

2.17 MECHANICAL SYSTEMS

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Description

The mechanical systems are those components that must be deployed, stowed, opened, or closed. Each of these components is physically moved by an electrical or hydraulic actuator.

The mechanical systems include the active vent system, external tank umbilical doors, payload bay doors, radiators, and landing/deceleration system. The landing/deceleration system is discussed in Section 2.14, and radiators are included in Section 2.9. The others are discussed in sequence in this section. Operations are discussed within each system description.

Certain other components that contain mechanical actuators are not included in this section, but are covered within the discussion of the system in which they are included. They are: (1)

payload retention latches, covered in Section 2.19, (2) star tracker doors and air data probes, discussed in Section 2.13, and (3) Ku-band antenna, found in Section 2.4.

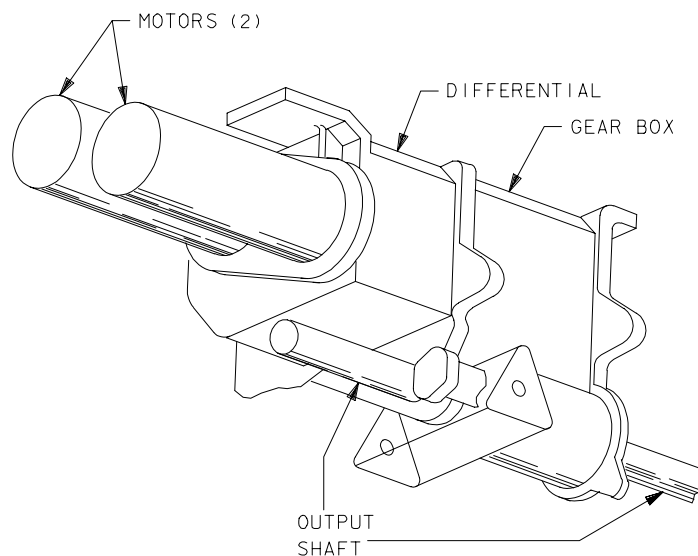
Electromechanical Actuators

The design of all orbiter electromechanical actuators is essentially the same. Each actuator assembly contains two three-phase ac motors, brakes, a differential, a gearbox, and limit switches. With the exception of the ET door centerline latches and vent doors, all actuator assemblies also contain torque limiters.

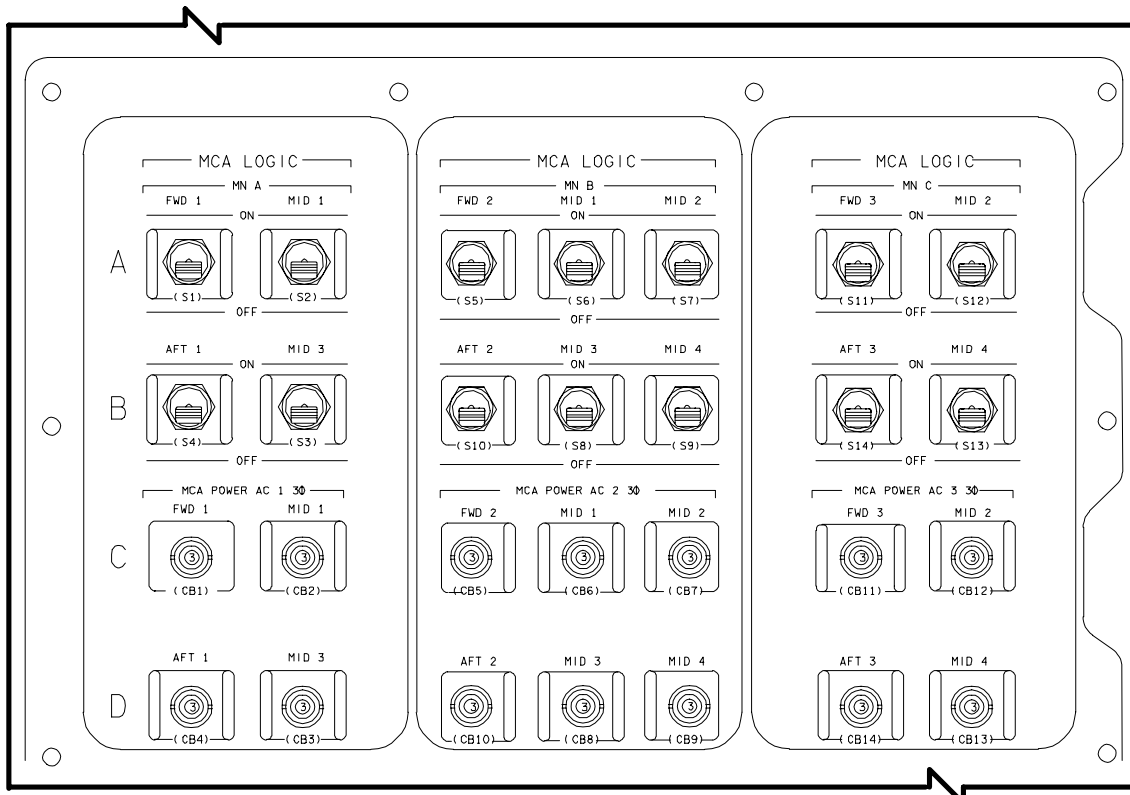
Power for the actuator motors and limit switches is provided by motor control assemblies (MCAs). Commands must be sent to the MCAs to turn the motors off and on. Commands can originate from the GPCs, CRT item entries, or hardwired switches. Multiplexer/demultiplexers (MDMs) send the commands to the MCAs. Each actuator motor is commanded by a separate MDM; the loss of one MDM will not cause the loss of an actuator.

When the actuator reaches the commanded position, the limit switches send signals back to the MCA to turn the ac power off. Signals are also sent to GPCs and talkbacks in the crew compartment.

The MCAs are controlled via the *MCA LOGIC* switches and circuit breakers on panel MA73C.



Electromechanical Actuator



MCA Controls on Panel MA73A

Active Vent System

The active vent system equalizes the unpressurized compartments of the orbiter to the ambient environment as the orbiter travels from the pressurized atmosphere of Earth to the vacuum of space.

The active vent system consists of 18 vent ports (9 on each side) in the orbiter fuselage. For identification, each door is numbered forward to aft, and each compartment has a dedicated vent on the left- and right-hand side of the orbiter. Each vent door has a pressure seal and a thermal seal, and is driven inward by an electromechanical actuator. The vent openings are sized according to the volume to be vented.

The doors for the vent ports are controlled to provide the capability to purge with dry air or nitrogen on the ground, or to exclude hazardous gases or contaminants.

Forward, mid, and aft MCAs power the vent door motors and limit switches. The crew can also use GNC OVERRIDE SPEC 51 to open or close the vent doors (VENT DOOR CNTL).

Vent Operations

The 18 doors are divided into six groups with two electromechanical actuators per group. Sequencing prelaunch is staggered with a 2.5-second delay between groups, and normal vent opening or closing time is 5 seconds. The vent doors are controlled by a GNC software sequence that can be started by a master timing unit, major mode transition, velocity, or CRT entry.

During countdown, the vent doors are in their purge positions until T-25 seconds when the OPEN sequence is automatically called by the redundant set launch sequencer. The vent doors remain open during ascent, orbital insertion, and all the on-orbit phases. During entry preparation, the crew closes all vent doors except vents 1, 2, 8, and 9 portside. These vents are left open to vent any hazardous gases during deorbit burn and to prevent vehicle overpressurization should a rapid OMS/RCS leak occur. These vents are automatically closed before entry interface.

PASS			BFS		
Major Mode	COMMAND		Major Mode	Command	
	Open	Close		Open	Close
301	All doors open	All doors close then L1 and 2 and 8 and 9 auto reopen	301	All doors open	All doors close, then L1 and 2 and 8 and 9 auto reopen
302	All doors open	CMD all vent doors close	302 (602)	All doors open	If 1 st CLS CMD, then CLS all vents; if not CMD ignored
303	All doors open	CMD all vent doors close	303 (603)	All doors open	If 1 st CLS CMD, then CLS all vents; if not CMD ignored
At 304 transition		CMD all vent doors close	At 304 transition		If no CLS flag set, then CLS all vent doors
304	L1 and 2 and 8 and 9 open	CMD all vent doors close	304	L1 and 2 and 8 and 9 open	None
305 9Mach 2.4)	All doors open auto or manual	All vent doors will close only if post roll-out	305 (Mach 2.4)	All doors open auto or manual	None

Vent Door Software Overview

External Tank Umbilical Doors

Electrical and fuel umbilicals between the external tank (ET) and the orbiter enter the shuttle through two aft umbilical openings located on the underside of the orbiter. The umbilical cavities contain the orbiter/ET attachment points and the fuel and electrical disconnects. After the ET separates from the orbiter, the two aft umbilical openings are exposed. Two ET umbilical doors cover the exposed areas, shielding them from entry heating.

Each umbilical door is covered with reusable thermal protection system tiles in addition to an aerothermal barrier that requires approximately 6 psi to seal the door with adjacent thermal protection tiles. The left door covers the liquid hydrogen umbilical, and the right door covers the liquid oxygen umbilical. Each door is approximately 50 inches square. Each door is driven open and closed by two three-phase ac motors and is connected to the orbiter by two hinges. Two different types of latches, centerline and uplock, hold the doors open and closed respectively.

Two centerline latches, one forward and one aft, hold the ET doors open during ascent. In the latched position, the centerline latch blades fit

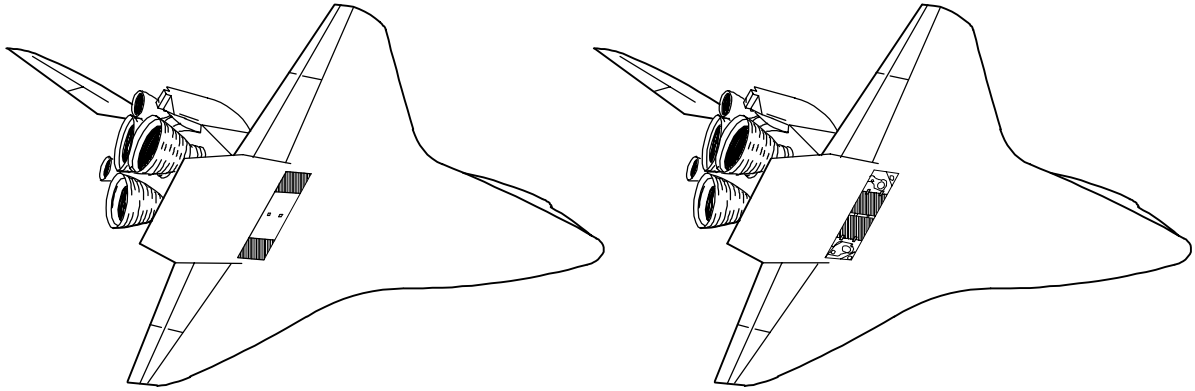
into a notch on the outer edge of the left and right doors. The centerline latches must be disengaged from the doors before both ET doors can be closed. When unlatched, the two centerline latches retract into the body of the orbiter and are then considered stowed. Nominally, 6 seconds are required to stow the centerline latches. The centerline latches are driven to the stowed position by two three-phase ac motors.

NOTE

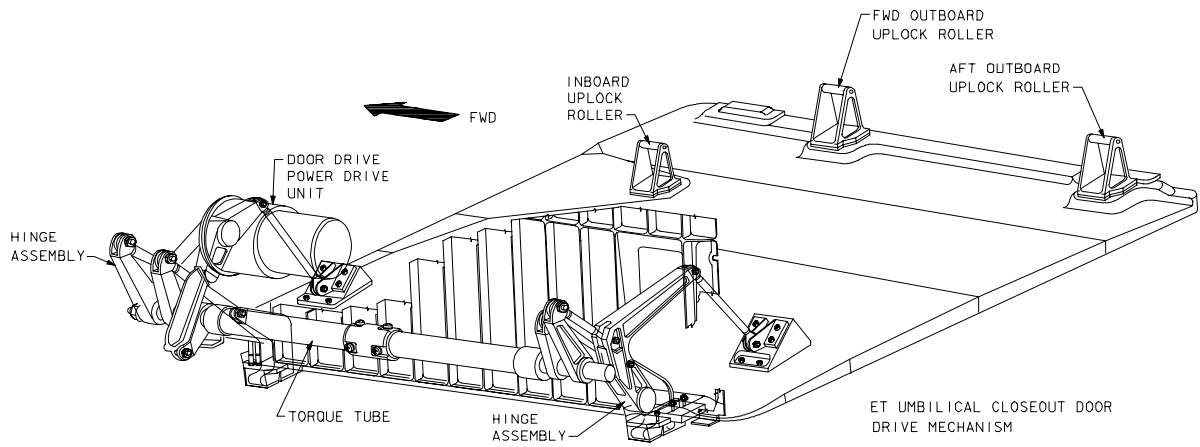
Once stowed, the centerline latches cannot be redeployed by the crew; the task must be completed by ground crews.

Three uplock latches are located inside each umbilical cavity; the latches engage three uplock rollers located on each door. The latches are designed to prevent the doors from vibrating or reopening during reentry, and to pull the doors up to the fully closed position flush with the orbiter body.

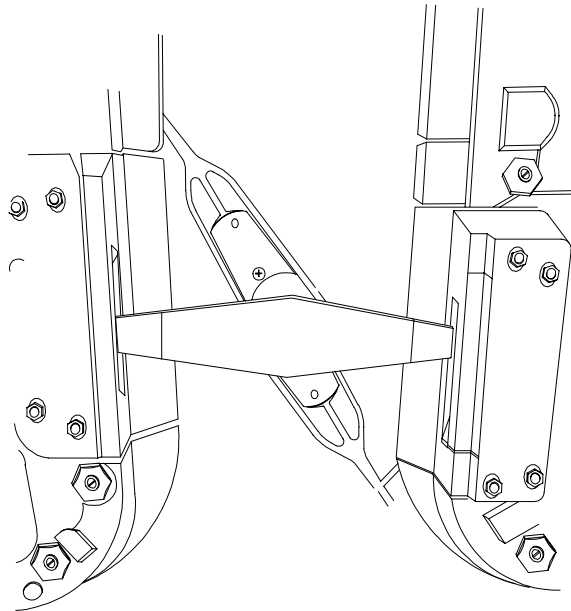
Each group of three latches is driven by two three-phase ac motors. The motors are reversible, allowing the crew to latch or unlatch the doors. Six seconds are required to latch the doors closed (dual motor time).



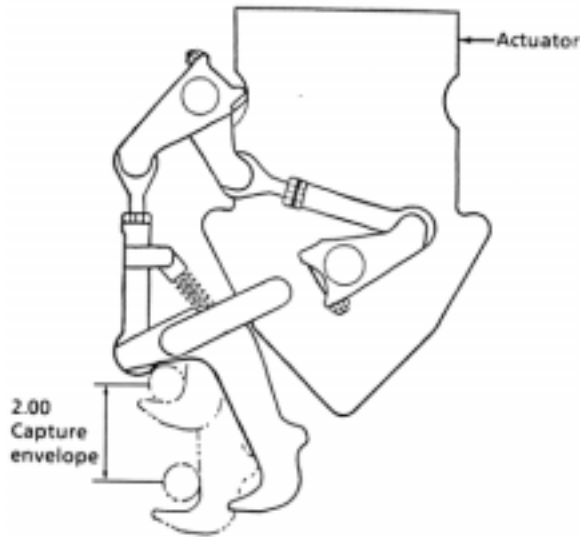
ET Door Positions



Right Side ET Umbilical Door



Centerline Latch Movement



Door Uplock Latch and Roller

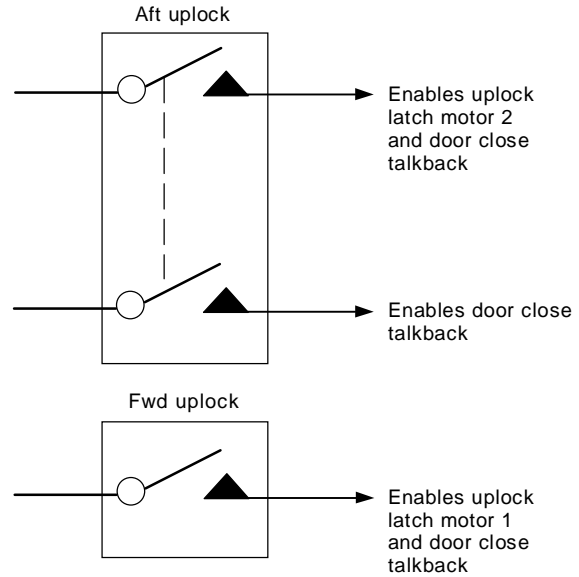
CAUTION

Thermal damage will occur if the ET doors are not fully latched flush with the orbiter body.

The status of the uplock latches is provided by limit switches.

When the door is within 2 inches of being closed, the door uplock latches can hook the three rollers and pull the door closed, compressing the aerothermal seals around each door.

The door ready-to-latch limit switches enable the door uplock latch drive mechanisms. The left door ready-to-latch limit switches enable the left door uplock latches, and the right door ready-to-latch limit switches enable the right door uplock latches. Two out of three ready-to-latch indications are required to enable the door uplock latches.



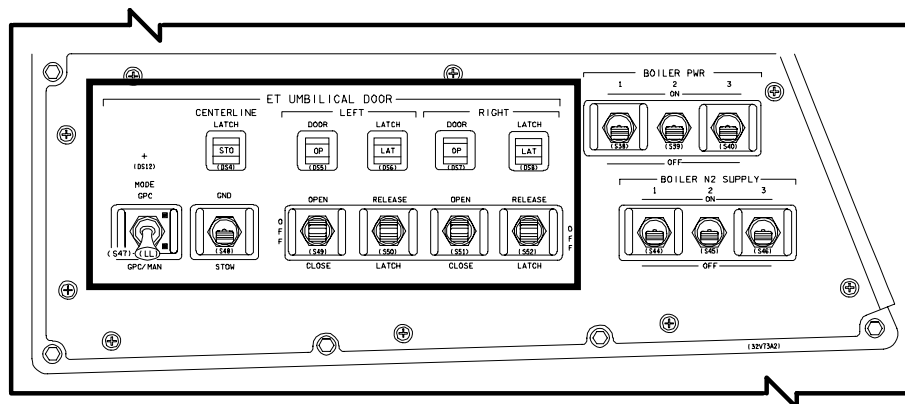
Uplock Latch Limit Switches

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ET Door Operations

The ET doors are closed post OMS-1 burn after MPS vacuum inerting. The doors are controlled by the crew by switches on panel R2. The doors are also automatically controlled by the PASS or (BFS) software during TAL and RTLS aborts, certain contingencies, or if selected by the crew on the GNC SPEC 51 OVERRIDE display. The *ET UMBILICAL DOOR MODE* switch on panel R2 in the *GPC/MAN* position enables manual flight crew control of the doors. Both the *GPC/MAN* and *GPC* positions allow software control of the doors.

The doors and latches must be sequenced in an orderly manner to prevent damage. First, the centerline latches are stowed, then the doors are closed, and finally the doors are latched.



ET UMBILICAL DOOR Controls on Panel R2

The *ET UMBILICAL DOOR CENTERLINE LATCH* switch on panel R2 is used by the crew to stow the centerline latches during normal operations. Positioning the switch to *STOW* provides electrical power to redundant ac motors that operate an electromechanical actuator for each centerline latch. This will cause the latches to rotate and retract such that the latch blades will be flush with the orbiter thermal protection system mold line when stowed. The stow time for the centerline latches with both motors in operation is approximately 6 seconds. The talkback above the switch will indicate barberpole when the latches are deployed, and *STO* when the latches are stowed. The microswitches that drive the talkback are located within the centerline latch drive mechanism and are activated based on the position of the latch. The *ET UMBILICAL DOOR CENTERLINE LATCH* switch is then taken back to the *GND* position, which removes power from the centerline latch motors.

The *ET UMBILICAL DOOR LEFT DOOR* and *RIGHT DOOR* switches on panel R2 are used by the crew to close the ET doors. Positioning the switches to *CLOSE* provides electrical power to redundant ac reversible motors, which drive the doors through a system of bellcranks and pushrods. With both motors in operation, the doors will close in approximately 24 seconds. As the doors move within 2 inches of being closed, two operations take place. First, microswitches within the door power drive unit inhibit power from the door drive motors. Second, two rollers mounted on the outboard edge of each door contact two ready to latch paddles in the umbilical cavity. The two ready to latch paddles drive three microswitches that enable the uplock latch motors and the onboard close talkback. Two of the three microswitch indications are needed to provide a *CL* indication on the door drive talkback.

The *ET UMBILICAL DOOR LEFT LATCH* and *RIGHT LATCH* switches on panel R2 are used by the crew to latch the ET doors. Positioning the switches to *LATCH* provides electrical power to redundant ac motors that drive the three uplock latches through a system of pushrods. The uplock latches engage three rollers that are located on the inside face of the ET door. The latch motors then pull the doors closed approximately 1 to 2 inches, which provides the 6 psi required to compress the

aerothermal barrier. Compression of the aerothermal barrier results in a seal that will protect the umbilical cavity from reentry heating. The drive time for the latches with both motors in operation is approximately 6 seconds. The onboard latch talkbacks will indicate *LAT* when the doors are latched. The *RELEASE* position of the switches is used postlanding to release the umbilical doors in preparation for door opening.

The *ET UMBILICAL DOOR LEFT LATCH* and *RIGHT LATCH* switches can be taken to *LATCH* simultaneously, which will override a power inhibit to the latch motors resulting from insufficient ready-to-latch indications. Mission Control has additional telemetry that will determine if a power inhibit exists because of missing ready-to-latch indications.

The *ET UMBILICAL DOOR MODE* switch on panel R2 positioned to *GPC* or *GPC/MAN* provides a backup method of stowing the centerline latches and closing the umbilical doors through the GNC SPEC 51 OVERRIDE display (*PASS* or *BFS*). Selecting item 40 (*ET UMB DR CLOSE*) in *PASS* or item 30 in *BFS* will bypass panel R2 switches and automatically close the ET doors. This software-driven method is automatically performed during *RTLS* and *TAL* aborts.

During these aborts, transition into MM 602 or 304 will automatically initiate the umbilical door closure sequence, providing the *RTLS* or *TAL* abort flag is set true. For the first 12 seconds of the sequence, the software commands the two centerline latches to the stowed position. From the sixth second until 54 seconds after sequence initiation, the umbilical doors are commanded closed. At 54 seconds, the umbilical door latches are commanded closed for another 12 seconds, for a total sequence time of 66 seconds. Note that all the times specified in the automatic closure are double the normal times, thus allowing for a single motor failure in any of the actuators. The panel R2 talkbacks remain active throughout the closure sequence, and may be used by the flight crew as insight into the completion of each actuator sequence.

A closeout curtain is installed at each of the orbiter/external tank umbilicals. After external tank separation, the residual liquid oxygen in the main propulsion system is dumped through the three space shuttle main engines, and the

residual liquid hydrogen is dumped overboard. The umbilical curtain prevents hazardous gases (gaseous oxygen and hydrogen) from entering the orbiter aft fuselage through the umbilical openings before the umbilical doors are closed. The curtain also acts as a seal during the ascent phase of the mission to permit the aft fuselage to vent through the orbiter purge and vent system, thereby protecting the orbiter aft bulkhead at station X_o 1307. The curtain is designed to operate in range of -200° F to +250° F.

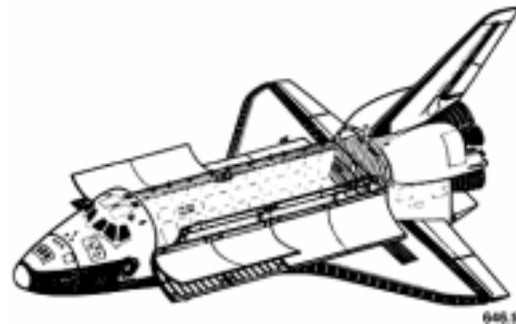
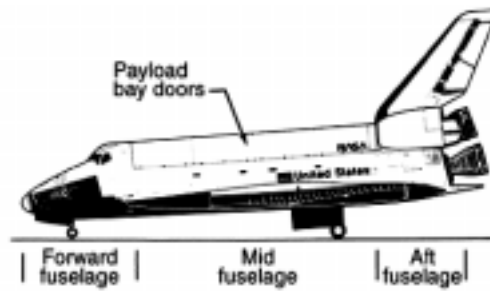
The umbilical doors are opened by the crew during postlanding activities. The crew can use only the panel R2 switches to open the ET doors.

Payload Bay Door System

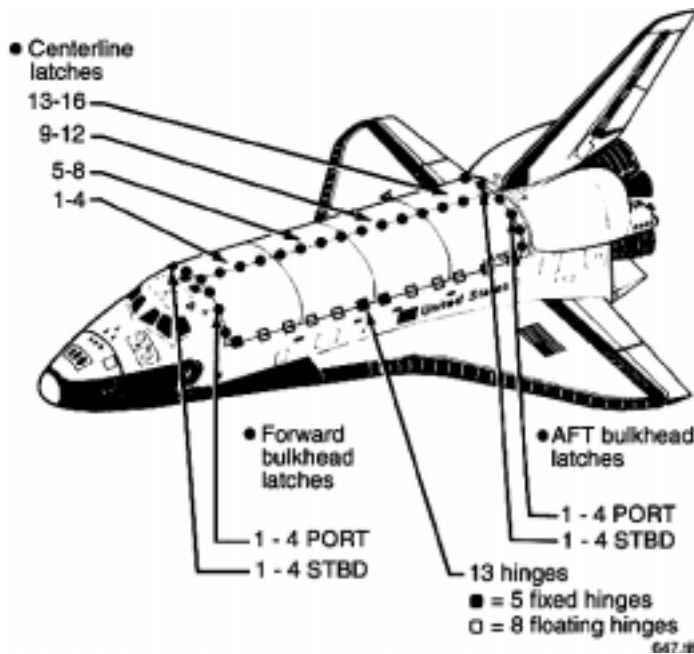
The payload bay doors provide an opening for payload deployment from and retrieval into the payload bay. The doors provide structural support for the orbiter midbody, and they house the ECLSS radiators that transfer heat from the vehicle to space.

There are two doors, port and starboard. Each door consists of five segments interconnected by expansion joints. The port door with attached systems weighs approximately 2,375 pounds, and the starboard door weighs about 2,535 pounds. The starboard door contains the centerline latch active mechanisms, which accounts for the weight difference. These

weights do not include the deployable radiator system, which adds 833 pounds per door. The doors are approximately 60 feet long with a combined area of 1,600 square feet. Thermal and pressure seals are used to close the gaps at the forward and aft fuselage interface, door centerline, and expansion joints. The starboard door overlaps the port door to form the pressure and thermal seal on the centerline.



Payload Bay Doors Location



Payload Bay Door Latch Locations

The starboard door must be opened first and closed last because of the arrangement of the centerline latch mechanism and the structural and seal overlap.

Each door is connected to the midfuselage by 13 hinges; five are shear hinges (nonmoving hinges) and eight are floating hinges (moving hinges that allow for thermal expansion and contraction of the doors). Each door is driven open and closed by two three-phase ac motors.

The doors are held closed by various latches. There are 16 centerline latches that secure the doors on the centerline: eight forward bulkhead latches that secure the doors on the forward bulkhead, and eight aft bulkhead latches that secure the doors on the aft bulkhead.

The centerline latches are ganged together in groups of four, giving four groups of four latches. The latches are numbered from 1 to 16 starting forward and moving aft. Each group of latches is driven by a typical orbiter electromechanical actuator.

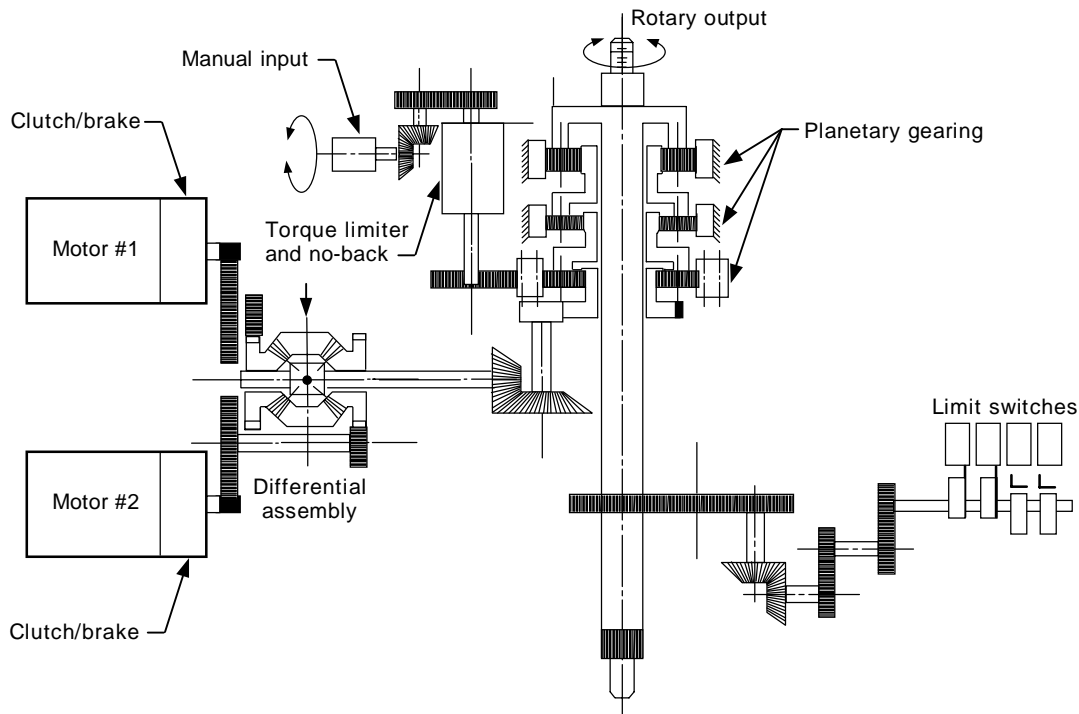
The motors are reversible, which allows the crew to latch or unlatch the doors.

The starboard door contains the centerline latch hooks, and the port door contains the centerline latch rollers. The hooks are the active portion of the centerline latch system; they rotate to grasp the latch rollers.

As the torque shaft rotates, the bellcrank and link cause the hook to rotate closed (or open), engaging the latch roller on the port door. Twenty seconds are required to open or close a group of centerline latches (dual-motor time).

The status of the centerline latch groups is provided by limit switches. There are two open and two closed limit switches associated with each centerline latch group. These limit-switch indicators relay the position of the latch group (i.e., latch group is open or closed). They also provide a method for enabling and disabling latch drive motors.

The bulkhead latches are ganged together in groups of four, giving a total of two groups of forward bulkhead latches, and two groups of aft bulkhead latches. Each group of latches is driven by a typical electromechanical actuator using two three-phase ac motors. The motors are reversible, which allows the crew to latch or unlatch the doors.



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Payload Bay Door Centerline Latch Actuator Schematic

The latch hooks for the bulkhead latches are located on the forward and aft edges of each door, and the latch rollers are located on the forward and aft bulkheads. The hooks are the active portion of the bulkhead latch system; they rotate to grasp the latch roller.

As the torque shaft rotates, the linkage connecting the latches begins to move. This causes a staggered latch open or close sequence; latch 1 closes first, then latch 2, 3, and 4. Thirty seconds are required to open or close a group of bulkhead latches (dual-motor time).

The status of the bulkhead latch groups is provided by limit switches similar to those used by the centerline latches. There are two open and two closed limit switches for each bulkhead latch group. These limit-switch indicators relay the position of the bulkhead latch group (i.e., latch group is open or closed). They also provide a method for enabling or disabling the centerline latch drive motors and the payload bay door drive motors.

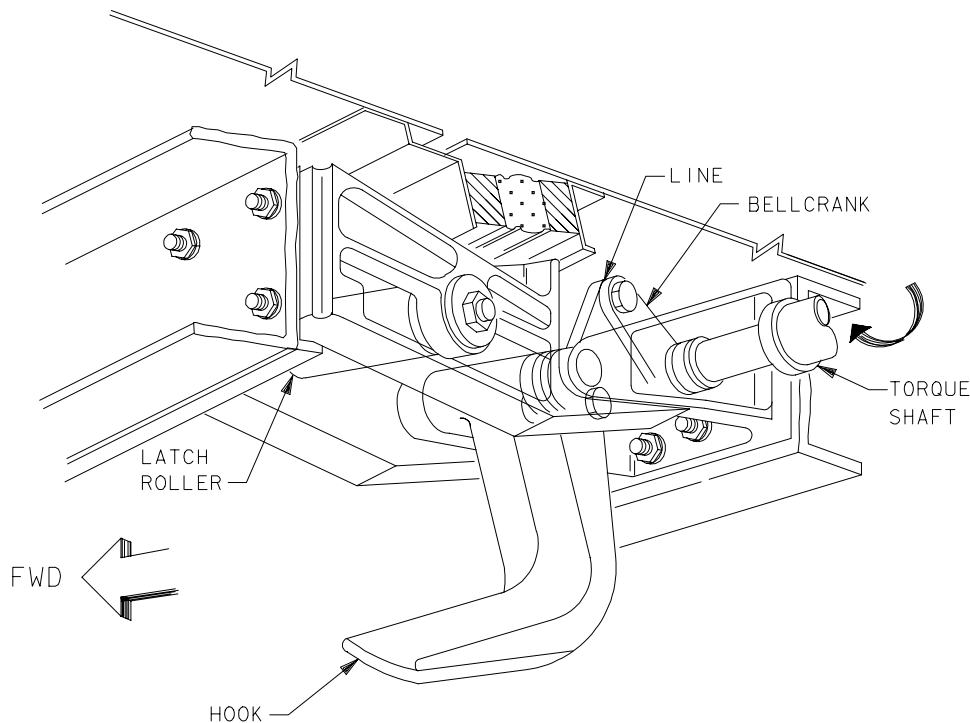
The doors are driven open or closed by a rotary actuator consisting of two three-phase ac motors per drive unit. (Each door contains its own.) Torque limiters are incorporated in the rotary

actuators to avoid damaging the door drive motors or mechanisms in the event of jamming or binding during operation. It takes 63 seconds to open or close each door (dual-motor time). The doors open through an angle of 175.5°.

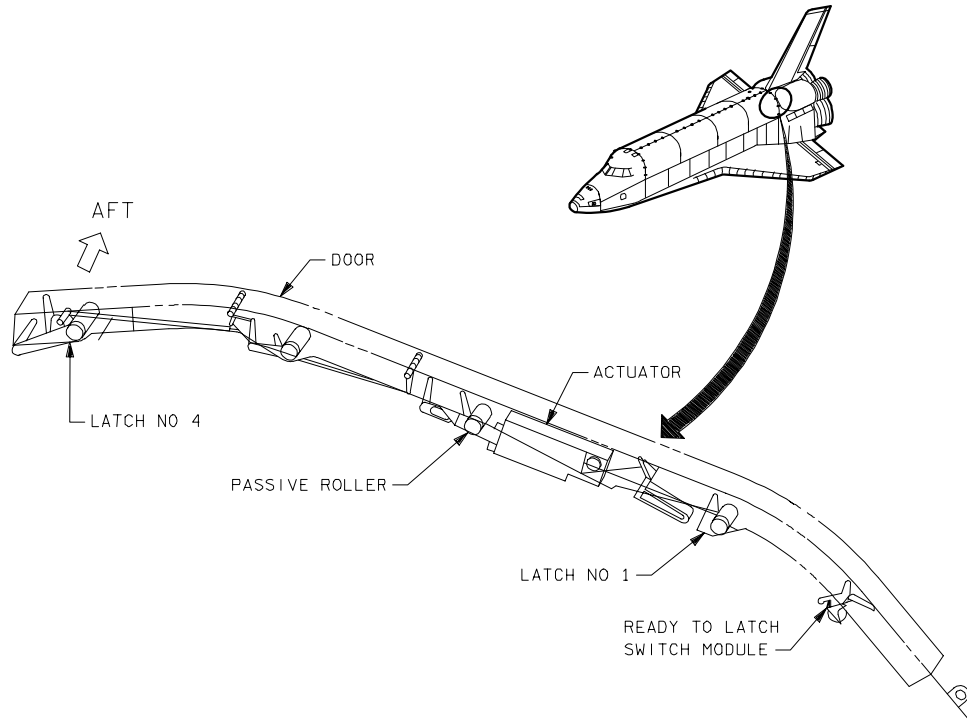
The electromechanical actuator drives a 55-foot-long torque shaft. The shaft turns the rotary actuators, causing the push rods, bellcranks, and links to push the doors open. The same arrangement pulls the doors closed.

The push-pull rod is color-coded to assist the crew in opening and closing the door. As the push rod opens or closes the door, certain colors are displayed. The crew can use this information to determine if the door is warped or jammed. If the door is completely opened, nine colored bands should be visible (six silver bands and three gold bands). If the door is completely closed, one gold band at the top of the push rod should be partially visible. Therefore, if any of the silver bands are visible, the door is warped or jammed.

Each band, gold or silver, represents the amount the doors are open or closed in degrees of rotation.



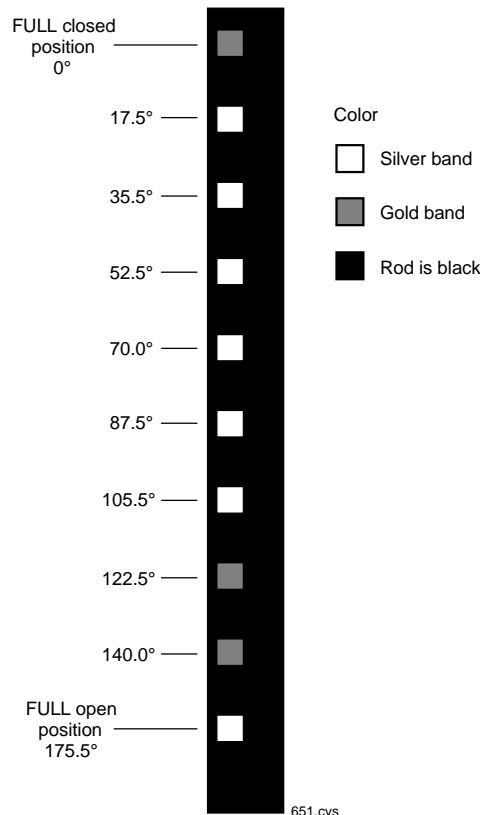
Payload Bay Door Centerline Latch



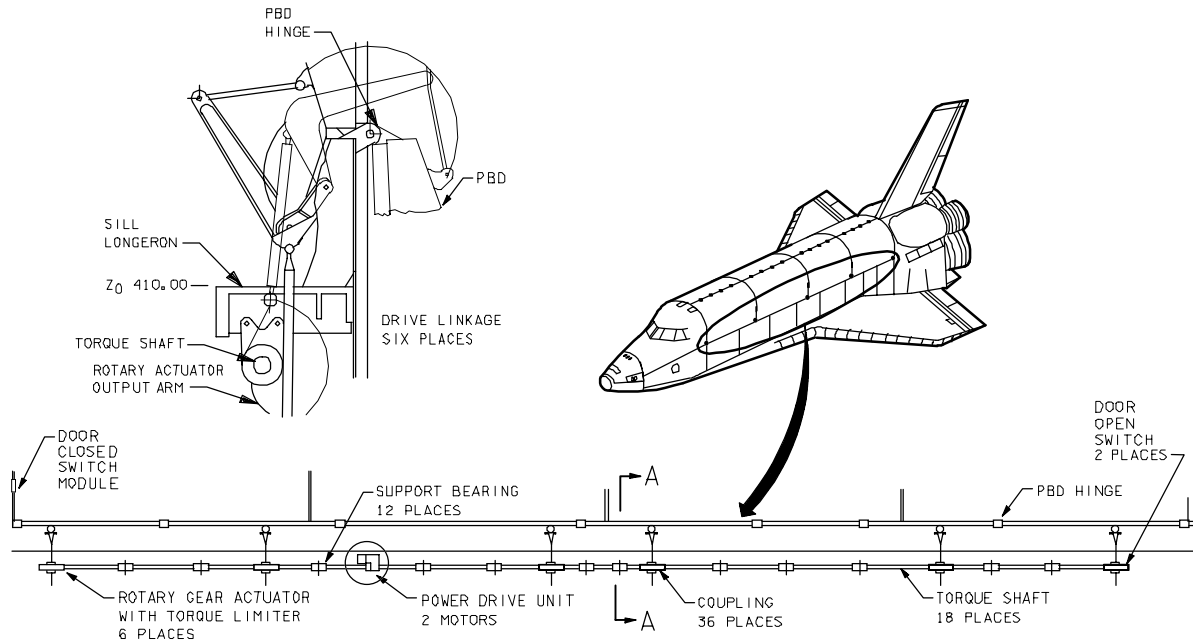
Payload Bay Door Bulkhead Latches

There are six push-pull rods per door. They can be located by looking along the sill longeron that runs along the entire length of the payload bay. There is actually a 10th band (silver) located below the two gold bands. This band is only partially visible when the doors are fully open.

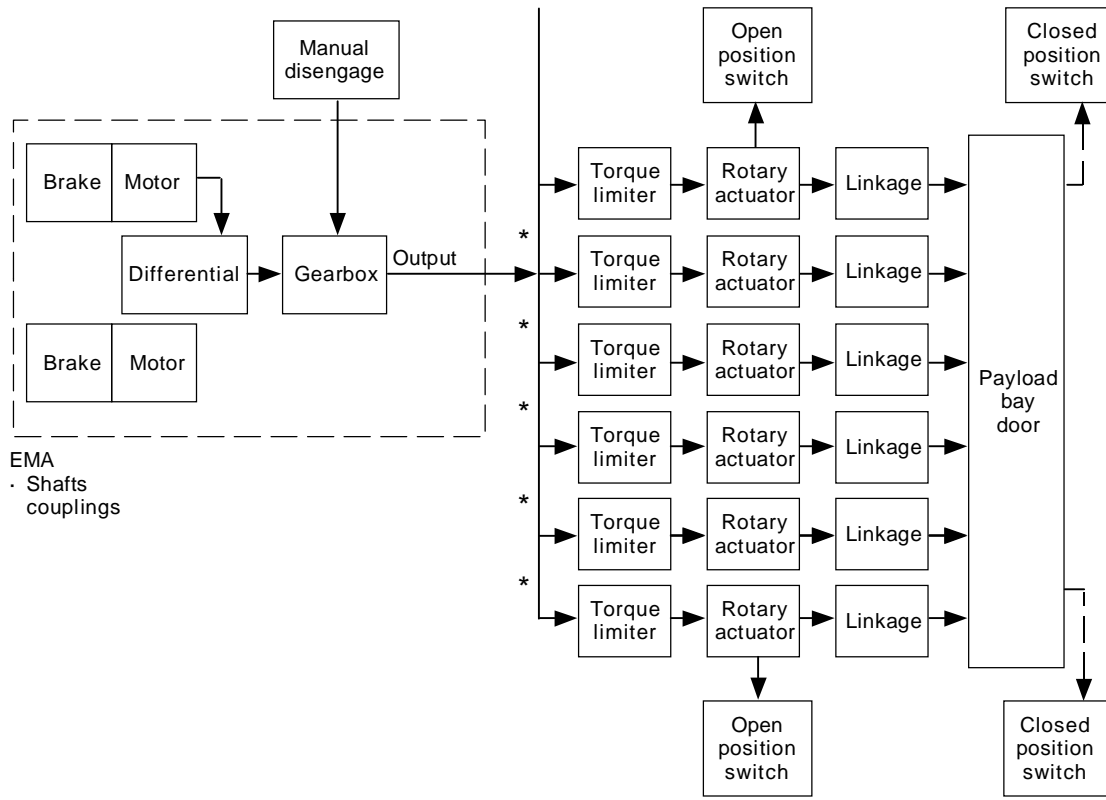
The status of the doors is provided by limit switches; these, however, are slightly different from the centerline latch and bulkhead latch limit-switch indicators. Each door has two closed limit-switch modules, one on the forward bulkhead and one on the aft bulkhead. Each closed switch module contains four limit switches, three ready-to-latch indicators, and one closed indicator. The ready-to-latch indicators determine when the door is within 4° of being closed. This is important because the forward and aft bulkhead latches are then within reach to latch the door closed. The closed microswitches indicate when the door is completely closed. Each door also has two open limit switches located on the torque shaft. These limit switches determine when the door drive unit has driven to the full open position.



Push-Pull Rod Markings



Payload Bay Door Drive System



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Payload Bay Door Drive System Mechanical Block Diagram

Payload Bay Door Operations: Opening

The payload bay doors are opened approximately 1 hour and 25 minutes into the nominal flight. Certain conditions must be met before the doors can be opened. The table below lists the failures that will force the crew to leave the doors closed and deorbit after three orbits.

If none of these conditions exists, mission control will give the crew the go-ahead to open the doors. The doors and latches must be opened in an orderly manner to prevent. First, centerline latch groups 5 to 8 and 9 to 12 open. These groups secure the mid-centerline region of the doors. When the orbiter is exposed to the cold environment of space, warping of the doors is likely. Opening these two groups first relieves the tension in the doors due to thermal expansion and contraction.

Next to open are centerline latch groups 1 to 4 and 13 to 16, which secure the centerline near the forward and aft bulkhead. Opening these groups next helps relieve the tension in the door due to thermal warping. Centerline latches must be opened before the bulkhead latches to decrease tension in the doors.

When all the centerline latches are open, the starboard forward and aft bulkhead latches open. This removes any tension in the starboard door due to the latches and thermal warping. The starboard door is then opened. It is opened first because it overlaps the port door and contains the centerline latch mechanisms. The port forward and port aft bulkhead latches on the port door are

opened next, followed finally by the port door.

The crew can use either the auto or manual mode to open the payload bay doors. Both sequences are controlled by software. In either mode, the crew makes item entries to the PL BAY DOORS display, which provides the interface between the crew and the doors. The display can be called up as PASS SM OPS 202 or 402 or as BFS SM OPS 0 or SPEC 63. Each operates exactly the same. Nominally, the doors are opened and closed using the primary software in OPS 202. When the primary software is not in OPS 2, and payload bay door operations are needed, the BFS is used. This occurs when the doors must be opened early (loss of cooling for example) or when the doors are closed late in preparation for entry. In addition, the crew uses control switches and talkbacks on panel R13L.

2021/ /		PL BAY DOORS		4 000/02:00:00	
AC POWER ON 1*		OFF 2		000/00:00:00	
AUTO MODE SEL 3		PBD SW-CL			
				MICRO-SW STAT	
				LATS DOORS	
				CC00 CRRRO	
				ABAB ABC	
CENTER LATCHES		MAN	OP/CL	AUTO	
		SEL		SEQ	
5- 8		4	OP		0011
9-12		5	OP		0011
1- 4		6	OP		0011
13-16		7	OP		0011
STBD					
FWD LATCHES		8	OP		0011 00000
AFT LATCHES		9	OP		0011 00000
DOOR		10*			
PORT					
FWD LATCHES		11	CL		1100 11110
AFT LATCHES		12	CL		1100 11110
DOOR		13	CL		
PBD SW BYPASS 14					
					OPEN 15
					STOP 16
					CLOSE 17

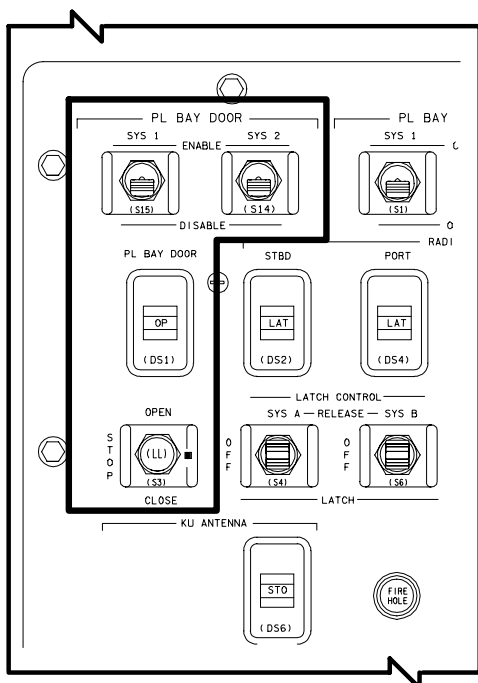
PL BAY DOORS Display

RAD/PLBD OPS NO GO FOR FOLLOWING FAILURES			
OMS/RCS	GNC	ECLS/EPS	MECH
1 OMS Engs	2 IMUs	1 H2O or Freon Lp	2 LG DPY METHODS
1 OMS Eng and 1 +X RCS Jet	3 RGAs	Both RFCAs	PRES or REDNT WINDOW PANE FAILURE
	3 Aas	Both Cab Fans	
1 OMS Inlet line			
	3 adtaS	3 OF 6 Av Bay Fans	
OMS Prop TK Leak			DPS
	3 Elevon or 2 BF Pos	2 FCs	3 GPCs
Aft RCS He or Prop Leak	Fdbks (same surface)	Any Mn or 3 phase AC Bus	2 PL MDMs
			2 FF or FA MDMs
COMM			APU/HYD
No Voice and No CMD	2 FCS CH (same surface)	Any CNTL or MPC Bus	2 APU/HYD/WSB
		3 IMU Fans	

Opening Doors in Auto Mode

The software monitors the latches and door drives for premature and out-of-sequence operation during the auto mode (i.e., door opening before it is unlatched). If any of the latches or doors are out of configuration, the auto mode stops, removes ac power to all the payload bay door (PLBD) motors, and generates a fault message PLBD CONFIG with an *SM ALERT*. If any latch or door drive exceeds its single-motor drive time, the auto sequence will stop, remove ac power to all the PLBD motors, terminate all drive commands, and generate a fault message PBD SEQ FAIL with an *SM alert*. These safety devices prevent door and latch damage.

To open the doors using the auto mode, the crew first sets the *PL BAY DOOR* switch on panel R13L to *STOP*. Then, using the *PL BAY DOORS* display, item 1, *AC POWER ON*, is executed to apply ac power to the latch and door drives. Item 3, *AUTO MODE SEL*, is executed to select the auto mode of operation. The auto sequence is initiated by placing the *PL BAY DOOR SYS 1* and *SYS 2* switches on panel R13L to *ENABLE*. (The auto sequence can also be initiated by selecting item 14 (PBD SW BYPASS) and then item 15 (OPEN). This can be used in the event of a switch failure or if the crew does not want to go to the aft station). The status of the doors is displayed on the *OP/CL STATUS* line of the display.



PL BAY DOOR Controls on Panel R13L

If item 14 is not selected, the *PL BAY DOOR* switch on panel R13L is set to *OPEN*, which initiates the auto sequence, centerline latches first. The status of the sequence as it proceeds can be monitored on the display. When *OP/CL* status of the door shows *OP*, the panel R13L *PL BAY DOOR* switch is set to *STOP*, *PL BAY DOOR SYS 1* and *SYS 2* are set to *DISABLE*, item 2 on the CRT (*AC POWER OFF*) is executed, and the payload bay floodlights are turned off.

Opening Doors in Manual Mode

The software does not monitor the latch and door opening during the manual mode as it does with the auto mode. The crew must monitor the limit-switch indications and motor drive times very carefully to determine if the doors and latches are opening properly. Any latch or door can be driven out of sequence (i.e., the bulkhead latches can be opened first). The crew should verify that the two gold bands are showing on each of the six push rods on the port and starboard doors. This indicates the doors are open, and no warping or jamming has occurred.

To open the doors using the manual mode, the crew sets the *PL BAY DOOR* switch on panel R13L to *STOP*, executes item 1, *AC POWER ON*, of the *PL BAY DOORS* display, and sets panel R13L *PL BAY DOOR SYS 1* and *SYS 2* switches to *ENABLE*. Then the manual sequence is initiated.

First, the centerline latches are opened. Using the display, items 4 and 5 are executed in sequence to open centerline latches 5 through 8 and 9 through 12. The *PL BAY DOOR* switch on panel R13L is set to *OPEN*. When the display indicates *OP* for centerline latches 5–8 and 9–12, the *PL BAY DOOR* switch is set to *STOP*. Centerline latches 5–8 and 9–12 are deselected on the CRT, and then centerline latches 1–4 and 13–16 are selected. The *PL BAY DOOR* switch is set to *OPEN*. When the display indicates that centerline latches 1–4 and 13–16 are open, the *PL BAY DOOR* switch is set to *STOP*. Centerline latches 1–4 and 13–16 are deselected on the CRT.

Next, the starboard forward and aft latches and door are opened. Items 8 and 9, *STB FWD*

LATCHES and AFT LATCHES, are selected on the CRT. The *PL BAY DOOR* switch is set to *OPEN*. When the display indicates the latches are open, *PL BAY DOOR* is set to *STOP*. The latches are deselected, and item 10, *STBD DOOR*, is selected. The *PL BAY DOOR* switch is set to *OPEN* and then to *STOP* when the display shows *OP*. *STBD DOOR* is deselected on the CRT.

Finally, the port forward and aft latches and door are opened, using items 11, 12, and 13 to follow a sequence nearly identical to the one described above for the starboard door. The exception is that after the door is opened, and *PL BAY DOOR* switch is set to *STOP*, *PL BAY DOOR SYS 1* and *2* switches are set to *DISABLE* before deselecting *PORT DOOR*. Item 2 is then executed to turn *AC POWER OFF*, and the payload bay floods are also turned off.

Payload Bay Doors: Closing

The payload bay doors are closed approximately 2 hours and 45 minutes before the deorbit burn. The sequence for closing the doors is the direct reverse of the sequence for opening them. The port door is closed first, followed by the port forward and port aft bulkheads. The starboard door is closed next, followed by the starboard forward and aft bulkhead latches. Finally, the centerline latch groups are closed in the following order: 1 to 4, 13 to 16, 5 to 8, and 9 to 12.

The crew can use an auto or manual mode for closing the doors. The difference in monitoring between the two modes is the same as it is for opening the doors. Panel R13L and the *PL BAY DOORS* display are also used for closing the doors. The payload bay doors are normally opened and closed using the auto mode.

Closing Doors in Auto Mode

To close the doors using the auto mode, the crew sets the *PL BAY DOOR* switch on panel R13L to *STOP*. Item 1 on the *PL BAY DOORS* display is executed to turn ac power on, and item 3, *AUTO MODE SEL*, is executed. The auto sequence is initiated by placing the *PL BAY DOOR SYS 1* and *SYS 2* switches on panel R13L to *ENABLE* and then setting the *PL BAY DOOR* switch to *CLOSE*. The status of the sequence is displayed on the CRT. When the sequence is complete, the *PL BAY DOOR* switch is set to *STOP*, *PL BAY DOOR SYS 1* and *SYS 2* are set to *DISABLE*, and item 2 on the CRT is executed to turn ac power off.

Closing Doors in Manual Mode

To close the doors using the manual mode, the crew sets the *PL BAY DOOR* switch to *STOP*, executes item 1 on the display, and sets *PL BAY DOOR SYS 1* and *SYS 2* switches to *ENABLE*. Then the manual sequence is initiated.

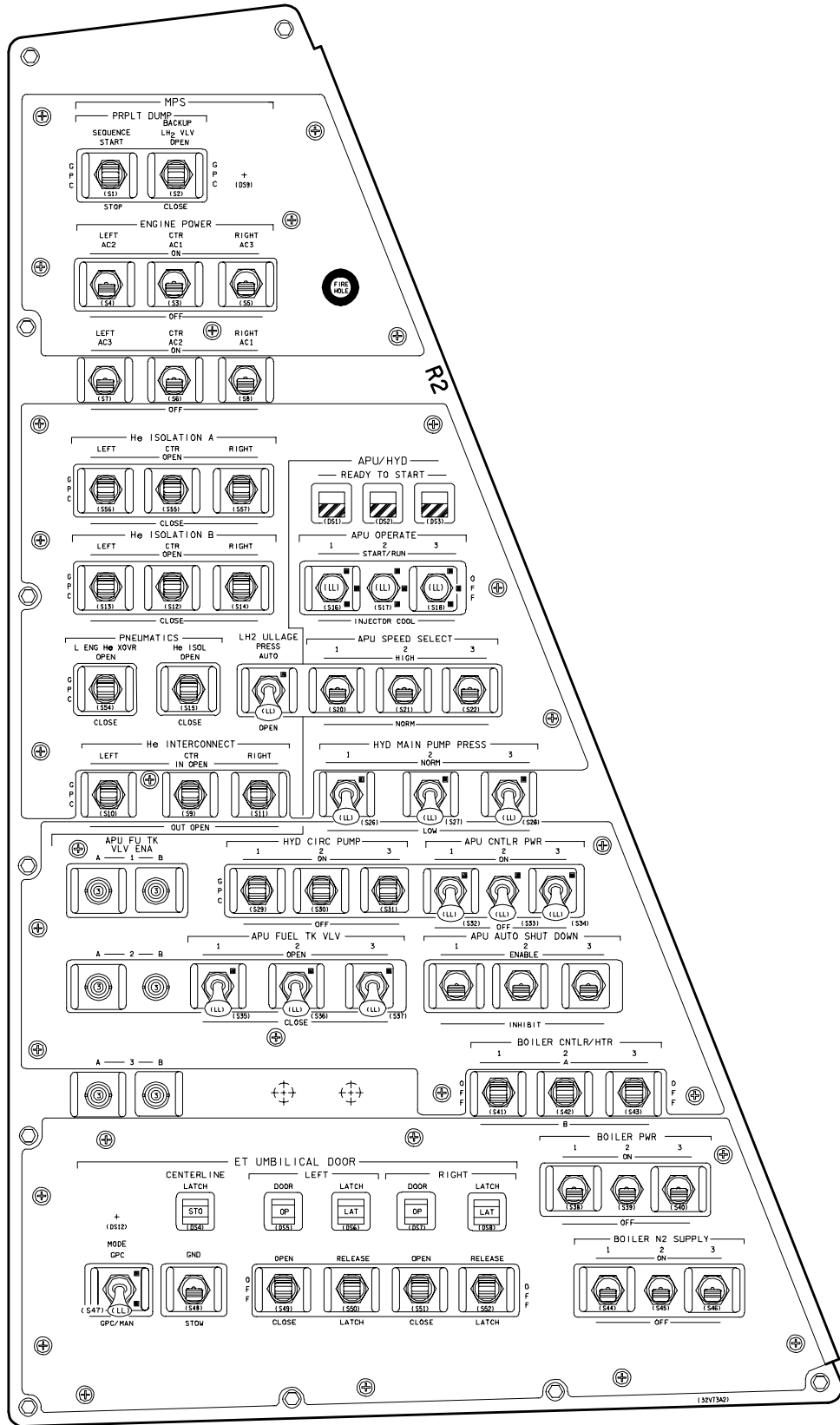
First, item 13, *PORT DOOR*, is selected. The *PL BAY DOOR* switch is set to *CLOSE*. When the port door is closed, items 11 and 12, *PORT FWD* and *AFT LATCHES*, are selected. *PL BAY DOOR* is set to *STOP*, and *PORT FWD* and *AFT LATCHES* and *DOOR* are deselected.

STBD DOOR is then selected and follows the same procedure as the port door. The centerline latches are then closed in the following sequence: 1–4 and 13–16 and 5–8 and 9–12. The two pairs of latch groups are selected, *PL BAY DOOR* is set to *CLOSE*, then *STOP*, and the latches are deselected.

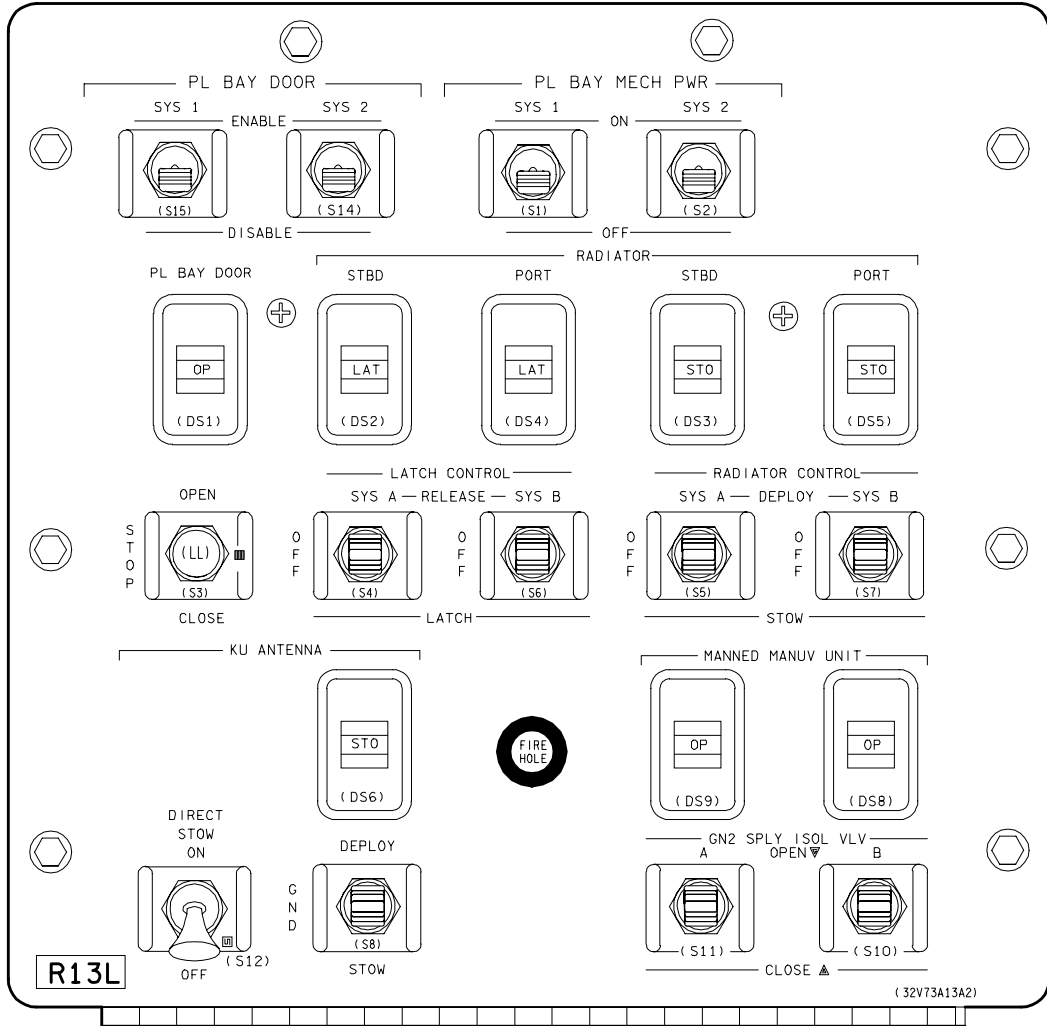
When the latches are closed, *PL BAY DOOR SYS 1* and *SYS 2* are set to *DISABLE*, and CRT item 2 is executed to turn off the power.

Mechanical Systems Summary Data

- Orbiter mechanical systems are those components that must be deployed, stowed, opened, or closed. Each is physically moved by an electrical or hydraulic actuator.
- All orbiter electromechanical actuators contain two three-phase ac motors, brakes, a differential, a gearbox, and limit switches. With the exception of the vent doors and ET door centerline latches, all actuator assemblies also contain torque limiters.
- Power for actuator motors and limit switches is provided by motor control assemblies that are controlled by panel MA73C.
- The active vent system equalizes the unpressurized orbiter compartments and controls the orbiter's internal environment by opening and closing vent doors in orbit or on the ground.
- The active vent system operates automatically, except for preentry when the crew uses GNC SPEC 51 OVERRIDE display to open or close the vent doors.
- The external tank umbilical doors shield the two aft umbilical openings on the underside of the orbiter. The doors are closed post-OMS 1 burn after MPS vacuum inerting.
- ET umbilical doors are controlled by the flight crew with switches on panel R2 or item entry on the GNC SPEC 51 OVERRIDE display.
- The payload bay doors provide an opening for payload deployment from and retrieval into the payload bay.
- Two doors, port and starboard, are connected to the midfuselage. They are held closed by groups of centerline and bulkhead latches.
- Payload bay doors are opened approximately 1 hour and 25 minutes into a nominal flight and closed about 2 hours and 45 minutes before the deorbit burn.
- Payload bay doors displays and controls are on panel R13L and the PL BAY DOORS display.



Panel R2



Panel R13L

3051/051/	OVERRIDE	2 008/04:13:37
		000/00:29:56
ABORT MODE	ENTRY FCS	
TAL 1	ELEVON	FILTER
ATO 2	AUTO 17*	NOM 20*
ABORT 3	FIXED 18	ALT 21
MAX THROT 4	SSME REPOS 19	ENA S POLE 24
PRPLT DUMP	IMJ STAT	ATT DES PRL
	1 3 25	SYS AUT DES
	2 26	1 28* 31
	3 27	2 29* 32
		3 30* 33
INH ICNCT 5		
OMS DUMP	ADTA	H α M DES
ARM 6	L 1	20466 + 7.0 0.58 34
START 7	3	20466 + 7.0 0.58 35
STOP 8	R 2	20892 + 6.9 0.58 36
9 QUAN/SIDE 78	4	20892 + 6.9 0.58 37
OMS DUMP TTG 520	ET SEP	ROLL MODE AUTO
	AUTO 38	AUTO SEL 42
AFT RCS 13	SEP 39	WRAP MODE 45
14 TIME 0	ET UMB DR	VENT DOOR CNTL
	CLOSE 40	OPEN 43*
FWD RCS 15	RCS RM MANF	CLOSE 44
16 TIME 0	CL OVRD 41	

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OVERRIDE Display (SPEC 51)

2021/ /	PL BAY DOORS	4 000/02:00:00
		000/00:00:00
AC POWER	ON 1*	
	OFF 2	PBD SW-CL
AUTO MODE	SEL 3	
CENTER LATCHES	MAN SEL	OP/CL AUTO SEQ
5-8	4	OP
9-12	5	OP
1-4	6	OP
13-16	7	OP
STBD		
FWD LATCHES	8	OP
AFT LATCHES	9	OP
DOOR	10*	
PORT		
FWD LATCHES	11	CL
AFT LATCHES	12	CL
DOOR	13	CL
PBD SW BYPASS 14	OPEN 15	
	STOP 16	
	CLOSE 17	

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PL BAY DOORS Display

Mechanical Systems Rules of Thumb

Always use a timer when operating mechanical systems, noting either dual or single motor time. Do not continue to command driving if greater than the single motor time has elapsed without the mechanism reaching the desired state.