICBC 3D RS-422 connection on PDIP 2

After 25 seconds, if no action has been taken, the Control Interface screen replaces the MET screen. The MET screen can be recovered by selecting "MET" in the ICBC 3D Control Interface function line.

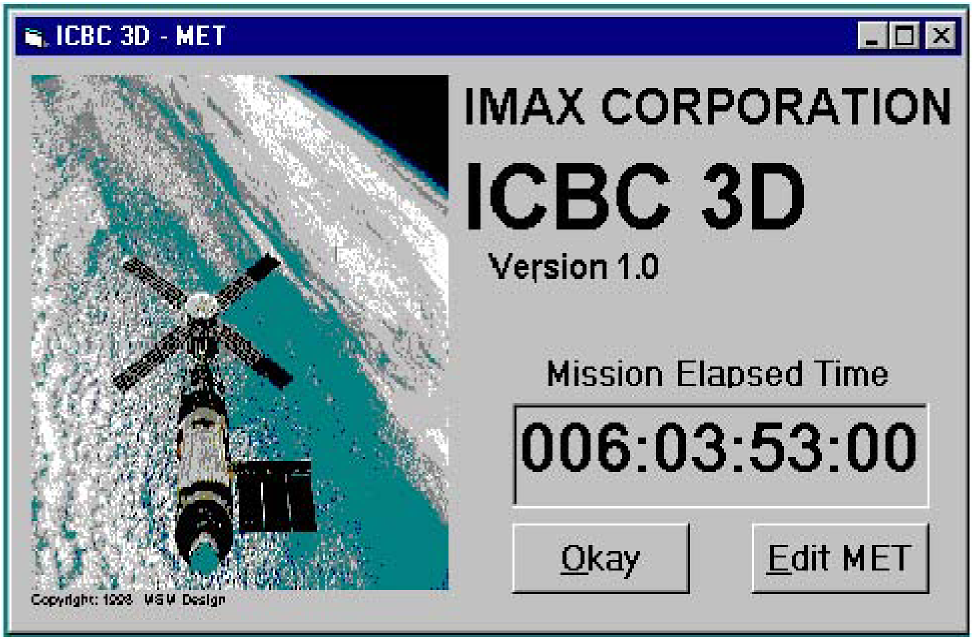

Figure 5-3. ICBC 3D MET screen

5.2.2 Control Interface

The ICBC 3D Control Interface screen serves as the main user interface between the crew and ICBC 3D. The screen has a function bar, five commandable sections, and a video display, as shown in Figure 5-4. The five commandable sections are: Current Camera Status, Systems Control, Frame Rate Setup, Lens Setup, and Camera Command. Each is discussed as follows.

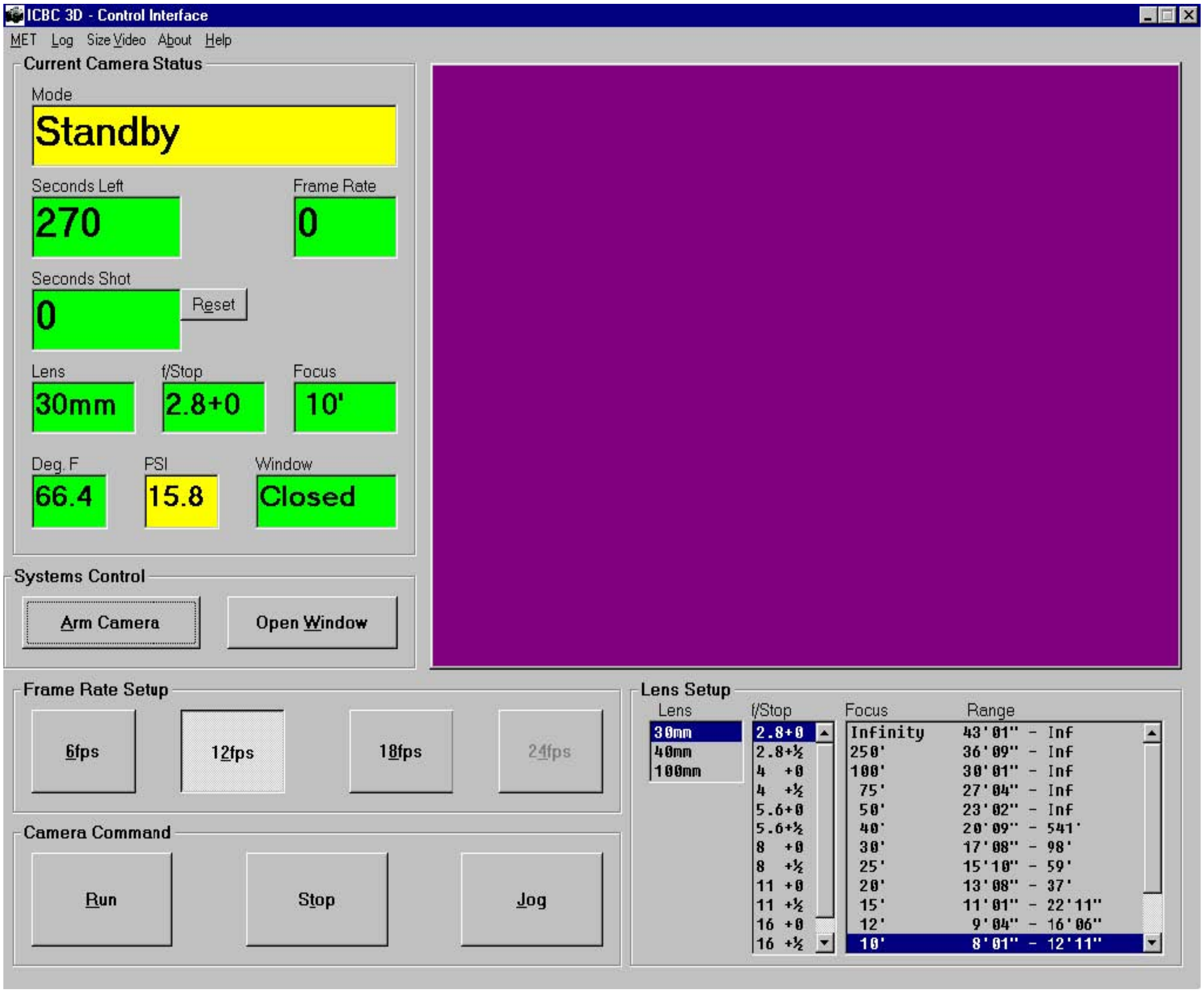

Figure 5-4. Control Interface screen

5.2.2.1 Function Bar

The Function Bar (Figure 5-5) gives access to the MET screen and the Log.

Figure 5-5. Function bar

5.2.2.2 Current Camera Status

The Current Camera Status display gives the crew insight into the current health and status of the ICBC 3D camera, as shown in Figure 5-6. It shows the status and settings of the camera with backgrounds color-coded based upon the current readings.
The information shown is as follows:

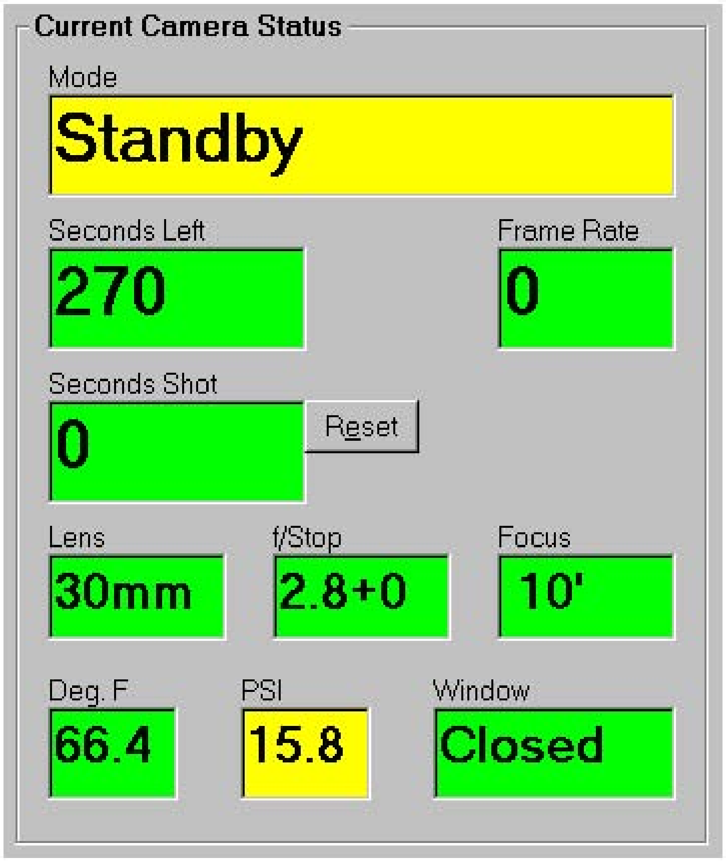

Figure 5-6. Current Camera Status screen

a. **Mode**

Indicates the current mode of the camera. The different modes and background colors are shown in Table 5-1.

Table 5-1. Camera modes and colors

Mode	Background Color
Ready	Green
Running	Green
Jogging	Green
Standby	Yellow
Arming	Yellow
Window Closing	Yellow
Window Opening	Yellow
Turret Moving	Yellow
Homing Turret	Yellow
Homing Lens	Yellow
Moving Lens	Yellow
Homing Iris	Yellow
Moving Iris	Yellow
No Connect	Red
Out Of Film	Red
Error/00	Red
Turret Error	Red
Lens Error	Red
Iris Error	Red
Program Shutdown	Red

b. **Seconds Left**

Indicates the number of seconds of film remaining in the feed magazine at the specified Frame Rate. To determine the amount of film available for operation at 24 fps, select the 24 fps button. The background goes to yellow when this number reduces to 59 seconds and to red when it is 30 seconds or less.

c. **Seconds Shot**

Indicates the number of seconds the camera has run since the Reset button was last pressed. Typically, this is reset to zero before beginning a shot.

d. **Frame Rate**

Indicates the current running speed of the camera.

e. **Reset**

Resets the Seconds Shot indicator to zero.

f. **Lens**

Indicates the focal length of the current lens pair selection.

g. **f-stop**

Indicates the aperture setting of the selected lens pair.

h. **Focus**

Indicates the nominal focus distance (in feet) of the selected lens pair.

i. **Deg F**

Indicates the internal temperature of the camera. The background is green for temperatures from 50° to 80° F. The background is yellow for temperatures from 40° to 49° F and 81° to 90° F. The background is red for temperatures below 40° F and above 90° F.

j. **PSI**

Indicates the internal pressure of the camera in pounds per square inch (psi). The background is green for pressures from 3.0 to 5.0 psi. The background is yellow for pressures from 1.0 to 2.9 psi and above 5.0 psi. The background is red for pressures below 1.0 psi.

k. **Window**

Indicates whether the window is open, closed, or transitioning. The window is part of the thermal stabilizing camera cover. Thus, if the window remains open for an extended period, the camera temperature could exceed acceptable limits. When the window is open, the background is yellow to indicate that the camera does not have thermal integrity.

5.2.2.3 Systems Control

The Systems Control display (Figure 5-7) allows the crew to Arm/Disarm the camera and Open/Close the window. Arming the camera brings the film tension in the magazines to a “Ready” mode.

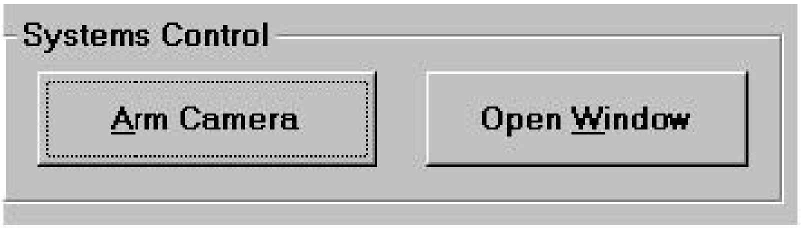

Figure 5-7. Systems Control screen

5.2.2.4 Frame Rate Setup

With this display, the crew can select the camera speed, as seen in Figure 5-8. Nominally, 24 fps is used.

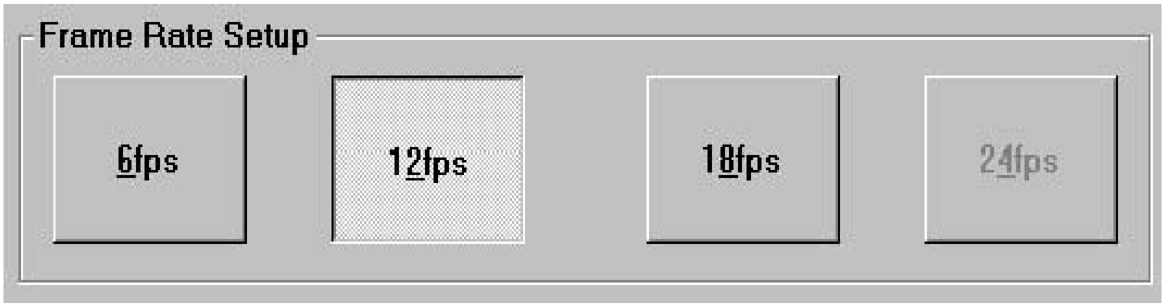

Figure 5-8. Frame Rate Setup screen

5.2.2.5 Lens Setup

Using this display, the crew can set the lens parameters for each shot. The display is shown in Figure 5-9. The fields include the following:

a. **Lens**

Selecting a lens causes the turret to rotate the selected lens pair into position in front of the camera.

b. **f-stop**

Selecting an f-stop setting causes the irises of the selected lens pair to either stop down or open up to that setting. The f-stop setting should be adjusted by incrementing one setting at a time.

c. **Focus and Range**

Selecting a focus distance causes the lens pair to focus at this nominal distance. Corresponding to each Focus setting is a Range, which indicates the depth of field for that Focus setting. Focus and Range cannot be set separately.

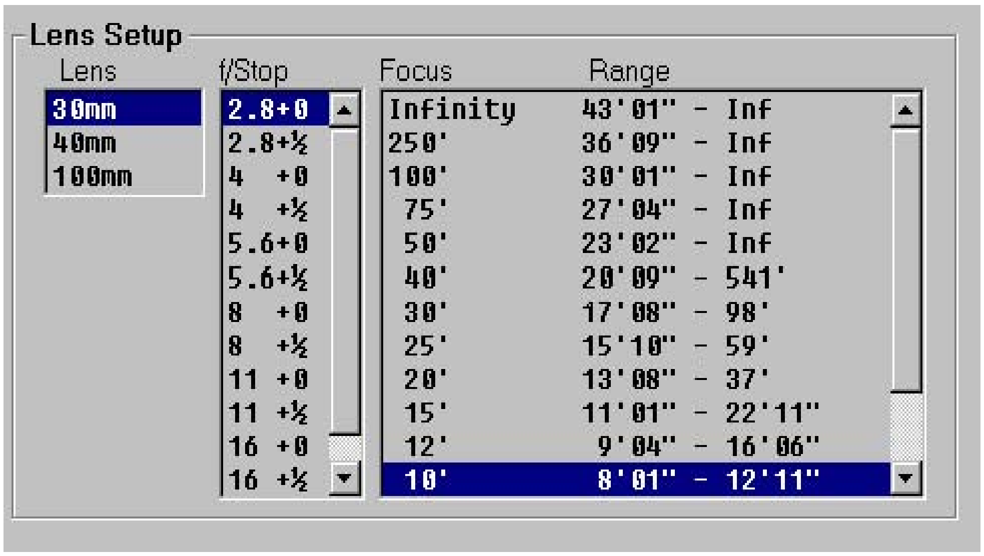

Figure 5-9. Lens Setup screen

5.2.2.6 Camera Command

This display (Figure 5-10) allows the crew to actually film a scene. The available options are Run, Stop, and Jog.

a. **Run**

This causes the camera to run and actually film a scene. The camera can be started in various states; however, if the camera is disarmed and the window is closed, the camera must achieve an armed and open window state before it will run. If the camera is armed, in Ready mode, and the window is open, the camera will start immediately when **Run** is selected. At approximately 25 seconds run time, a warning box pops up indicating that 30 seconds run time is about to expire. This feature was added to inhibit running the film out to completion. The user is given the choice to continue for another 30 seconds of filming. The software will continue to annunciate this warning every 30 seconds.

b. **Stop**

When selected, the camera stops immediately.

c. **Jog**

Causes the camera to run at 1 fps and may be used for troubleshooting.

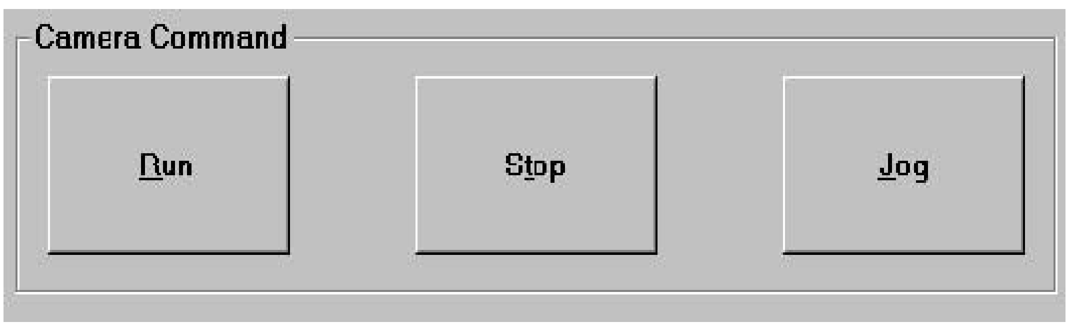

Figure 5-10. Camera Command screen

5.2.2.7 Video Display

The Video Display shows the field of view as seen through the left lens when the window is open. The intensity of the video image has been roughly calibrated to show the brightness of the image as it would appear on the film. If the image on the PGSC appears too dark or washed out, it is likely that the f-stop has been incorrectly selected. However, the brightness of this video display should not be used for selecting the f-stop setting.

6.0 CABIN EQUIPMENT

ICBC 3D cabin equipment includes a digital audio recorder system, used to record ambient cabin sounds and crew comments during filming; any PGSC, used as the command and control interface to the ICBC 3D camera system; a spotmeter to aid in film exposure readings for each shot, and Canon® XH-G1 hi-definition camcorder. Each is described as follows.

6.1 ICBC 3D DIGITAL AUDIO RECORDER

The digital audio recorder system consists of 1 compact flash-based recorder, 4 AA batteries (80 batteries total manifested), 20 4GB compact flash (CF) cards, and 2 microphone assemblies (2 spare microphone assemblies manifested as well). All pieces are Commercial Off-the-Shelf (COTS) products modified for flight. The audio recording system will be used during operation of the ICBC 3D to record crew comments and ambient on-orbit sounds. This hardware will be stowed in a middeck locker for launch and landing.

6.1.1 Digital Audio Recorder

The audio recorder is a Fostex model FR-2LE CF card-based professional audio recorder (Figure 6-1 and Figure 6-2). The recorder is a COTS model that has been modified for safety and off-gassing considerations. It will record approximately 40 hours of audio at a quality of 16bit/44.1kHz onto 20 4GB CF cards. The recorder has two powered XLR microphone inputs. In addition, overwrite protection is built in to eliminate overwriting previous audio recordings. Nominal operations will never record over another recording. All recorder settings will be preset on the ground, so the crew will not need to change any settings during the mission. The recorder is powered using 4 AA batteries (80 batteries total flown for all IMAX operations).

Figure 6-1. ICBC 3D digital audio recorder (front)

Figure 6-2. ICBC 3D digital audio recorder (top)

6.1.2 Compact Flash Cards

The ICBC 3D Digital Audio Recorder uses standard Compact Flash Type I/II cards. Each 4GB CF card can record approximately two hours of audio at 16bit/44.1kHz quality. CF cards are stowed in the ICBC locker.

6.1.3 Microphone Assemblies

The microphone assemblies flown are Crown model PZM-6D pressure zone microphones (Figure 6-3). The advantage of PZM microphones is that they are designed to reduce the delay between direct and reflected sound waves reaching the microphone, thus improving sound quality greatly. The microphones can be temporarily fixed to the orbiter, using hook Velcro pads located on the microphone bodies. The microphone cables that connect the microphone assemblies to the audio recorder include XLR connectors to interface directly with the recorder. Two microphone and cable assemblies will be flown, one 15 ft- and one 30 ft-length.

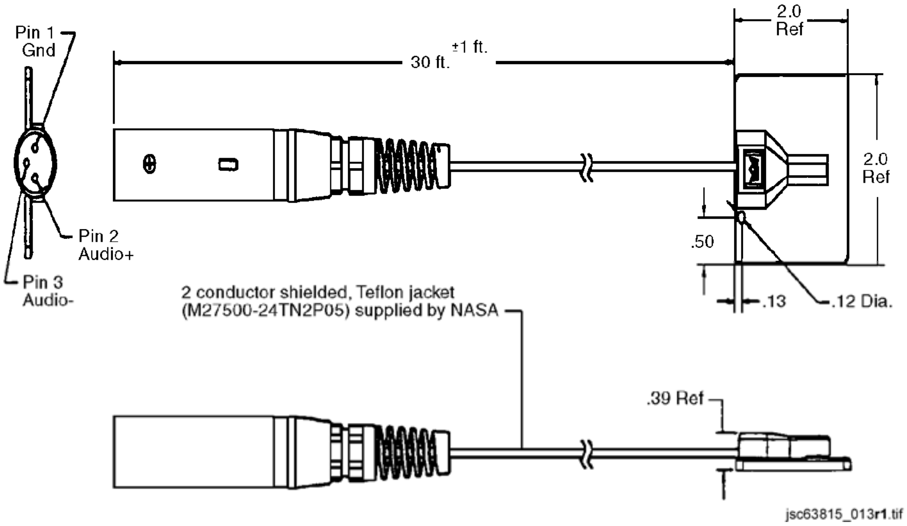

Figure 6-3. Microphone assembly

6.2 ICBC 3D PGSC

The ICBC 3D software serves as the crew interface to the camera system mounted in the payload bay. This software is loaded on all PGSCs, which are IBM A31p models with a single bay expansion chassis available. The PGSC being used for ICBC 3D operations connects to the PDIP via an RS422 and video cable. ICBC 3D electrical interfaces are shown in Figure 6-5.

The crew uses the PGSC to send commands to the ICBC 3D camera system. These commands include configuration commands, such as lens selection and f-stop; and operation commands, such as run (film a scene) and stop. Furthermore, by using a video camera within the camera container, looking out the camera window, the crew is able to see the same view as the camera.

6.3 CANON® XH-G1 HI-DEFINITION CAMCORDER

STS-125 is not flying the IMAX in-cabin camera that flew on previous IMAX missions. To film in-cabin scenes, IMAX has manifested a Canon XH-G1 Hi-definition camcorder, also referred to as the Canon G1 (Figure 6-4). Video is captured using three 1/3 in 16:9 Charged Coupled Device (CCD) imaging sensors, delivering a hi-definition video resolution of 1440 x 1080 pixels (or approximately 1.56 megapixels). All video is recorded onto Mini-DV tapes. Since the equivalent resolution of an IMAX 70mm frame of film is nearly 60 times greater, the G1 camcorder will not be used to film the same scenes as the ICBC 3D. In the final production, this would result in a noticeable difference in video quality. However, when transitioning to different scenes (namely outside shots to in-cabin footage), the difference is much less noticeable to the audience. To obtain the 3D effect from 2D video, IMAX has developed a complex method of creating a “second eye” from the camcorder video. This has been successfully completed with 2D video from previous IMAX flights. The Canon XH-G1 will eventually become the standard Government-Furnished Equipment (GFE) camcorder for both the Space Shuttle and International Space Station programs; therefore, all camcorder operations will be controlled by the IMAX customer and the Photo/TV group.

Figure 6-4. Canon XH-G1 Hi-definition Camcorder

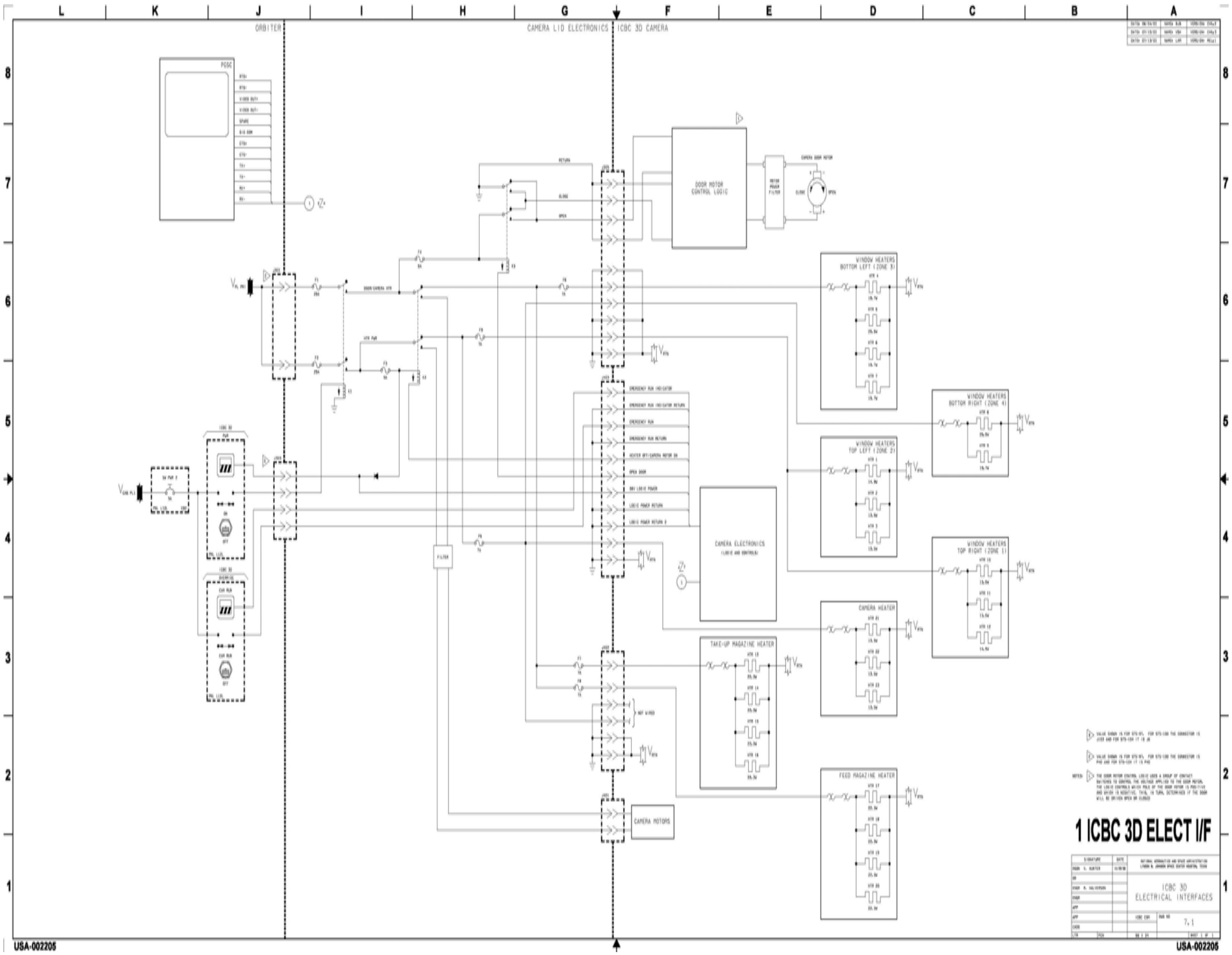

Figure 6-5. ICBC 3D electrical interfaces

APPENDIX A
ACRONYMS AND ABBREVIATIONS

3D	Three Dimensional
ACO	Assembly and Checkout Officer
AFD	Aft Flight Deck
bp	barberpole
CCD	Charge Coupled Device
CF	Compact Flash
CIOB	Cargo Integration and Operations Branch
COTS	Commercial Off-the-Shelf
CR	Change Request
CSM	Cargo Systems Manual
EVA	Extravehicular Activity
fps	frame pairs per second
GAS	Get-Away-Special
GFE	Government-Furnished Equipment
GHE	Ground Handling Equipment
gr	gray
HST	Hubble Space Telescope
ICBC	IMAX Cargo Bay Camera
ICBC 3D	IMAX Cargo Bay Camera 3D
ISS	International Space Station
ITS	Integrated Truss Structure
MET	Mission Elapsed Time
MLI	Multilayer Insulation
MOD	Mission Operations Directorate
MPA	Mounting Plate Assembly
NASA	National Aeronautics and Space Administration
OCA	Orbiter Communications Adapter
ORUC	Orbital Replacement Unit Carrier
PAT	Payload Accommodation Terminal
PCN	Page Change Notice
PDIP	Payload Data Interface Panel
PGSC	Payload General Support Computer

PLO	Payload Officer
psi	Pounds per square inch
RF	Radio Frequency
RICS	Remote IMAX Camera System
SIP	Standard Interface Panel
SM	Servicing Mission
SSP	Standard Switch Panel
SSP2	Standard Switch Panel 2
STS	Space Transportation System
tb	talkback
USA	United Space Alliance

APPENDIX B
SAFETY SUMMARY

B.1 ICBC 3D FLIGHT SAFETY SUMMARY

The ICBC 3D camera, containers, and the mounting configuration are completely new designs from the previous ICBC system. The ICBC 3D system is currently scheduled to fly for the first time on STS-92 (ISS-03-3A). Therefore, its components are considered new hardware and have been assessed for potential hazards per NSTS 1700.7B, “Safety Policy and Requirements for Payloads Using the Space Transportation System,” and as outlined in NSTS 13830C, “Payload Safety Review and Data Submittal Requirements for Payloads Using the: - Space Shuttle - International Space Station.”

The hazards identified as generic have been documented on a Flight Payload Standardized Hazard Control Report, JSC Form 1230. Four payload unique hazards have been identified for ICBC 3D, they are structural failure (except camera elements), shatterable material, failure of ICBC 3D container, and structural failure of camera elements. The hazards are documented in Payload Hazard Reports ICBC 3D-F-1, -2, -3, -4, respectively.

B.1.1 Structural

Safety of payload structural elements in the cargo bay is addressed in unique hazard report # ICBC 3D-F-1. It addresses failure of structural elements under combined inertial, pressure, and thermal loads during all mission phases. This hazard report covers MPA, Pickup Plate, Interface Plate, the camera and the magazine containers (excluding glass window), and the window door assembly. The structural hazards due to the IMAX Camera system are covered in unique hazard report # ICBC 3D-F-4.

B.1.2 Fracture Control

The ICBC 3D window glass is considered a fracture critical element. Hazards associated with its failure under combined inertial, pressure, and thermal loads during all mission phases are addressed in hazard report # ICBC 3D-F-2. The fracture control analysis for the camera elements and the rest of the hardware is addressed in hazard report #’s ICBC 3D-F-4 and ICBC 3D-F-1, respectively.

B.1.3 Pressure System

Hazard report # ICBC 3D-F-3 addresses failure of the container due to excessive pressure differential. An additional breather valve was installed (total 4 valves) and the maximum design pressure (MDP) of 8 psid was calculated based on failure of two valves. However, the pressure differential of 8 psid will remain for a brief period of time. On orbit, the remaining two valves will maintain the pressure inside the container to 5 psid, and –1 psid during return.

B.1.4 Thermal

As described in Section 4, the heaters will be used to maintain the thermal environment inside the ICBC 3D. The heaters are located on the magazines, on the camera, and on the glass window. The thermostats on-off points will be set at 50° F and 65° F for the camera and the magazine heaters, and 58° F and 70° F for the window heaters. Two thermostats in series are used to control a group of heaters. Moreover, a thermal analysis was also performed with all the heaters failed on and the payload bay facing the sun. It indicated the highest temperature, 280° F, at the magazine location, which is below the auto-ignition temperature of the payload bay.

An additional thermal analysis was performed with all the heaters of the window, the camera, and the containers failed on separately, and the payload bay facing the sun. The case with the window heaters failed on was determined to be the worst case. The highest temperature, approximately 180° F, was indicated at the external surface of the window door, which is below the touch temperature limit of the payload bay. Also, the electrical wire insulation is rated to 392° F.

B.1.5 Electrical

The ICBC 3D is DC powered and does not employ voltages in excess of 32 V dc. A review of the payload electrical schematic will verify compliance with TA-92-038. The ICBC 3D does not have any safety critical function. The PGSC and its power cable are SSP-provided.

B.1.6 Materials

The hazards associated with the use of flammable and off gassing materials are addressed in hazard report # STD-ICBC 3D-1. The materials for the payload provided crew cabin hardware (electrical and data cables) are selected from the approved list of materials MSFC standard. Therefore, these cables were only baked and not off-gas tested. All the structural material (except glass) was selected from MSFC-SPEC-522, Table 1. Use of all ICBC 3D materials will be reviewed and approved by JSC EM2/MA Materials Branch.

B.1.7 Toxic Materials

The ICBC 3D camera employs three beryllium (Be) components, two claw arms and one conrod, in its film advance mechanism. Two claw arms advance the film by holding it through the perforations at the upper and lower edges of the film, and the conrod drives the claw arms. Providing ball bearings, securing with a retaining ring, and Loctite prevents rubbing between these parts, as well as providing very close tolerance fit. The surfaces at which the claw arms contact the film have heavy nickel plating. The IMAX Corporation concluded, after analyzing a similar design of camera mechanism, that the wear due to rubbing will not be sufficient to damage the film or Be parts. Also, an evaluation by the JSC Toxicologist indicates that this mechanism will be safe for flight.

B.1.8 Reflight Safety Analysis

The ICBC 3D audio recording system last flew on STS-88 as part of ICBC. Therefore, for the ICBC 3D on STS-92, and subsequent flights, the audio tape recording system is considered as reflown/series hardware. The only modification made to the hardware was to the battery charger. The charger was approved for use only as a power supply for the audio recorder on STS-88 because it did not meet the EMI requirements in the battery-recharging mode. The battery charger was modified to improve its EMI performance in the charging mode. However, subsequent tests after the modification show that the charger still does not satisfy the transient requirements. Therefore, the charger will only be used as a power source for the audio recorder and will not be used to charge the batteries.

APPENDIX C
CSM CHANGE CONTROL

C.1 INTRODUCTION

C.1.1 Purpose

The purpose of this appendix is to delineate configuration control procedures for the Cargo Systems Manual (CSM). This will ensure the proper coordination of changes and provide a record of proposed changes, rationale, and disposition.

C.2 CONFIGURATION CONTROL PROCEDURE

C.2.1 Submission of Changes

Proposed changes are solicited from any individual or any organization having a valid input. Changes should be submitted to the CSM book manager at mail code DO5, NASA/Johnson Space Center, Houston, Texas 77058.

Individuals desiring to submit a change should complete all applicable items on the Cargo Operations Change Request Form (Figure C–1). This form should be typed or neatly printed. Additional pages may be used if the space provided is not adequate. The original completed form should then be forwarded to the CSM book manager.

C.2.2 Disposition of Changes

The CSM book manager will obtain formal concurrence and comments from the necessary personnel, including customer representatives. All proposed modifications to the Change Request (CR) will be coordinated with all necessary personnel prior to disposition.

Upon obtaining the required concurrences, the CSM book manager will present the proposed change to the appropriate section head for final disposition.

A copy of all dispositioned CRs will be retained by the CSM book manager for future reference. A courtesy copy of all approved CRs will be sent to ZC01/J. Woodall, EV12/D. Sykes, and MS3/F. W. Parker.

C.3 CSM REVISIONS/PCNs

C.3.1 Development

The CSM book manager will compile all approved changes and any typographical errors and incorporate them into a revision or Page Change Notice (PCN) to the document.

Pen and ink changes may be used to correct typographical errors if there are no other changes on the page concerned.

C.3.2 Approval

Any revisions/PCNs to the document will be approved by the appropriate section head. Revisions/PCNs to the final versions will also be approved by the manager of the Space Shuttle Systems Integration Office. Revisions will also need to be initialized by the lead Payload Officer (PLO).

C.3.3 Publication

Revisions/PCNs will be made on an as-required basis. Revisions/PCNs will be printed and distributed to the standard distribution list.

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JSC Form 385 (November 17, 2000) (Informed November 2000)

Figure C-1. Change request form

DOCUMENT NUMBER: JSC-64065
Basic

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