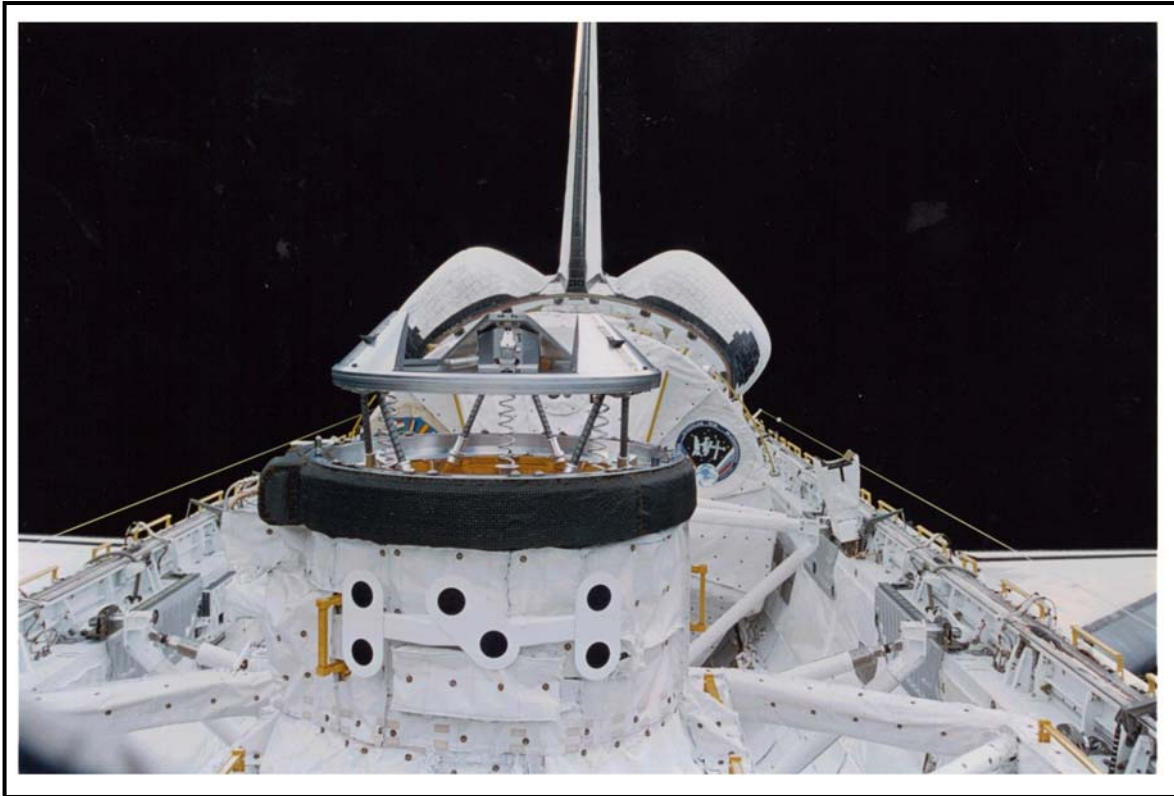


Space Flight Operations Contract

Androgynous Peripheral Docking System Reference Guide



February 14, 2005

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Androgynous Peripheral Docking System

Reference Guide

Original approval obtained

Gary Rowen
Book Manager
USA/Shuttle Systems

Original approval obtained

E. Grant Slusser, Jr.
Manager
USA/Shuttle Systems

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APDS OPERATIONS SUMMARY

Flight Day 2

CENTERLINE CAMERA INSTALLATION

The ODS C/L Camera is a CTVC mounted on a bridge inside the external airlock for docking. This camera looks out through the ODS hatch window at the ISS and PMA docking target during approach.

It is the primary method of determining vehicle alignment during latter stages of approach and docking and is considered mandatory per the flight rules for completion of the approach.

DOCKING MECHANISM INITIALIZATION

This procedure verifies and configures the switches and circuit breakers of the Docking System Power Panel (A6L), the APDS Control Panel (A7L), and the ML86B panel.

DOCKING MECHANISM POWERUP

Provides Main A and Main B bus power to the Power Switching Unit (PSU) avionics box to power motors.

Activates heaters on the docking mechanism petals and associated structural hardware.

Powers the Data Collection Units (DCU).

Provides power to the control panel push-buttons and status lights.

Provides logic power from the control panel to the PSU box.

Verifies operation of the control panel.

DOCKING RING EXTENSION

The active ring is extended from the launch position (FINAL position), to the ready-to-dock position (INITIAL position).

At Initial Position the slip clutch is moded to SLIP.

The docking ring at Initial Position provides maximum attenuation and compliance at contact.

DOCKING MECHANISM POWERDOWN

Powers down the docking panels, Docking System Power and APDS Control Panel.

Removes power from the PSU avionics box.

Flight Day 3

CONFIGURE FOR DOCKING (A step in the APPROACH cue card)

DOCKING MECHANISM POWERUP (As done on Flight Day 2)

DOCKING PREP

This procedure provides power to the avionics and verifies the mechanism is in the proper configuration to dock. The vestibule and truss lights are powered on at this time.

DOCKING SEQUENCE (cue card)

Contact/Capture/Damping

Five seconds after capture, dampers automatically energize to damp relative motion between orbiter and ISS. The ISS also enters into free drift.

Disable and Release Dampers

Power is removed from dampers by crew pb action. The ring is retracted for five seconds then extended for five seconds. This procedure helps to assure that the dampers have mechanically disengaged.

Retract Ring

Once ring alignment has been achieved and relative motion damped out, the ring is retracted. Ring retraction is terminated automatically, at approximately 5% base position, shortly after the hooks begin to drive.

Close Hooks

When the APDS and Pressurized Mating Adapter (PMA) surfaces come together the active hooks on the APDS are automatically powered on to engage the passive hooks on the Station PMA. When this is complete, also referred to as "hard dock", the interface is sealed and attitude control may be resumed either by ISS or Shuttle

Load Relieve Capture Latches (Extend Ring)

The ring is commanded to extend for ten seconds. The ring moves slightly which allows compression loads on the capture latches to be relieved allowing capture latches to be more easily opened. (Note: If load relief cannot be accomplished, capture latches can still be successfully opened.)

Open Capture Latches

Capture latches are then commanded open from their closed position. The active ring capture latches no longer engage the ISS PMA striker plates.

Retract Ring to FNL POS

The active ring is now driven to the final position, the position the ring was in at launch.

Power Off

De-energizes relays in the docking system avionics boxes.

TERMINATE RNDZ OPS

Docking Mechanism Powerdown is performed and truss and vestibule lights are powered off.

DOCKING MECHANISM POWERDOWN (as done on Flight Day 2)

Flight Day 8 (or as scheduled in flight plan)

UNDOCKING / SEPARATION TIMELINE

DOCKING MECHANISM POWERUP (as done on Flight Days 2 and 3)

UNDOCKING PREP

Similar to DOCKING PREP, this procedure provides power to the avionics and verifies the mechanism is in the proper configuration to undock.

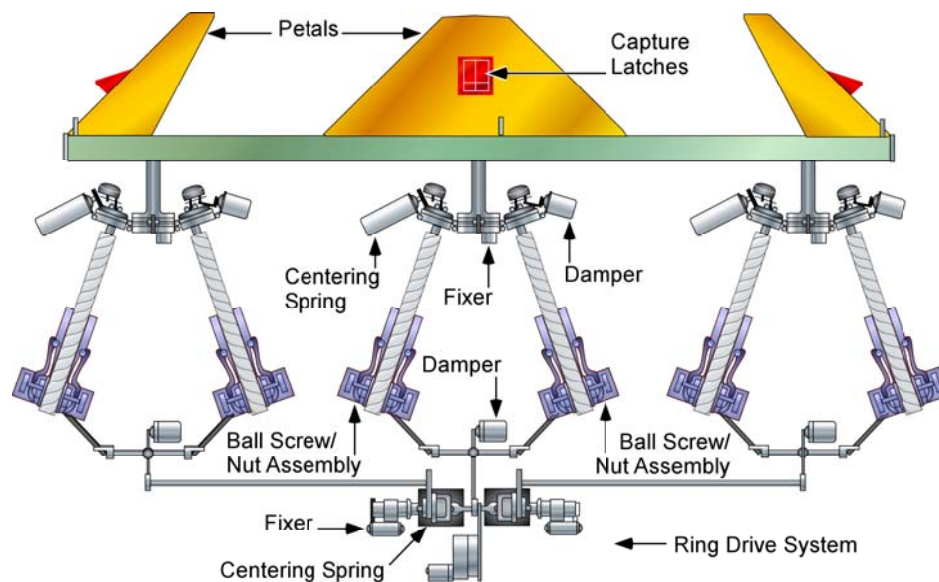
COMMAND UNDOCKING

APDS circuit protection is removed and the Undocking push-button is pushed. This procedure disengages the APDS active hooks from the ISS PMA passive hooks allowing physical separation of the Orbiter from the Station. Undocking springs on both the APDS and ISS PMA mechanisms assist with pushing the Orbiter from the Station. The APDS is then powered off and the Docking Mechanism Powerdown performed. The vestibule and truss lights are then powered off.

DOCKING MECHANISM POWERDOWN (as done on Flight Days 2 & 3)

- **ACTIVE DOCKING RING**

- ❖ Ring Drive System
- ❖ Ball Screw / Nut Assemblies
- ❖ Centering Springs
- ❖ Dampers
- ❖ Fixers
- ❖ Petals
- ❖ Capture Latches



Active Ring Components

Ring Drive System

- Two redundant DC Motors
- Power Drive Unit (PDU)
- Gear Drive Train
 - The PDU enables the DC motors to rotate three pairs of ball nuts that drive the ring to extend/retract through a clutch mechanism
- Clutch
 - Two modes of operation; LOCK and SLIP
 - To drive the ring, the clutch is moded to LOCK (or engaged) when **RING IN** or **RING OUT** pb is pushed.
 - At Initial Position the clutch is driven to SLIP (or disengaged) by the APDS logic which provides the mechanism with compliance and attenuation at contact. Therefore, SLIP mode is required for docking.
 - When mated the ring cannot extend or retract without being in the LOCK position.

Ball Screw / Ball Nut Assembly

- Each assembly (three) consists of a pair of ball screws and ball nuts
- Three assemblies work together to perform two functions:
 - Allows the ring to extend or retract
 - Enhances likelihood of capture (e.g., depress one petal, others rise up)
- Provides 6 degrees of freedom: pitch, yaw, roll and translation (X,Y,Z)

Centering Springs

- Consists of five springs; two within the ring drive system and one positioned at the base of each petal
- Used to maintain ring alignment during all phases of operation

Dampers

- Electromagnetic brakes (Eddy current dampers)
- Dampers serve two purposes
 - To absorb energy induced upon initial contact between the two vehicles
 - To help slow the relative motion between the two vehicles
- Activated automatically five seconds after capture logic complete; remains on until **POWER ON / POWER OFF** command issued
- Total of six dampers on the active docking ring; three high-energy and three low-energy
 - High Energy Dampers - Located at the base of each ball screw / nut assembly. (These feature dovetail grooves and sometimes do not release mechanically when electrically disengaged - the reason for the Release and Disable Dampers procedure in the Docking Sequence Cue Card)
 - Low Energy Dampers - Located under each petal (smooth plates that always mechanically release when electrically disengaged)

Fixers

- Mechanical devices that limit the active docking ring movement to translation in the +/- Z_0 direction
- Automatically activated during ring extension and ring retraction to maintain alignment
- Solenoid devices that lock ring gear train together to limit deflections of the ring during ring drive
- Total of five fixers
 - 3 located on the top of each ball screw / nut assembly to provide rotational and lateral alignment
 - 2 located on the ring drive system to provide angular alignment
- Can be inhibited by crew command, **FIXER OFF**, from the APDS Control Panel

Petals

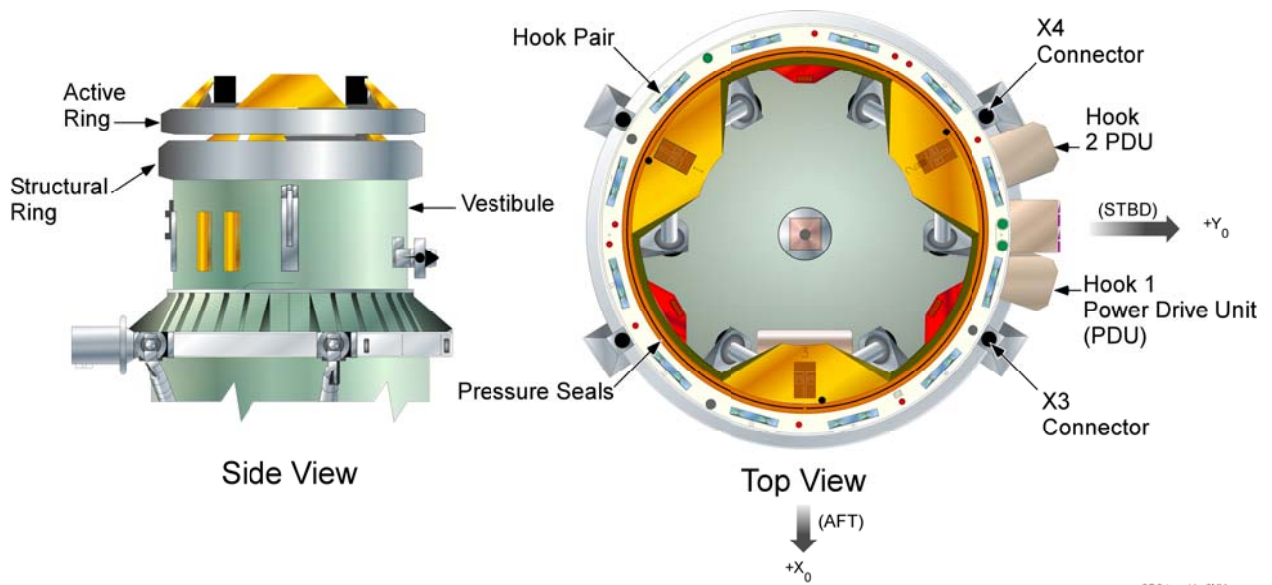
- Three petals equally spaced around the circumference of the docking ring
- Petals act as guides and interface with the three petals located on the ISS PMA

Capture Latches

- One pair of capture latches located on each petal
- Provide a temporary docking interface (soft dock) between the Orbiter and ISS

- **STRUCTURAL RING**

- ❖ Hooks
- ❖ Alignment Pins
- ❖ Sensors
- ❖ Pressure Seals
- ❖ Undocking Springs
- ❖ X3 / X4 Connectors



Structural Ring

Hooks

- 12 pairs of hooks (24 total)
 - 12 active, 12 passive – each pair of Hooks has one active and one passive hook
 - Active hooks are used to engage ISS passive hooks and provide a hard mate between the two vehicles
- Hooks are grouped together, even and odd
 - Group 1 contains hooks 1, 3, 5, 7, 9, 11
 - Group 2 contains hooks 2, 4, 6, 8, 10, 12
- Each group of hooks has two DC motors
 - Hooks 1 - motors 1 & 2
 - Hooks 2 - motors 1 & 2
- DC Motors in the Power Drive Unit (PDU) drive one of set of hooks and the remainder of hooks in that group are attached by a cable-pulley system (See drawing on pg 33).

Alignment Pins

- Four 60 mm tapered pins; two located 120° apart on the Shuttle side and two on the Station side
- Used to align APDS and PMA structural rings during docking, just prior to hard mate.

Sensors

- Multiple sensors located around the Structural Ring
- Used to provide docking system status

Pressure Seals

- Two concentric orange 3mm thick seals that are embedded within the APDS structural ring.
- Used to provide the airtight seal between the Shuttle and Station.

Undocking Springs

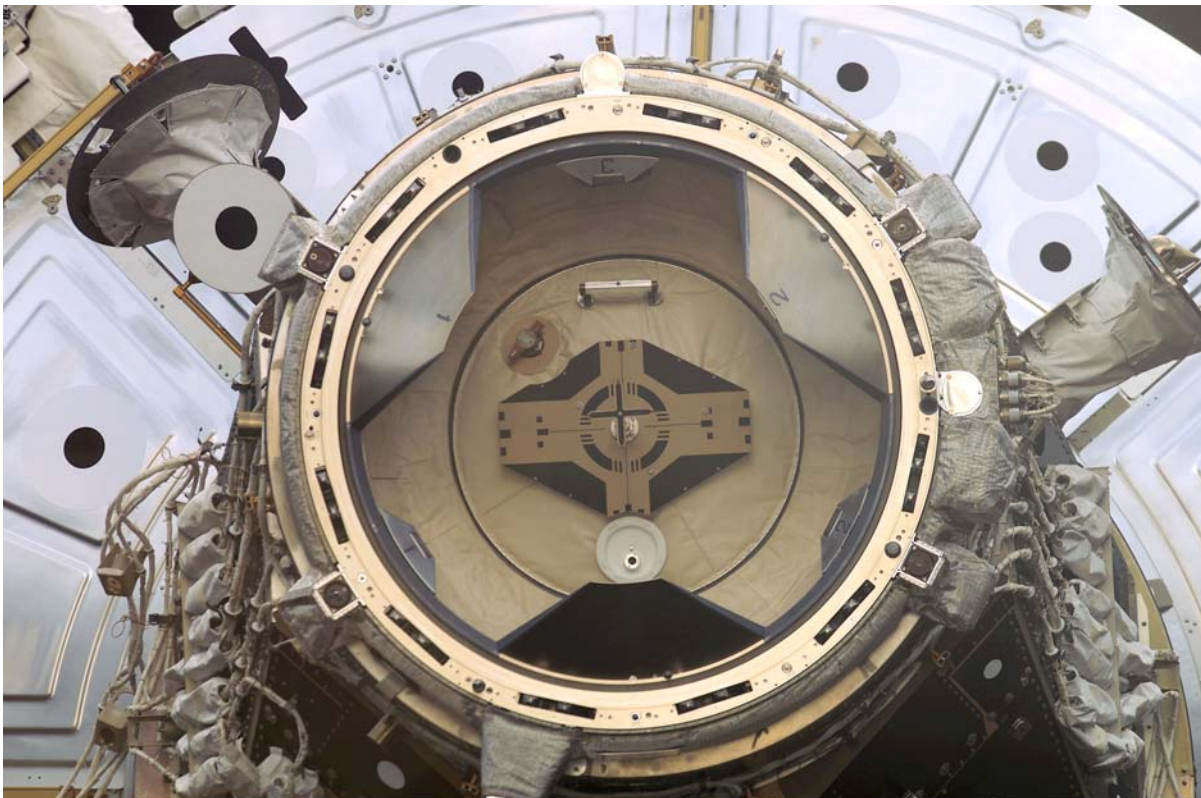
- Total of four undocking springs; two located 180° from one another on the Shuttle side and two on the Station side.
- Used to push apart the two vehicles during post-undocking
- Four undocking springs provide combined separation force of between 551lbs and 595 lbs.

X3 / X4 Connectors

- Located on the Structural Ring
- Provides an electrical path to drive the ISS PMA Active Hooks to engage the APDS passive shuttle hooks (in the event some of the ODS APDS active hooks have failed to engage the PMA passive hooks)

Pressurized Mating Adapter

- Mounted on the ISS Node 2/3
- Twelve pairs of hooks on the PMA directly oppose twelve pairs of hooks on ODS.
- Twelve passive hooks on the PMA are “grabbed” by twelve APDS active hooks
- In the event of failure of ODS hook or hooks, one group of six active PMA hooks “grab” the opposing six passive APDS hooks on the ODS
- There are two groups of hooks on the PMA
 - Group 1 active hooks grab ODS Hooks 2 passive hooks
 - Group 2 active hooks grab ODS Hooks 1 passive hooks
- PMA hooks entirely controlled from A6 Docking System Power Panel
- There are no hook disengage pyrotechnics on PMA; all pyros are on the ODS APDS active and passive hooks and are controlled from the A6 Docking System Power Panel
- Conditions required before PMA hooks can be commanded closed:
 - Hard mate (“hard dock”) as been achieved
 - At least one group of six hooks has been successfully closed
 - X3/X4 connectors mated for electrical continuity to command PMA hooks



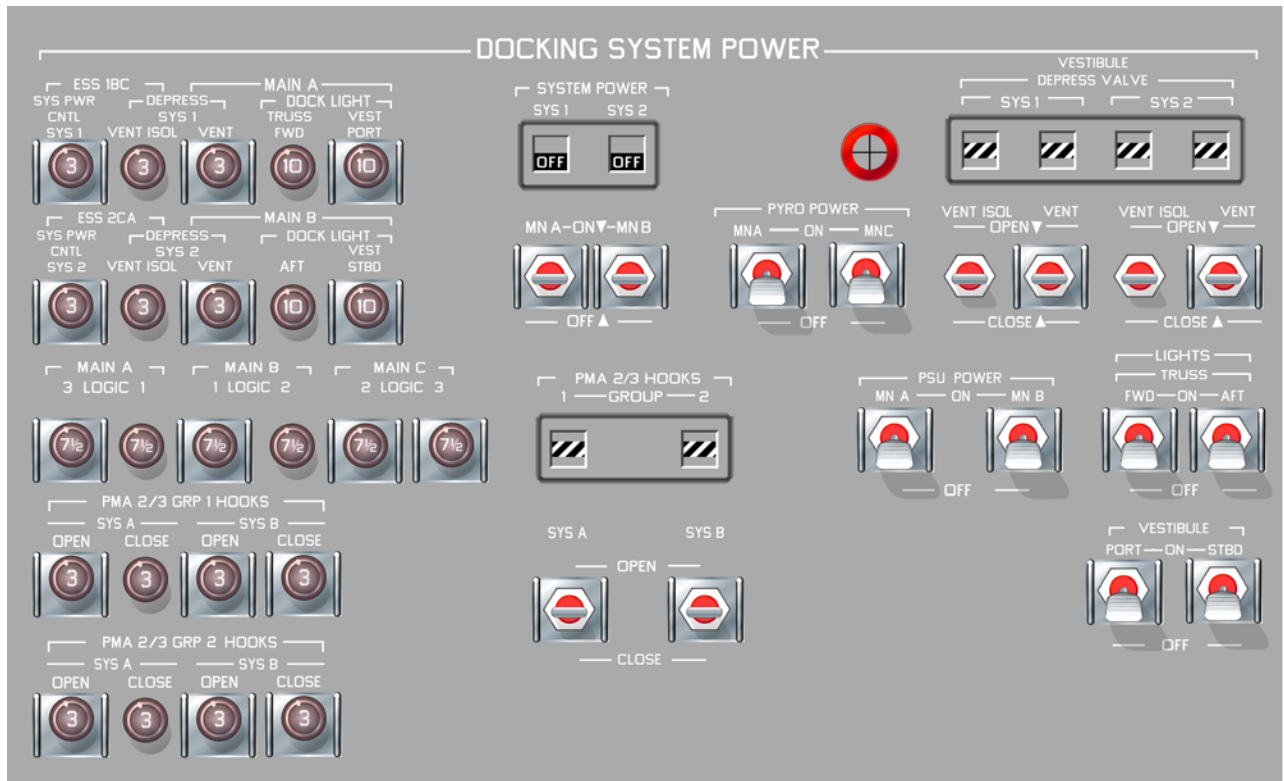
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CREW INTERFACES

- ❖ Panel A6L – Docking System Power Panel
- ❖ Panel A7L – APDS Control Panel
- ❖ SM SPEC 167 – Docking Status

Panel A6L – Docking System Power Panel

- **Switches and circuit breakers provide:**
 - Orbiter power to the APDS avionics
 - Control of and circuit breaker protection for the following:
 - Vestibule depress vent and isolation valves
 - PMA 2/3 Group 1 and Group 2 hooks
 - Pyro Firing Control Unit (PFCU)
 - Vestibule and truss lights



Doc sys power.CNV

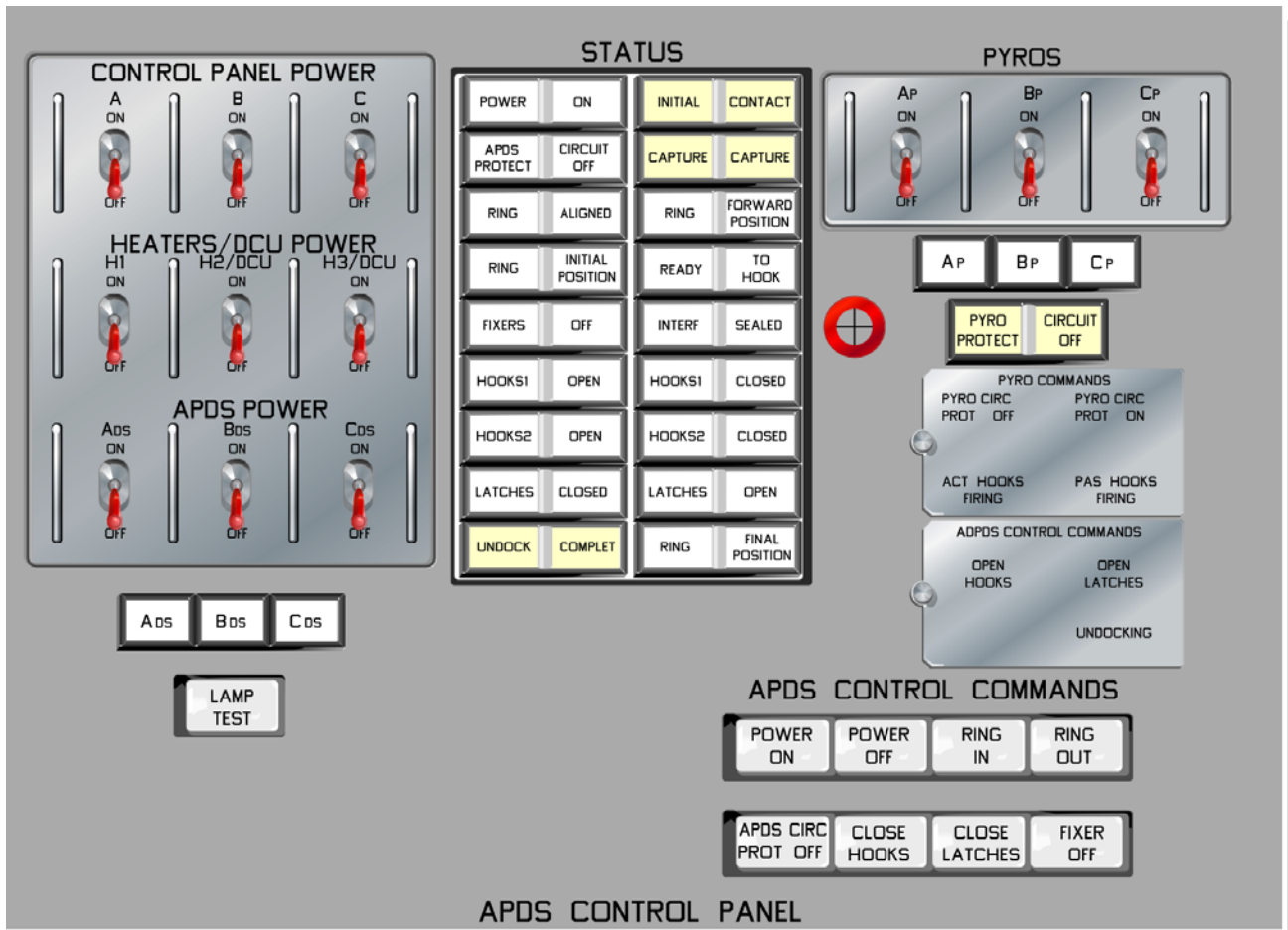
A7L - APDS Control Panel

- Russian built panel

- Circuit Breakers provide
 - Control bus power
 - APDS logic bus power
 - DCU power
 - Pyro power

- Push button commands:
 - Power the avionics
 - Extend and retract the active ring
 - Open and close the hooks
 - Open and close the capture latches
 - Fire pyrotechnics to open hooks (contingency)

- Status lights:
 - Power and circuit protection
 - Ring position
 - Hooks open and close
 - Contact capture and undocking
 - Latches open and close



APDS control panel.CNV

Notes:

- APDS CIRC PROT OFF pb push is required before OPEN HOOKS, RING OUT, OPEN LATCHES, or UNDOCKING will function
- All pushbuttons require “Two Fingers Two Seconds rule” – use two fingers for maximum of two seconds

Summary of SM SPEC 167 – Docking Status

- **Provides additional status information:**
 - Drive control, logic, bus power
 - Active ring
 - Structural ring hooks and Pressurized Mating Adapter hooks
 - Capture latches
 - Orbiter Docking System (ODS) X3/X4 Connectors
 - Pyro bus

2011/ /167		DOCKING STATUS				UL 4	
CONTACT	OFF	CNTL PNL	PWR A / B / C	CNTL CMD	PWR ON		
CAPTURE	OFF	HTR/DCU	PWR A / B / C	RNG DR	BUS	1 / 2	
DAMPING	OFF	APDS	PWR A / B / C	HKS DR	BUS	1 / 2	
RNG ALGN	ON	APDS	CIRC PROT OFF	DAMPER	BUS	1 / 2	
RING POS	/	/FNL		FIXER	BUS	1 / 2	
DRV CMD	OFF		PMA 2/3	OP / CL			
FIXERS	OFF		HK1 CMD	/			
CLUTCH LOCK	/		IND	/			
PETAL POS 1	2	3	HK2 CMD	/			
RING 50	50	50	IND	/			
BASE 5	5	5	HK CLS				
UNDOCK CMPLT	ON		1/3/5	7/9/11			
RDY TO HOOK	OFF		2/4/6	8/10/12			
HK1 DRV CMD	OFF		ODS INDIV	HK CL	ODS CONN		
POS 5			1 3 5 7 9 11		X3 OFF		
IND OP /					X4 OFF		
HK2 DRV CMD	OFF						
POS 5			2 4 6 8 10 12				
IND OP /							
CAP LAT CMD	OFF		PYRO LOGIC PWR	/ /			
IND /CL			PYRO CIRC PROT	ON / /ON			
MAN REL	CL		PYRO MNA 40/6 AMP	OFF /OFF			

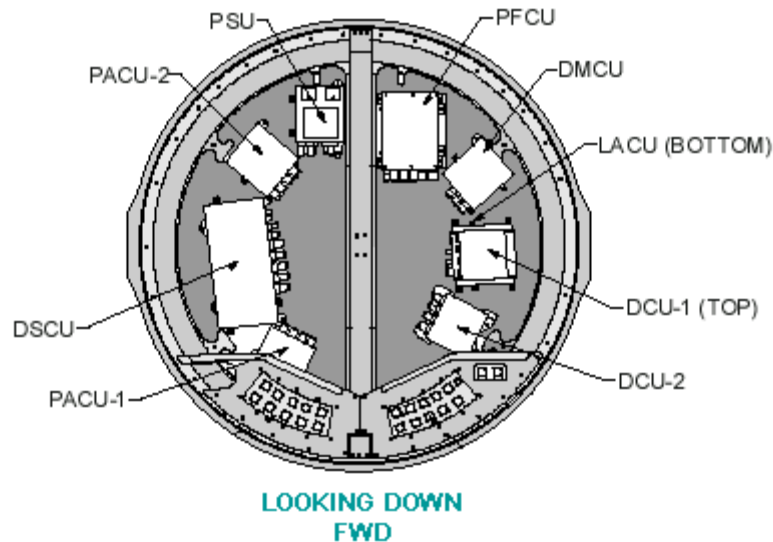
SPEC 167 PRO

Notes:

- Loss of DCU 1, DCU 2, DSC OA1, DSC OA2, or DSC OA3 will cause the loss of data to Spec 167 display and to the MCC.
- APDS CONTROL PANEL, A7, status lights are not effected by loss of data to Spec 167
- Effected parameters are published in the Flight Data File, REFERENCE DATA, Page 2-20 (see page 35 in this reference guide)

Avionics

The APDS avionics are located in the subfloor of the external airlock and consists of the following control systems:



Power Switching Unit (PSU)

- Relay box that distributes Orbiter power to APDS avionics

Docking System Control Unit (DSCU)

- Interfaces with all other avionics with the exception of the PFCU
- Controls timing and sequencing of the auto docking sequence

Docking Mechanism Control Unit (DMCU)

- Avionics that operate the ring motors

Pressure Actuation Control Unit (PACU)

- Avionics that operate the hook motors

Latch Actuator Control Unit (LACU)

- Avionics that operate the capture latch motors
- Latch open/close powered by APDS power and not PSU

Pyro Firing Control Unit (PFCU) (contingency only)

- Avionics that operate pyrotechnical devices to release active or passive hooks on the structural ring

Data Collection Units (DCU)

- Two DCUs
- Processes APDS telemetry to SPEC 167
- Provides power to telemetry sensors
- Not setup to be redundant; each DCU processes its own specific data

TABLE OF ACTIONS, TALKBACKS and TELEMETRY

A7 APDS CONTROL PANEL

APDS CONTROL COMMANDS				
PUSH BUTTONS	RESULTS	A7 PANEL	SPEC 167	COMMENTS
POWER ON	Powers on the system Stops ring drive Disables dampers	Appropriate status lights illuminate	CNTL CMD PWR - ON	Maximum of two hour time limit
POWER OFF	Removes power from the avionics Stops ring and hook drive	Status lights extinguish	CNTL CMD PWR - OFF	
RING IN	Commands ring to retract	None	RING DRV CMD - ON FIXERS - ON (unless powered off by FIXERS OFF pb-push) CLUTCH - LOCK PETAL POS 1 2 3 BASE - readings decrement	RING FORWARD or INITIAL POSITION, lights extinguish as ring moves away from position
RING OUT	Commands ring to extend	None	RING DRV CMD - ON FIXERS - ON (unless powered off by FIXERS OFF pb-push) CLUTCH - LOCK PETAL POS 1 2 3 BASE - readings increment	RING FINAL or INITIAL POSITION lights extinguish as ring moves away from position Requires APDS Circ Prot Off pb pushed first
APDS CIRC PROT OFF	Enables Ring Out, Open Hooks, Open Latches, and Undocking pushbuttons	APDS CIRCUIT PROTECT OFF light illuminates	APDS CIRC PROT - OFF	
CLOSE HOOKS	Initiates closing of the APDS active hooks	Hooks1(2) closed light at completion of drive	HK1 DRV CMD - ON HK1 POS - incrementing HK1 IND - blank HK2 DRV CMD - ON HK2 POS - incrementing HK2 IND- blank	Backup procedure in event auto close fails

APDS CONTROL COMMANDS (continued)				
PUSH BUTTONS	RESULTS	A7 PANEL	SPEC 167	COMMENTS
CLOSE LATCHES	Moves capture latches to the closed position	LATCHES CLOSED light illuminates	CAP LAT CMD - ON (during transit) CAP LAT IND - CL	Need all 3 latches closed to get light on A7 Panel
FIXER OFF	Inhibits fixers Disables ring Initial Position logic	FIXERS OFF light illuminates	RING FIXERS - OFF	Requires a POWER OFF cmd to reset
OPEN HOOKS	Initiates opening of the APDS active hooks	Hooks1(2) open light at completion of drive	HK1 DRV CMD - ON HK1 POS - decrementing HK1 IND - blank HK2 DRV CMD - ON HK2 POS - decrementing HK2 IND - blank	Requires APDS Circ Prot Off pb pushed first Contingency if Undocking pb fails
OPEN LATCHES	Moves capture latches to the open position	LATCHES OPEN light illuminates	CAP LAT CMD - ON (during transit) CAP LAT IND - OP	Requires APDS Circ Prot Off pb pushed first
LAMP TEST	Tests status lamps	All 18 status lights plus pyro status lights illuminate	None	ADS, BDS, CDS, AP, BP, CP lights are not tested (they are already illuminated)
PYRO COMMANDS				
PUSH BUTTONS	RESULTS	A7 PANEL	SPEC 167	COMMENTS
PYRO CIRC PROT OFF	Enables pyro commands	PYRO CIRCUIT PROTECT OFF light illuminates	PYRO CIRC PROT - OFF	
PYRO CIRC PROT ON	Disables pyro commands	PYRO CIRCUIT PROTECT OFF light extinguishes	PYRO CIRC PROT - ON	
ACT HOOKS FIRING	Fires pyros to physically disengage active hooks on APDS	None	None	Passive hooks on PMA cannot be pyro disengaged
PAS HOOKS FIRING	Fires pyros to physically disengage passive hooks on APDS (assumes PMA active hooks engaged)	None	None	Active hooks on PMA cannot be pyro disengaged.

CIRCUIT BREAKER/SWITCHES				
PUSH BUTTONS	RESULTS	A7 PANEL	SPEC 167	COMMENTS
CONTROL PANEL POWER A B C ON/OFF	Provides power to control panel push-buttons and status lights	None	CNTL PNL PWR - A/B/C	CNTL PNL A directly powers Col 1 and 3 CNTL PNL C, 2 & 4
HEATERS/DCU POWER H1 H2/DCU H3/DC ON/OFF	Activates nine 10-watt heaters on elements of the docking mechanism. H2 or H3 power DCU 1 & 2	None	HTR/DCU PWR - A/B/C	Makes most tlm available for Spec 167 and flight controllers
APDS POWER Ads Bds Cds ON/OFF	Provides logic power from the control panel to the PSU box	Ads, Bds and Cds lights illuminate	APDS PWR - A/B/C	
PYROS AP BP CP ON/OFF	Power to pyro logic busses	AP BP and CP lights illuminate	PYRO LOGIC PWR - A/B/C	
EVENT DRIVEN				
EVENT	RESULTS	A7 PANEL	SPEC 167	COMMENTS
Ring in Final position	Active ring depresses final position plunger sensors	RING FINAL POSITION light illuminates	RING POS - FNL	
Ring in Initial position	Active ring sensors in ball screws see initial position	RING INITIAL POSITION light illuminates	RING POS - INIT	Potentiometers measure position
Ring in Forward position	Active ring sensors in ball screws see forward position	RING FORWARD POSITION light illuminates	RING POS - FWD	Potentiometers measure position
Hooks 1 in closed position	Sensors in Hook 1 PDU see closed position	HOOKS1 CLOSED light illuminates	HK1 POS - 95% HK1 IND - CL	
Hooks 1 in open position	Sensors in Hook 1 PDU see closed position	HOOKS1 OPEN light illuminates	HK1 POS - 5% HK1 IND - OP	
Hooks 2 in closed position	Sensors in Hook 2 PDU see closed position	HOOKS2 CLOSED light illuminates	HK2 POS - 95% HK2 IND - CL	
Hooks 2 in open position	Sensors in Hook 2 PDU see closed position	HOOKS2 OPEN light illuminates	HK2 POS - 5% HK2 IND - OP	
Ball screws are all extended equidistantly	Active ring is in alignment	RING ALIGNED light illuminates	RNG ALGN - ON	
Shuttle is not docked	Undock plunger-sensors on APDS extend outward	UNDOCK COMPLET light illuminates	UNDOCK CMLPT - ON	

EVENT DRIVEN (continued)				
EVENT	RESULTS	A7 PANEL	SPEC 167	COMMENTS
Active ring makes physical contact with PMA	Active ring ball screws move	INITIAL CONTACT light illuminates	CONTACT - ON	
At least one capture plunger has been depressed slightly	Capture plunger has been depressed 0.8mm	None	CAPTURE - ON	Also known as "Capture Long"
Active ring capture latches have captured the PMA striker plates	Three capture plungers are depressed 10mm. Capture logic satisfied	CAPTURE light illuminates	CAPTURE - ON	Also known as "Capture Short" Dampers auto on in five seconds
APDS structural ring is starting to depress the compression seals	Interface sealed plunger-sensors on structural ring are depressed	INTERF SEALED light illuminates	None	
PSU MN A, B switches on A6 panel moved to ON	Power busses in PSU are activated	None	RNG DR BUS - 1/2 HKS DR BUS - 1/2 DAMPER BUS -1/2 FIXER BUS - 1/2	
Satisfied capture logic automatically powers on dampers	Dampers activated	None	DAMPING - ON	Five minute limit. POWER ON or OFF pb-push powers off dampers
Power applied to Fixers	Fixers powered on	None	RING FIXERS - ON	
Clutch engaged or disengaged	Engaged when ring in or ring out pb pushed	None	CLUTCH - LOCK /blank or CLUTCH - blank/SLIP	Ring in INITIAL position modes clutch to SLIP
Power applied to ring motors	Active ring in motion	None (other than position lights extinguishing)	PETAL POS 1 2 3 BASE incrementing or decrementing	
Ball screws no longer equidistant	Active ring out of alignment	RING ALIGNED light extinguishes	RNG ALGN - OFF PETAL POS 1 2 3 BASE are not within + or - 1 of each other or PETAL POS 1 2 3 RING are not within +/- 1	Expected when APDS first makes contact with PMA and until centering springs bring ring into alignment
APDS structural ring and PMA are close enough for hooks to engage	Ready to hook plunger-sensors indicate closeness	READY TO HOOK light illuminates	RDY TO HOOK - ON	Hooks close cmd automatically sent by APDS logic

EVENT DRIVEN (continued)				
EVENT	RESULTS	A7 PANEL	SPEC 167	COMMENTS
Hook drive motors activated	Hooks begin driving	None (other than HOOKS OPEN or CLOSE lights extinguishing)	HK1 & HK2 DRV CMD - ON HK1 & HK2 POS incrementing or decrementing	
In-between sensor signals that APDS active hooks are in transition between open and close positions	Ring drive motor stops after hooks have begun driving	None	RING DRV CMD - OFF	
Individual hooks have closed	A sensor located on each hook drive wheel is tripped	None	ODS INDIV HK CL 1,3,5,7,9,11 - CL 2,4,6,8,10,12 - CL	
Individual hooks are not closed	A sensor located on each hook drive wheel is no longer tripped	None	ODS INDIV HK CL 1,3,5,7,9,11 - blank 2,4,6,8,10,12 - blank	
Crew has manually opened capture latches	Capture latches manually released	None	CAP MAN REL - OP	
Electrical connectors on APDS have mated with connectors on PMA	Electrical continuity obtained with PMA active hook circuitry	None	ODS CONN X3 - ON ODS CONN X4 - ON	Continuity required to activate PMA active hooks

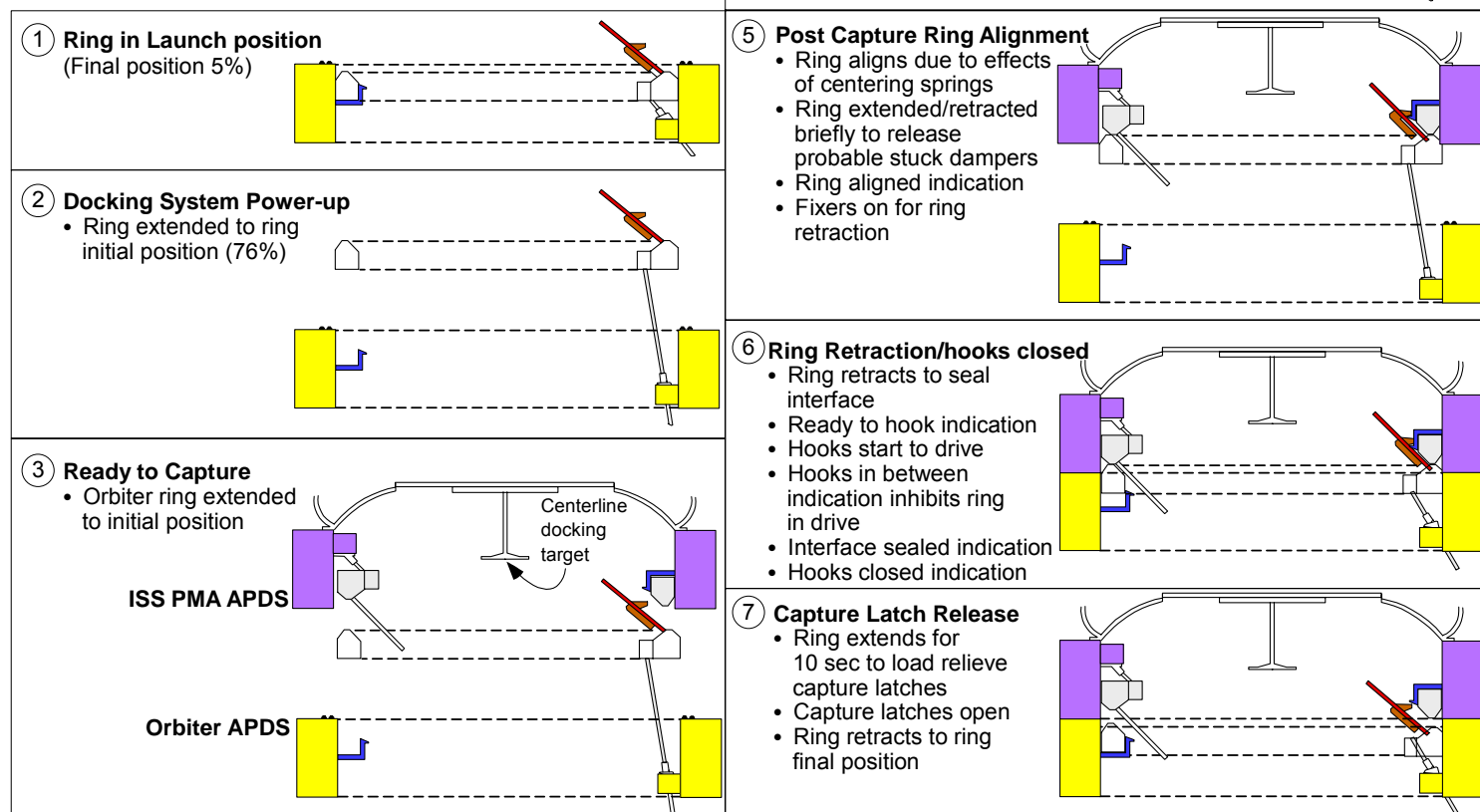
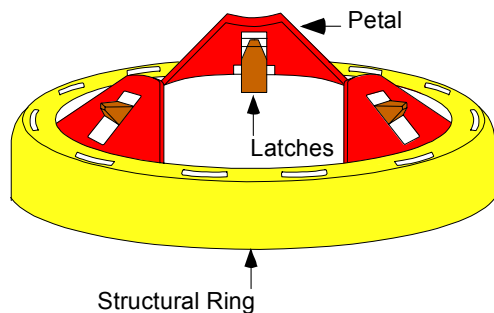
A6 DOCKING SYSTEM POWER

SWITCH ACTION	RESULTS	A6 PANEL	SPEC 167	COMMENTS
SYSTEM POWER SYS 1, MN A ON/OFF	Makes Main A power available to panel logic busses	SYSTEM POWER, SYS 1 tb - ON or OFF	None	
SYSTEM POWER SYS 2, MN B ON/OFF	Makes Main B power available to panel logic busses	SYSTEM POWER, SYS 2 tb - ON or OFF	None	
PYRO POWER MN A ON/OFF	Applies/removes Main A power to 6 and 40 amp busses that fire pyros	None	PYRO MNA 40/6 AMP - ON/ON or OFF/OFF	
PYRO POWER MN C ON/OFF	Main C power to 6 and 40 amp busses to fire pyros	None	None	
PSU POWER MN A, MN B ON/OFF	Makes Main A and B power available to motors	None	RNG DR BUS - 1/2 HKS DR BUS - 1/2 DAMPER BUS -1/2 FIXER BUS -1/2	
VESTIBULE DEPRESS VALVE VENT ISOL OPEN/CLOSE	Opens/closes ODS vestibule vent isolation valves	VESTIBULE DEPRESS VALVE SYS 1, SYS 2 VENT ISOL tb - OP or CL	None	
VESTIBULE DEPRESS VALVE VENT OPEN/CLOSE	Opens/closes ODS vestibule vent valves	VESTIBULE DEPRESS VALVE SYS 1, SYS 2 VENT tb - OP or CL	None	
PMA 2/3 HOOKS GROUP 1 SYS A SYS B CLOSE	PMA Group 1 hooks in closed position	PMA 2/3 HOOKS GROUP 1 tb - CL	PMA 2/3 HK1 IND CL - 1,2 HK CLS 1/3/5, - CL HK CLS 7/9/11 - CL	Two switches
PMA 2/3 HOOKS GROUP 1 SYS A SYS B OPEN	PMA Group 1 hooks in open position	PMA 2/3 HOOKS GROUP 1 tb - OP	PMA 2/3 HK1 IND OP - 1,2	Two switches
PMA 2/3 HOOKS GROUP 2 SYS A SYS B CLOSE	PMA Group 2 hooks in closed position	PMA 2/3 HOOKS GROUP 2 tb - CL	PMA 2/3 HK2 IND CL - 1,2 HK CLS 2/4/6, - CL HK CLS 8/10/12 - CL	Two switches
PMA 2/3 HOOKS GROUP 2 SYS A SYS B OPEN	PMA Group 2 hooks in open position	PMA 2/3 HOOKS GROUP 2 tb - OP	PMA 2/3 HK2 IND OP - 1,2	Two switches

EVENT DRIVEN				
EVENT	RESULTS	A6 PANEL	SPEC 167	COMMENTS
PMA Group 1 active hooks were commanded to close	PMA 2/3 GROUP 1 active hook motors in transit to the closed position	PMA 2/3 HOOKS GROUP 1 tb - bp	PMA 2/3 HK1 CMD CL - 1,2 HK1 IND - blank	
PMA Group 1 active hooks were commanded to open	PMA 2/3 GROUP 1 active hook motors in transit to the open position	PMA 2/3 HOOKS GROUP 1 tb - b	PMA 2/3 HK1 CMD OP - 1,2 HK1 IND - blank	
PMA Group 2 active hooks were commanded to close	PMA 2/3 GROUP 2 active hook motors in transit to the closed position	PMA 2/3 HOOKS GROUP 2 tb - bp	PMA 2/3 HK2 CMD CL - 1,2 HK2 IND - blank	
PMA Group 1 active hooks were commanded to close	PMA 2/3 GROUP 2 active hook motors in transit to the open position	PMA 2/3 HOOKS GROUP 2 tb - bp	PMA 2/3 HK2 CMD OP - 1,2 HK2 IND - blank	

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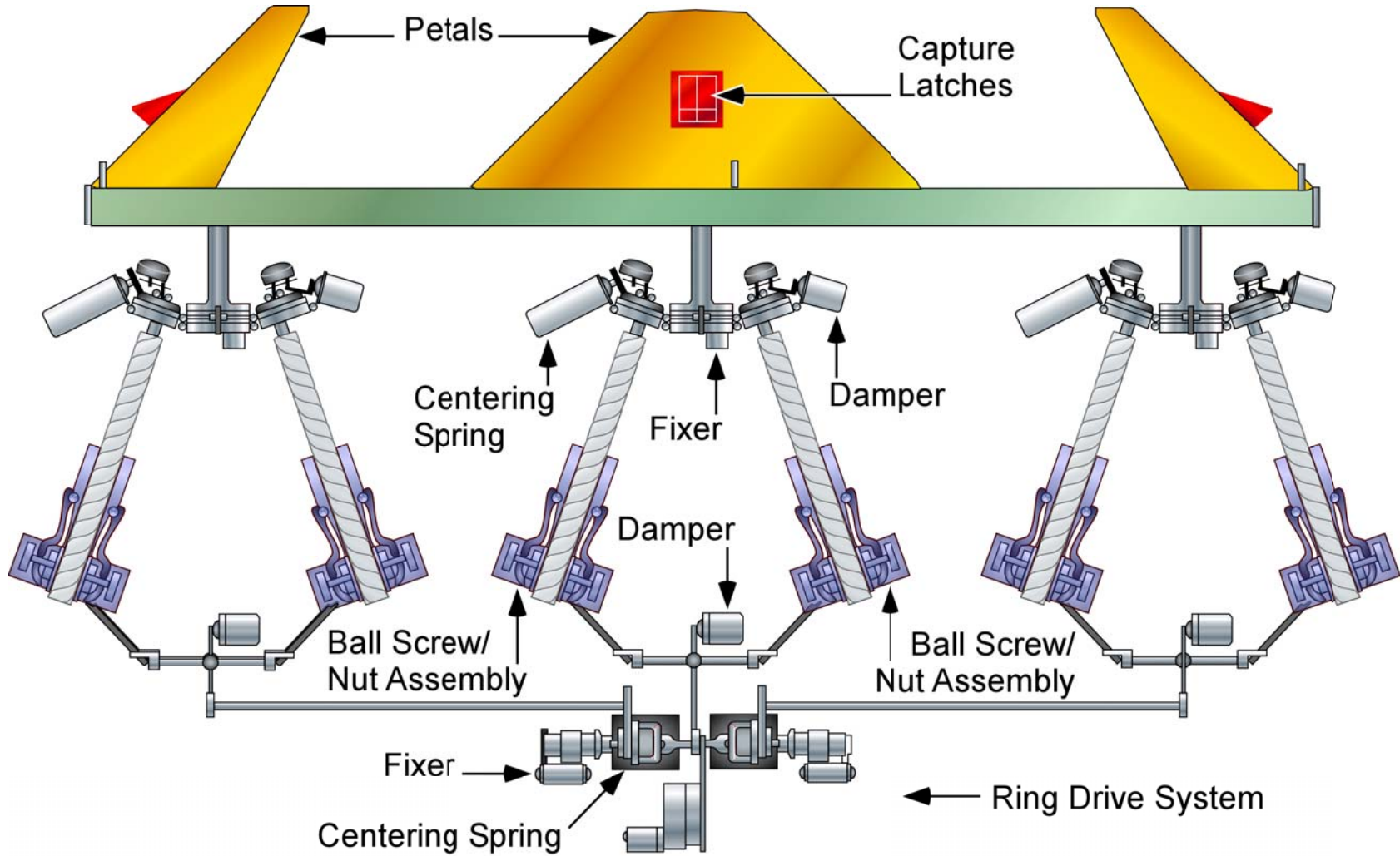
ORBITER DOCKING SEQUENCE



For training purposes only

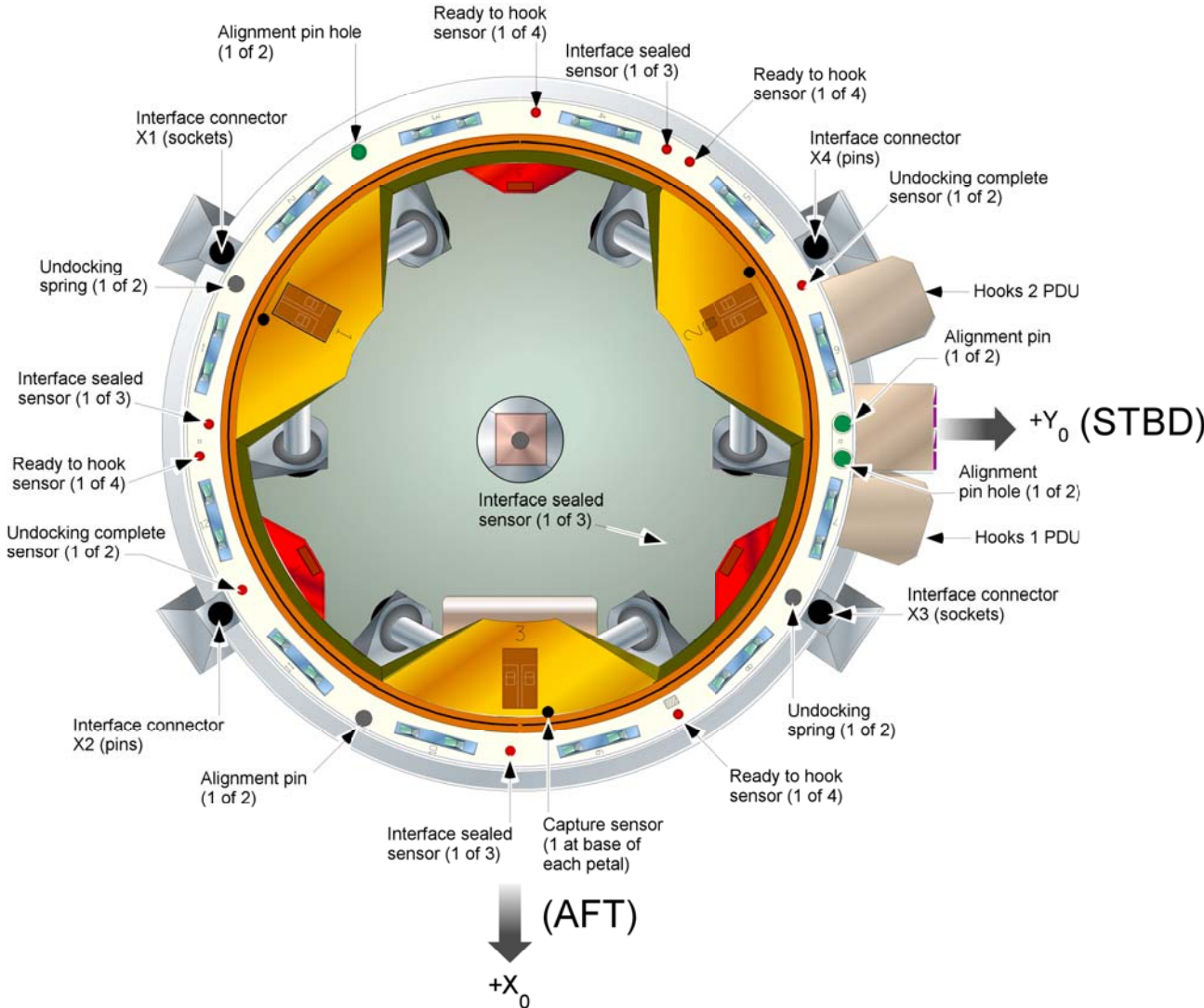
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ACTIVE RING COMPONENTS



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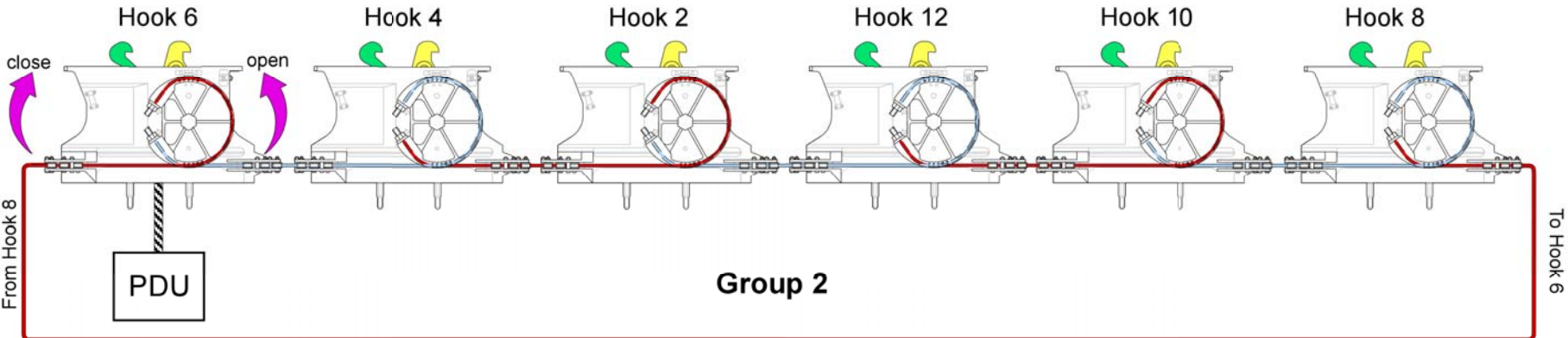
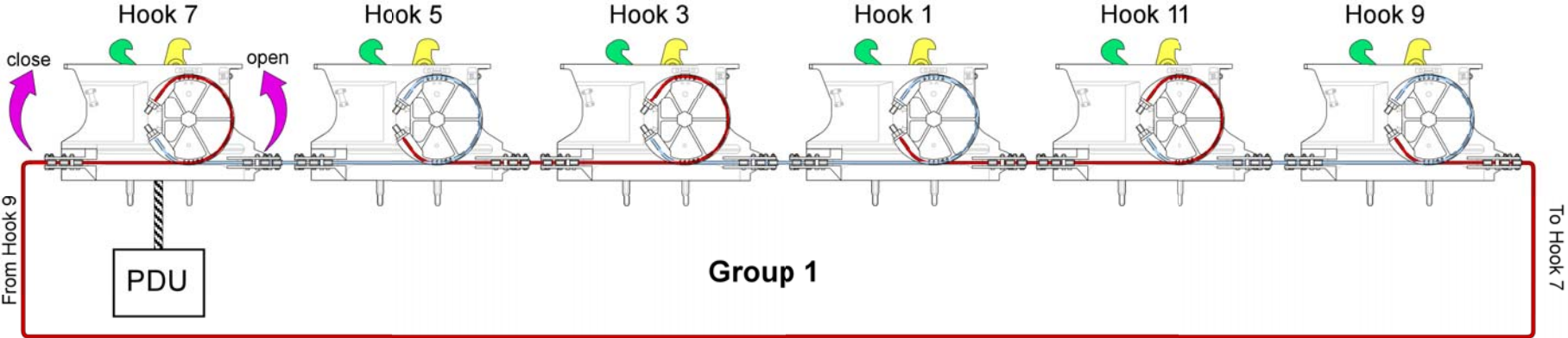
STRUCTURAL and ACTIVE RING KEY MAP



Ring keymap.CNV

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CABLE PULLEY SYSTEM



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APDS MDM Telemetry Sources

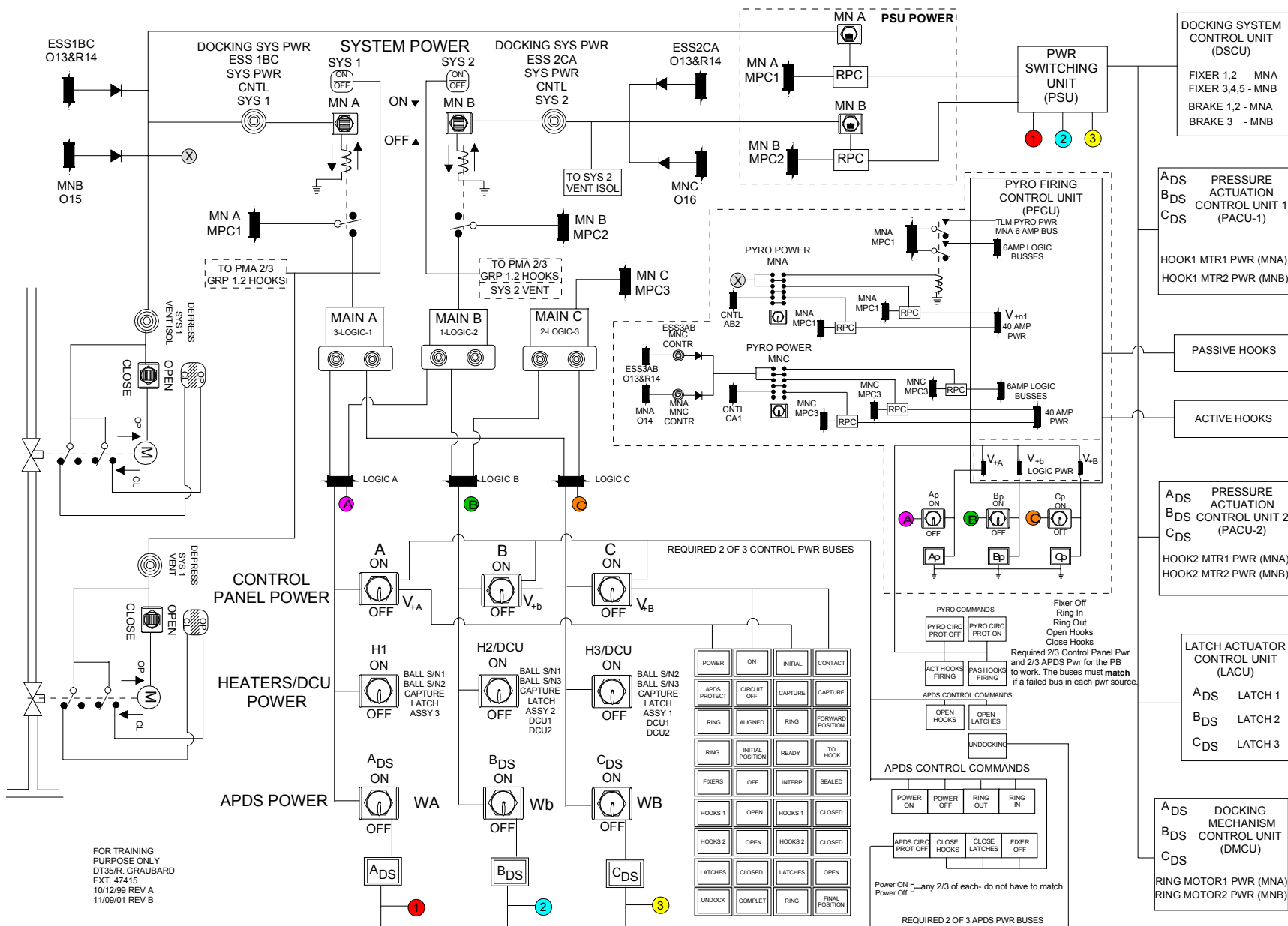
CONTACT	OF3 ₁	CNTL PNL PWR	OA3 ₂ / OA2 ₂ / OA2 ₂	CNTL CMD PWR	OA3 ₁
CAPTURE	OA1 ₁	HTR/DCU PWR	OA2 ₂ / OA2 ₂ / OA3 ₂	RING DR BUS	OF3 ₁ / OA3 ₁
DAMPING	OF3 ₁	APDS PWR	OA3 ₂ / OA3 ₂ / OA3 ₂	HKS DR BUS	OA3 ₁ / OA3 ₁
RNG ALGN	OF3 ₁	APDS CIRC PROT	OA1 ₁	DAMPER BUS	OA3 ₁ / OA3 ₁
				FIXER BUS	OA3 ₁ / OA1 ₁
RING	POS	OA2 ₂ / OA2 ₂ / OA2 ₂	PMA 2 / 3	OP	/ CL
	DRV CMD	OA1 ₁	HK1 CMD	OF1	OF2 / OF1 OF2
	FIXERS	OA1 ₁	IND	OF1	OF2 / OF1 OF2
CLUTCH		OA1 ₃ / OA2 ₄	HK2 CMD	OF1	OF2 / OF1 OF2
PETAL	POS	1 2 3	IND	OF1	OF2 / OF1 OF2
	RING	OF1 ₂ OF2 ₂ OF2 ₂	HK CLS		
	BASE	OF2 ₂ OF2 ₂ OF1 ₂	1/3/5	OA1 ₃	7 / 9 / 11 OA1 ₃
UNDOCK	CMPLT	OA1 ₂	2/4/6	OA2 ₄	8 / 10 / 12 OA2 ₄
RDY TO	HOOK	OA1 ₂	ODS	INDIV	HK CL
HK1	DRV CMD	OA1 ₁	1 3 5 7 9 11		ODS CONN
	POS	OF1 ₁	OA1 ₃ OA1 ₃ OA1 ₃ OA1 ₃ OA1 ₃ OA1 ₃		X3 OA2 ₄
	IND	OA1 ₂ / OA1 ₂			X4 OA1 ₃
HK2	DRV CMD	OA1 ₁	2 4 6 8 10 12		
	POS	OF1 ₁	OA2 ₄ OA2 ₄ OA2 ₄ OA2 ₄ OA2 ₄ OA2 ₄		
	IND	OA2 ₂ / OA2 ₂			
CAP	LAT	CMD	OA1 ₁	PYRO LOGIC PWR	OA3 ₂ / OA3 ₂ / OA3 ₂
		IND	OA2 ₂ / OA2 ₂	PYRO CIRC PROT	OA1 ₁ / OA1 ₁
	MAN	REL	OA2 ₂	PYRO MNA 40/6 AMP	OA1 / OA1

Subscript 1 = Data Collection Unit 1 Telemetry Subscript 3 = Dedicated Signal Conditioner OA1 Telemetry
Subscript 2 = Data collection Unit 2 Telemetry Subscript 4 = Dedicated Signal Conditioner OA2 Telemetry

Notes:

- Parameters without a subscript are not processed by a DCU or DSC
- This chart is published in the Flight Data File, REFERENCE DATA, Page 2-20

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FOR TRAINING
PURPOSE ONLY
DT35/R. GRAUBARD
EXT. 47415
10/12/99 REV A
11/09/01 REV B

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QUICK REFERENCE NOTES

POWER ON - powers on system, stops ring drive and disables dampers

POWER OFF - removes power from system, stops ring and hook drive, and disables dampers

APDS CIRC PROT OFF - enables RING OUT, OPEN HOOKS, OPEN LATCHES and UNDOCKING pushbuttons

FIXER OFF - inhibits fixers and disables Initial Position sensor logic

Two Fingers Two Seconds Rule - use two fingers on a pb for max of two seconds

Sensor - one set for A7 logic; separate set for Spec 167

NO GO for DOCKING:

POWER Failed OFF (All STATUS Lts ↓) - inability to drive the ring, hooks or latches

CAPTURE It Failed ON - could indicate that an erroneous command caused the docking sequence to activate prematurely

DAMPING tlm Failed ON - compromises compliance at contact

FIXERS tlm Failed ON - system too rigid and risks severe damage

Dampers - damp relative motion between orbiter and the ISS, auto on 5 sec after capture, powered off by crew
POWER ON/OFF pb-push

QUICK REFERENCE NOTES

Fixers - inhibit misalignment of the docking ring during ring retraction. Automatically powered on during RING IN/OUT pb-push commands. During Disable and Release Dampers, fixers are inhibited by FIXER OFF pb-push to prevent overloading a fixer if the ring drives out of alignment due to a stuck damper. FIXER OFF pb-push disables Initial Position sensor logic.

Clutch - in LOCK during ring retraction/extension. Must be in SLIP at contact to allow for compliance

Ring Alignment - when all ball screws are equidistant. A7 RING ALIGNED It = lit, Spec 167 RNG ALGN tlm = ON, Spec 167 Base/Ring tlm within +/- 1

Ring Base at 20% - point at which the 60mm alignment pins will engage the alignment sockets on the PMA; at this point any ring misalignment is no impact.

Final Position - launch position and position after hard dock with capture latches opened

Initial Position - maximum attenuation capability in all axes

Forward Position - hard stop position that forces ring alignment

Capture Latches - closed for docking and opened for undocking

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Change History

Rev. letter	Description	Date
Basic		02/14/2005