Alpha Magnetic Spectrometer - 02 (AMS-02)
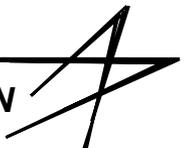# Critical Design Review

Avionics Overview

Prepared By: P. Nemeth

Contents

- Power Distribution
  - Power Distribution Box
  - Cryomagnet Avionics Box (and associated hardware)
    - Dump Rectifiers
    - Cryomagnet Self Protection (CSP)
    - Uninterruptible Power Source (UPS)
  - Cryocooler Electronics
- Interconnect Diagrams
  - Pad and STS
  - ISS
- AMS Data Overview
  - Housekeeping
  - Science Data
- Testing
  - Data
  - Power
  - EMC

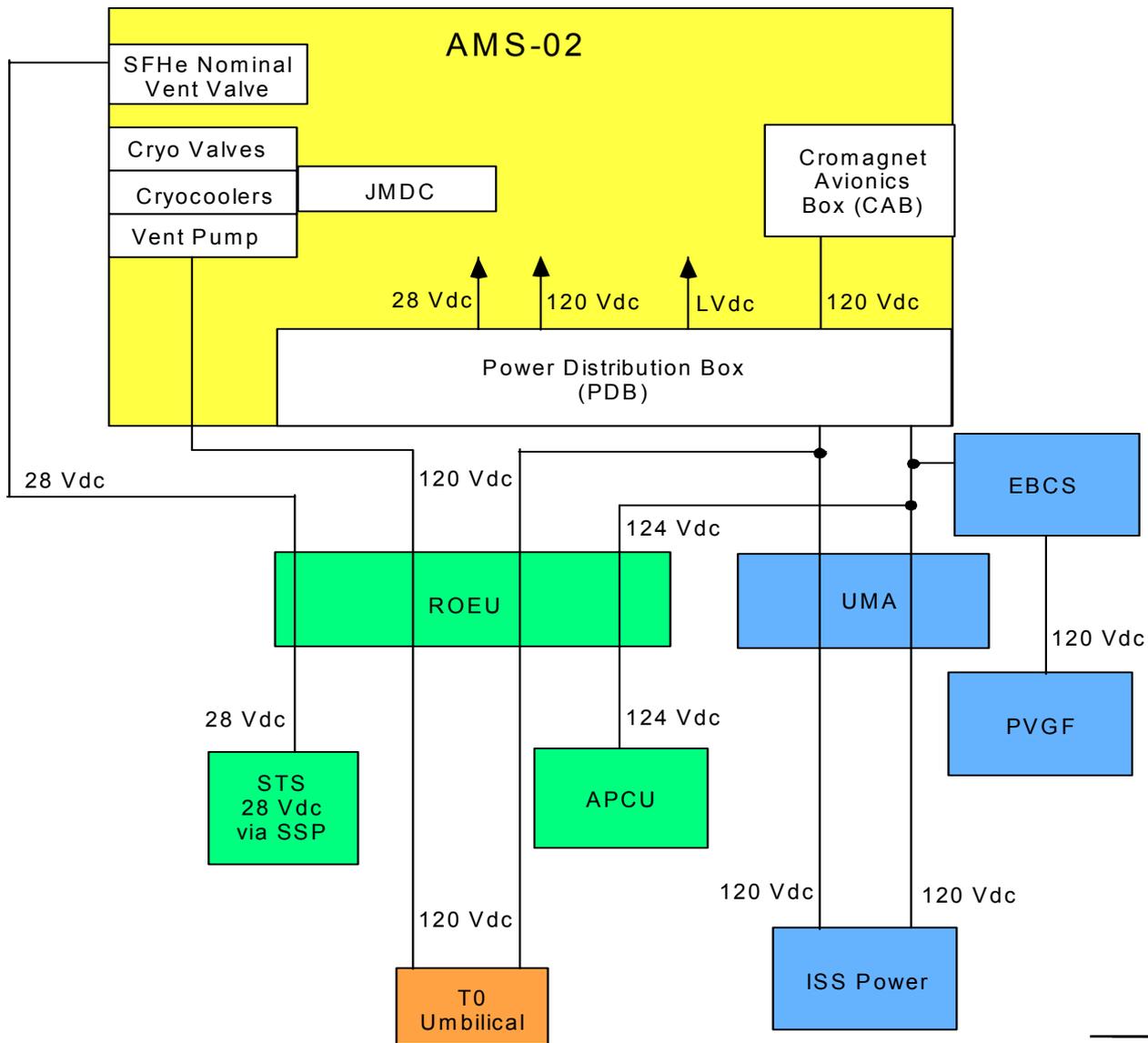*L O C K H E E D   M A R T I N*
Space Operations
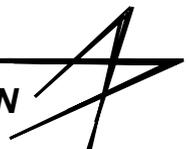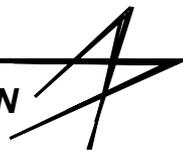
Power Distribution

- Payload will meet 1 Megohm isolation requirement

- The AMS Power Distribution Box (PDB) serves as the primary 'front end' for power distribution to the subsystems/sensor packages

  – Wire sizing is designed to meet NSTS 1700.7B, "Safety Policy and Requirements For Payloads Using the Space Transportation System", NSTS 1700.7B ISS Addendum, "Safety Policy and Requirements For Payloads Using the International Space Station", and NASA Technical Memorandum #TM 102179, "Selection of Wires and Circuit Protection Devices for NSTS Orbiter Vehicle Payload Electrical Circuits"

L O C K H E E D   M A R T I N
Space Operations
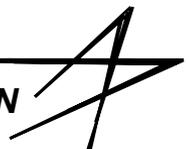
AMS-02 STS Power Distribution Block Diagram

Power Distribution Box

- PDB consists of one 124 Vdc input section, and three output sections:
  - 124 Vdc
  - 28 Vdc (Isolated)
  - Control and Monitor (Isolated Low Voltage)

- All 124Vdc outputs isolation is provided by the end subsystem

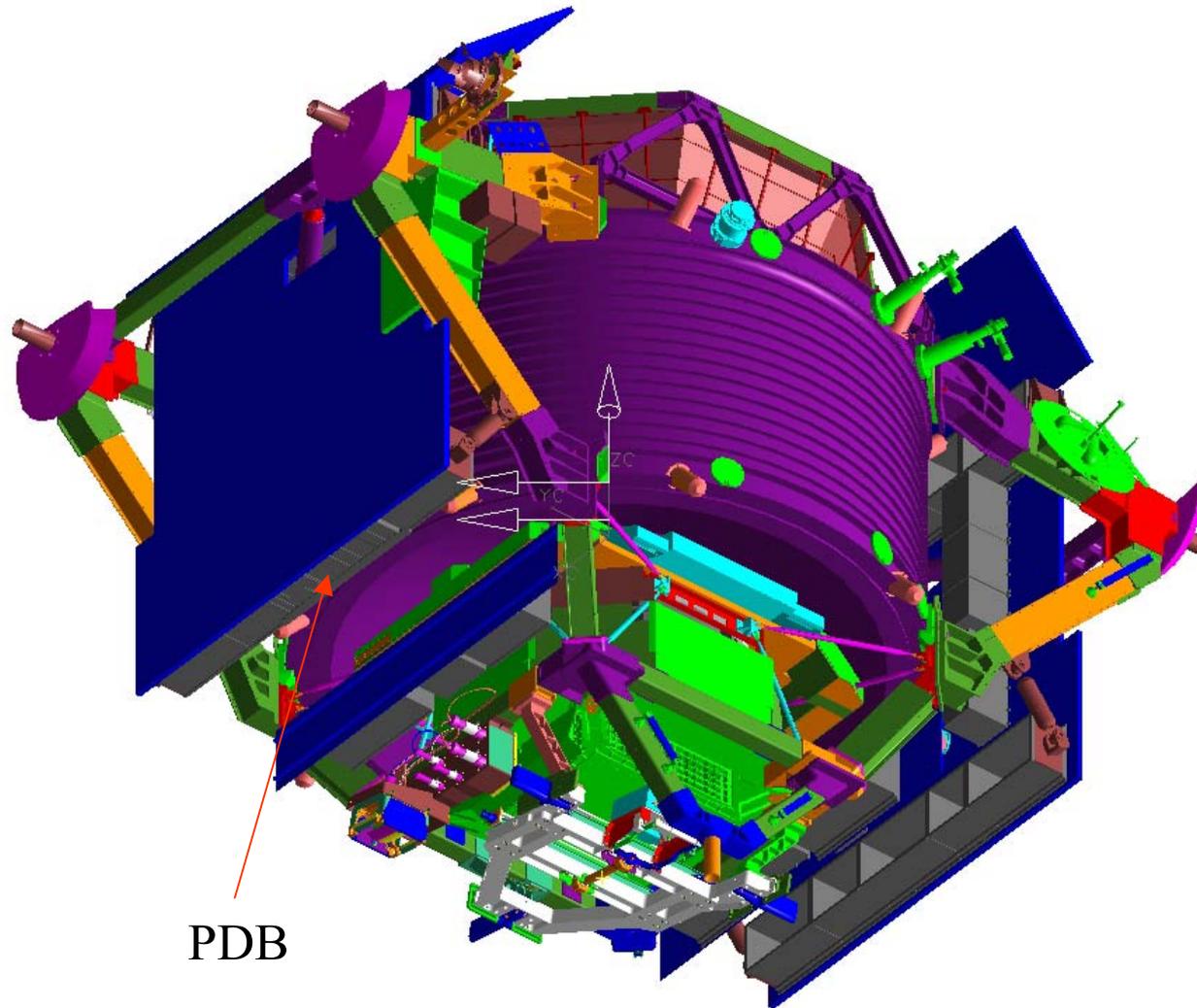- Control and Monitor circuit protection provided by the DC to DC converter (current limiting)

L O C K H E E D   M A R T I N
Space Operations

POWER DISTRIBUTION BOX (PDB)
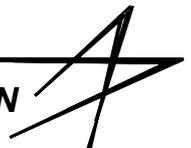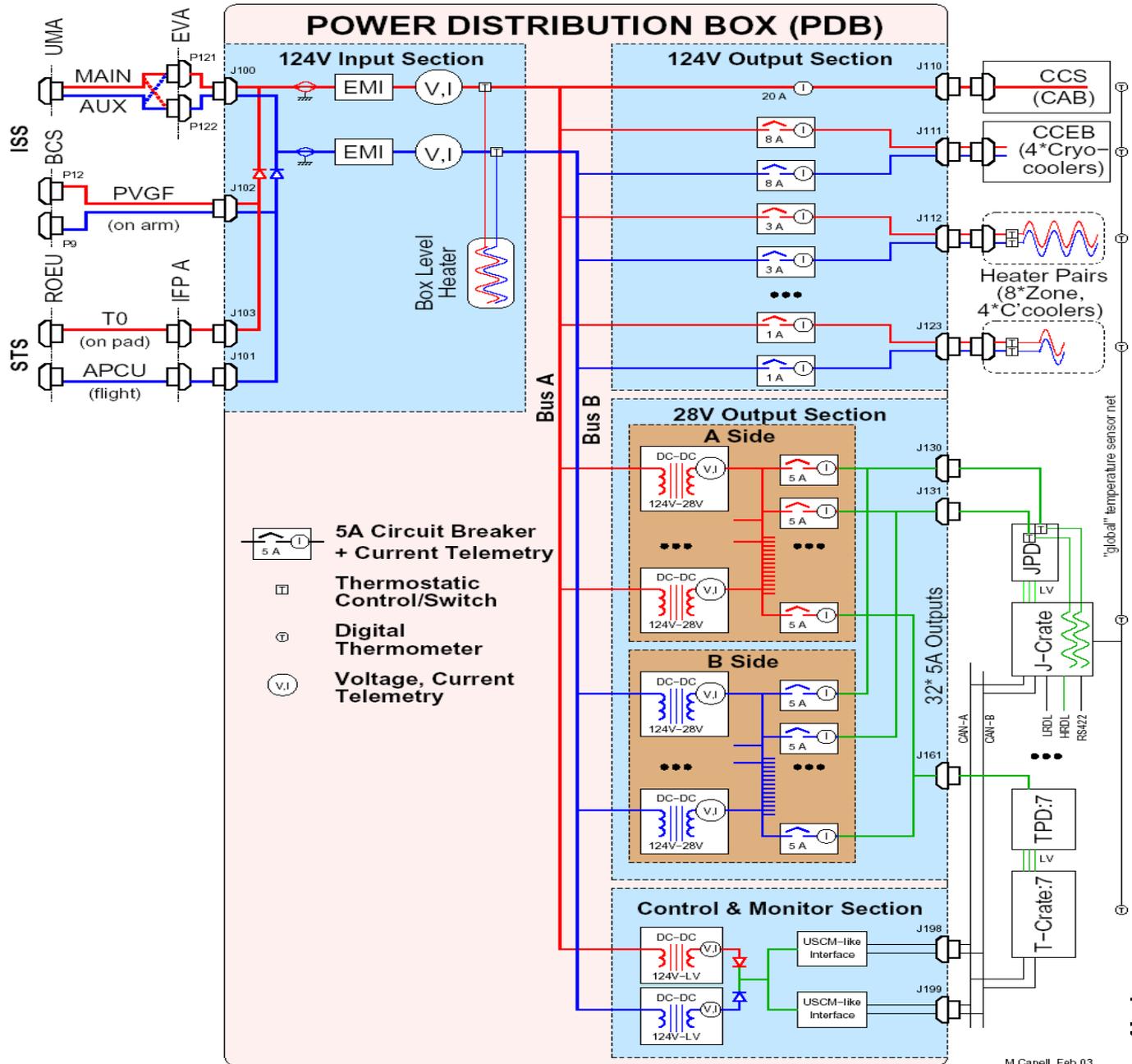
PDB Location

PDB

LOCKHEED MARTIN
Space Operations

PDB
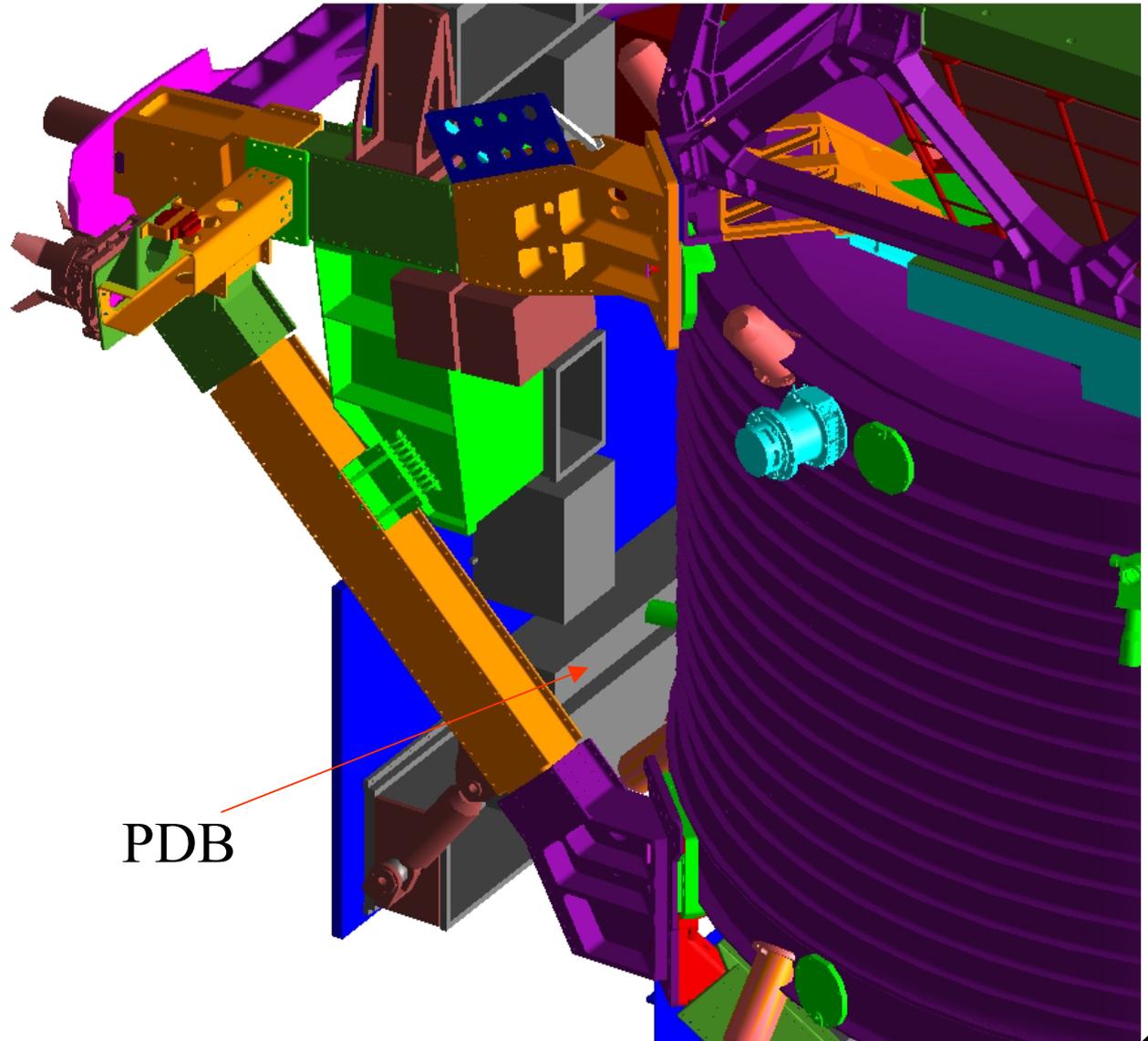
L O C K H E E D   M A R T I N
Space Operations
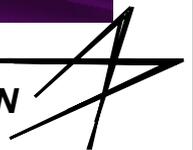
Cryomagnet Avionics Box (CAB)

- Isolation for the 120Vdc line (feed thru from PDB) is performed via DC to DC Converters

- Cryomagnet Current Source

- Magnet Charge/Discharge Circuit
  - Persistent Switch
  - Shunt
  - Dump Rectifiers

- Cryomagnet Control Unit
  - Sensor Monitoring/Signal Conditioning
  - Cryomagnet Self Protection (CSP)
  - Uninterruptible Power Source (UPS)

L O C K H E E D   M A R T I N
Space Operations

Cryomagnet Avionics Box (CAB)

120 Vdc From PDB

Cryo Current Source (CCS)

Semiconductor Switch

Power Switch

PWM

120 Vdc
1875 W_{max}

459 A
1500 W

Hi-Voltage Isolation

Hi-Voltage Isolation

Magnet Controller

28 Vdc from PDB

Hi-V Isolation DC to DC Converter

28 to 43 Vdc DC to DC Converters

Uninterruptible Power Source

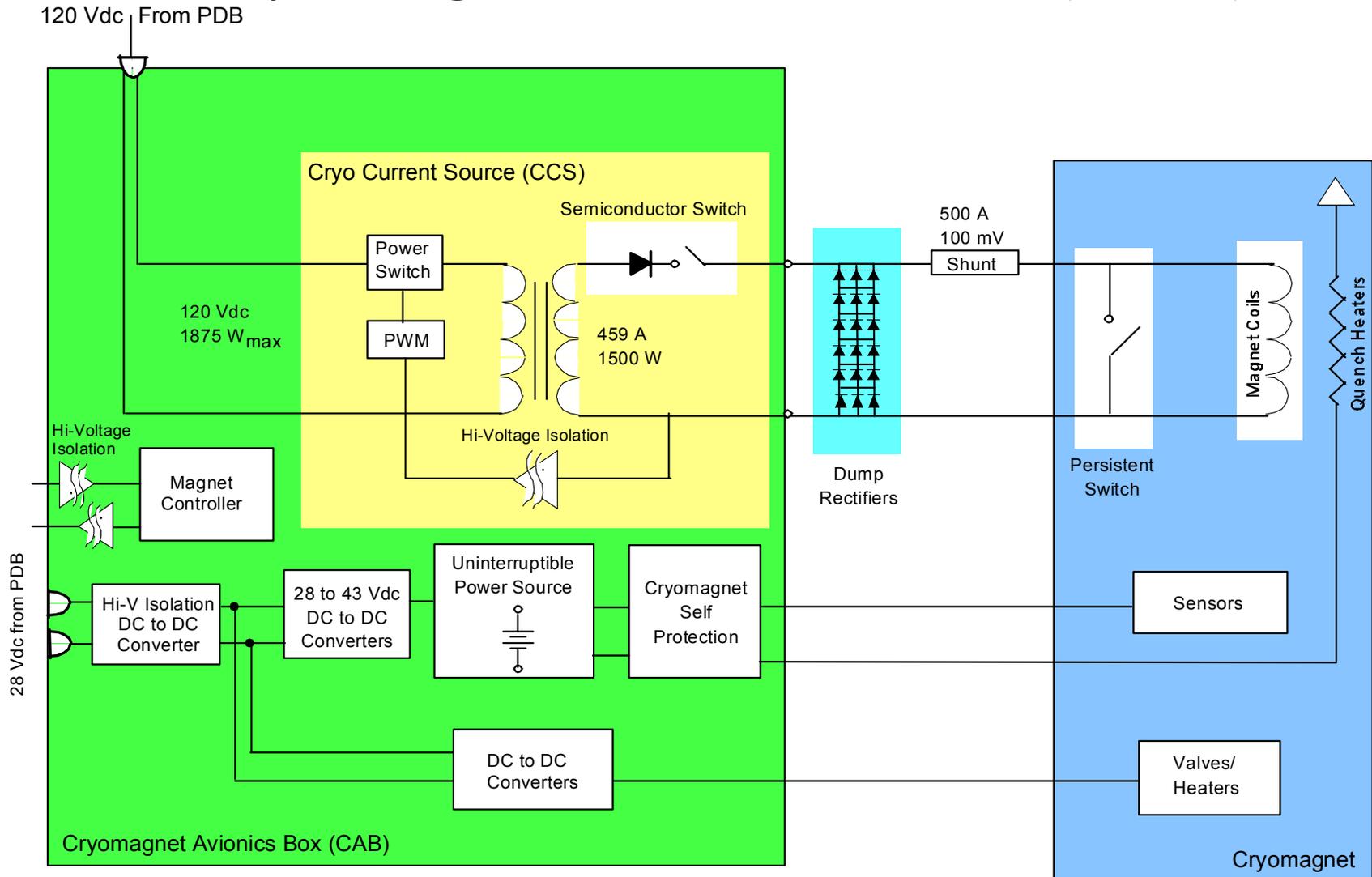Cryomagnet Self Protection

DC to DC Converters

Cryomagnet Avionics Box (CAB)

500 A
100 mV
Shunt

Dump Rectifiers

Persistent Switch

Magnet Coils

Quench Heaters

Sensors

Valves/ Heaters

Cryomagnet

L O C K H E E D   M A R T I N
Space Operations

Dump Rectifiers

- In the event that the magnet must be powered down, the persistent switch will be opened to allow the current in the magnet to be dumped to a bank of 18 rectifiers (six sets in series of three rectifiers in parallel)

- These rectifiers will be protected by a cover to prevent incidental contact

- The rectifiers will be mounted on the two wake-side sill trunnion joints (large thermal mass)

L O C K H E E D M A R T I N
Space Operations
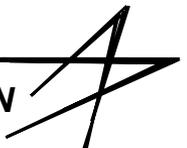
Dump Rectifiers (cont.)

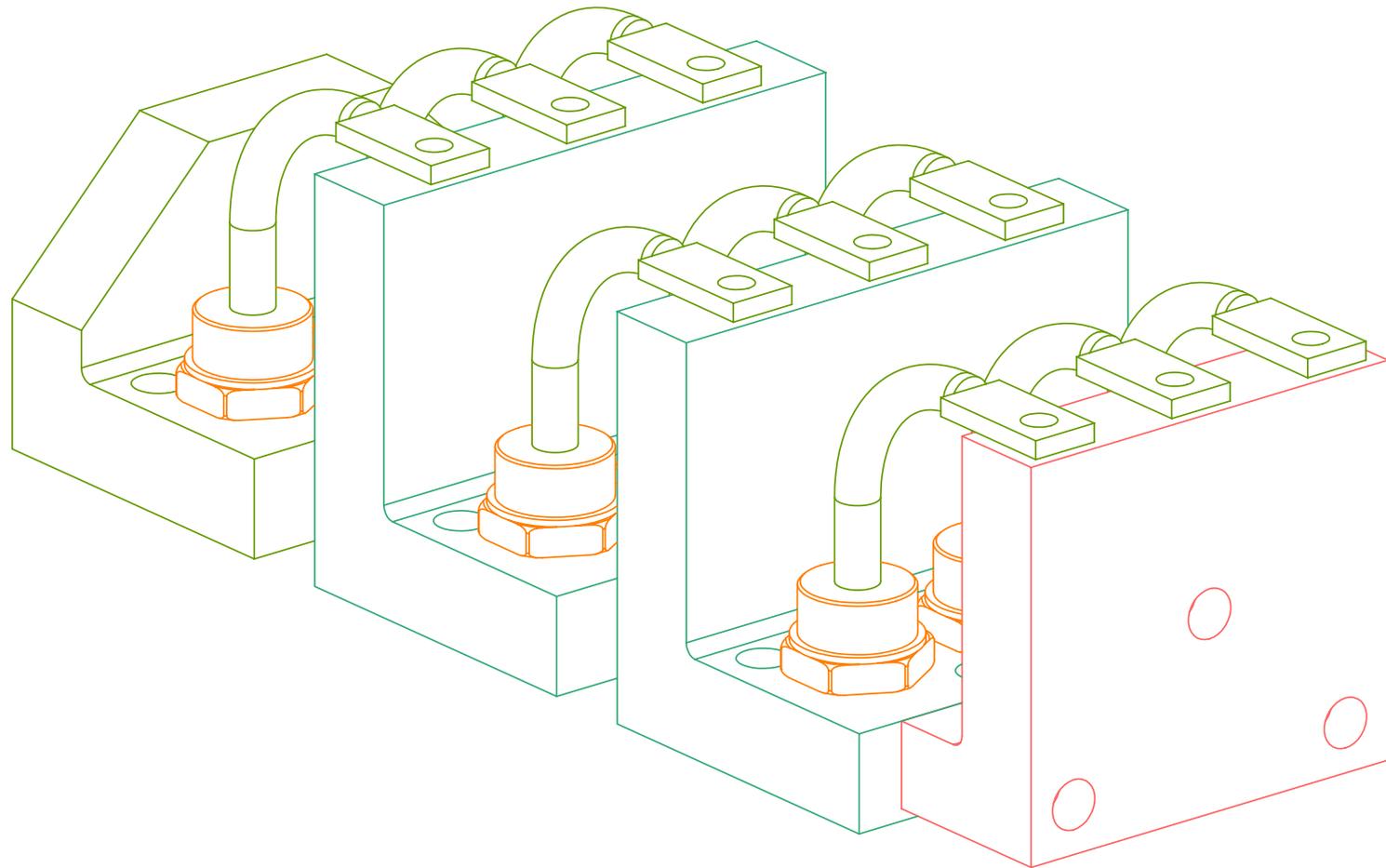- Worst case thermal analysis reveals that with a continuous load rectifiers will maintain junction temps well below ratings even if one of a parallel series of three fail.

- Dump time is estimated at 80 minutes
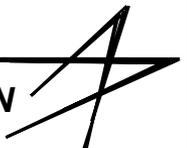
L O C K H E E D   M A R T I N
Space Operations

Dump Rectifiers (Cont.)

Dump Rectifiers (Cont.)

14.1
[359]

5.2
[132]

4.4
[113]
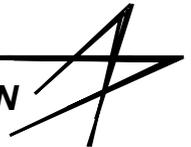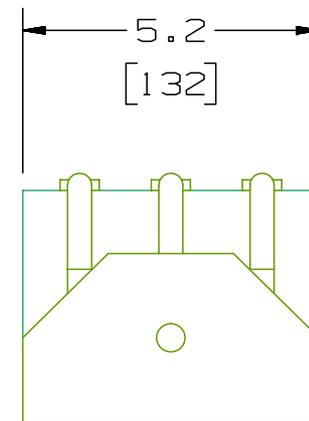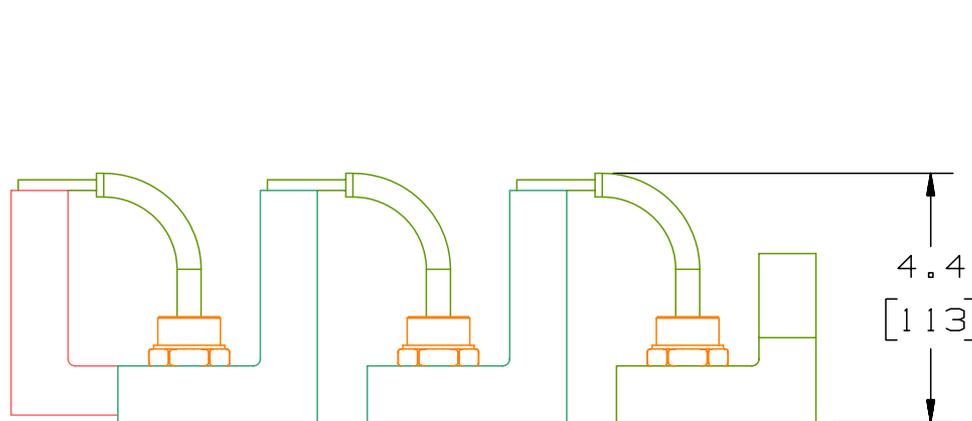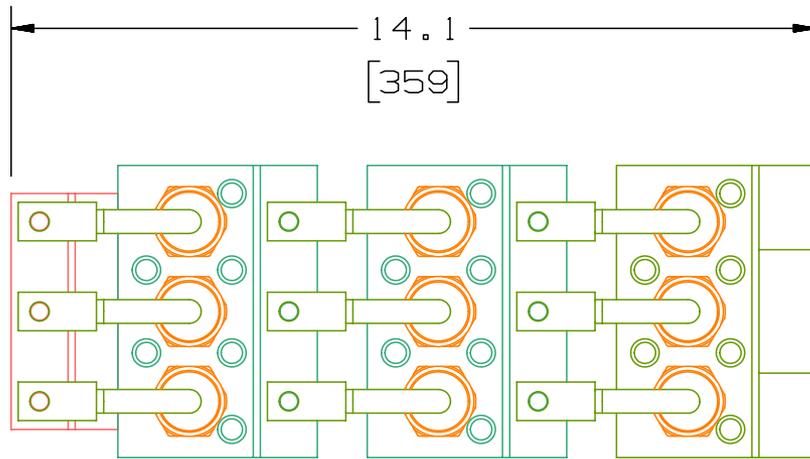
L O C K H E E D M A R T I N
Space Operations
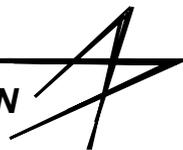
Dump Rectifier Mounting Locations

TFR-TRI WORK (EXPLODED)
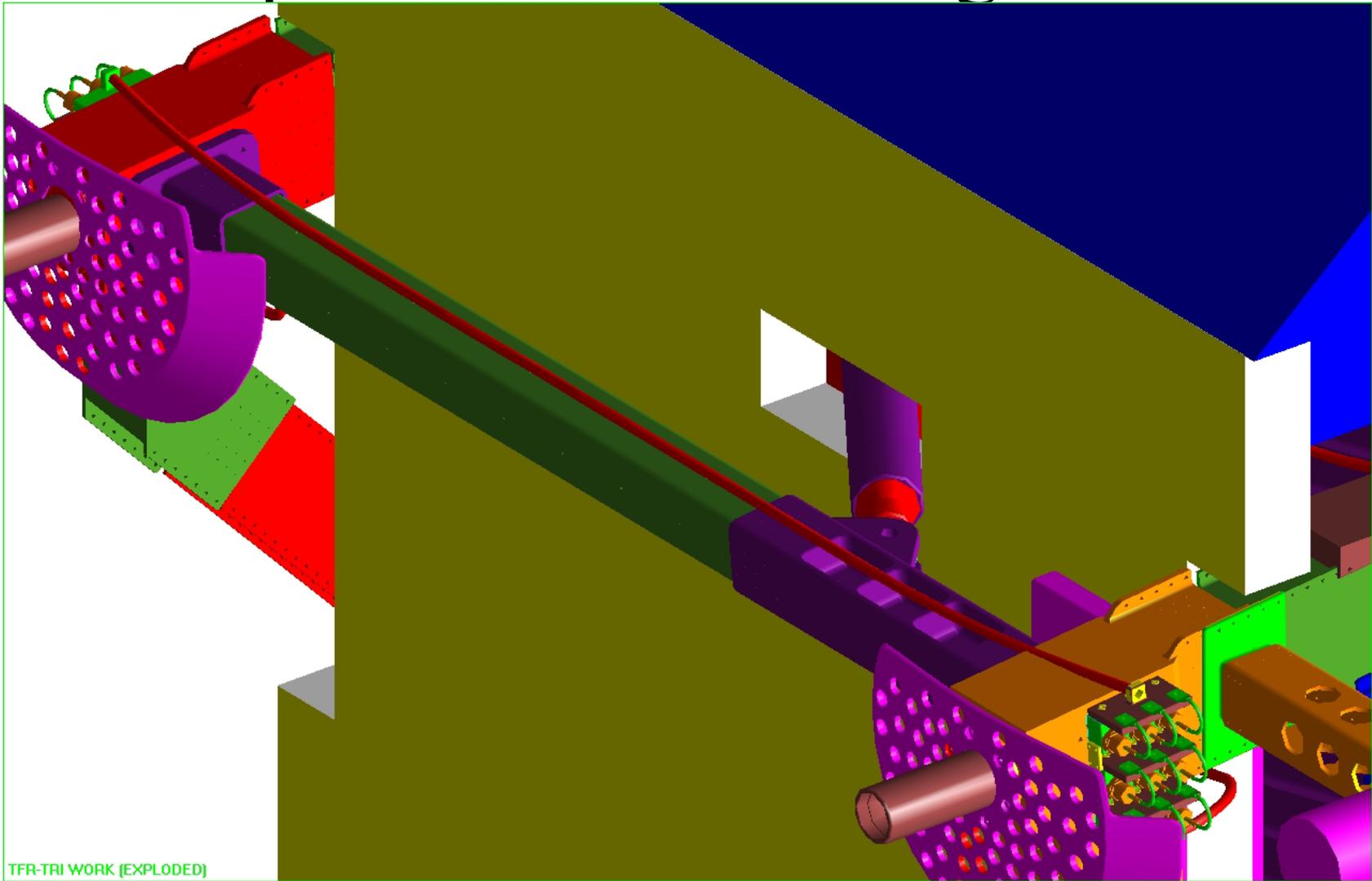
L O C K H E E D   M A R T I N
Space Operations

Dump Rectifier Cover

Access hole
Close out plates

Rectifier Cover
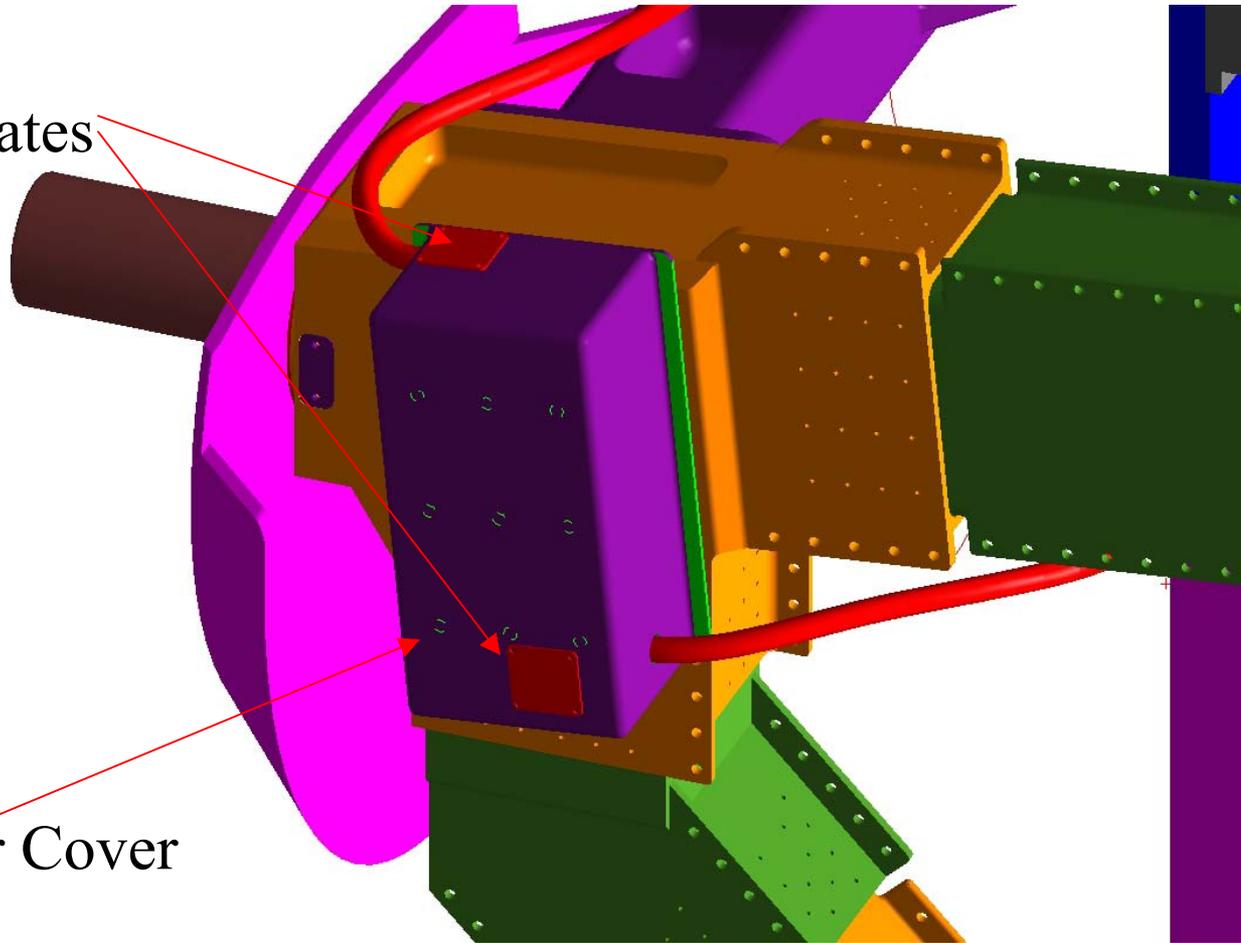
L O C K H E E D   M A R T I N
Space Operations

Cryomagnet Self Protection (CSP)

- Designed for mission success purposes only, no safety hazard

- CSP circuitry is designed to identify a quench condition in any individual coil and quench entire magnet evenly

- Redundant heater chains routed to alternating coils (either chain sufficient to quench magnet)

- Protects magnet by ensuring no magnet conductor deformation due to isolated heating, which could result in degraded performance

- The magnet structure will remain safe even if CSP circuitry does not function

L O C K H E E D   M A R T I N
Space Operations
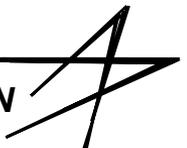
CSP Functional Block Diagram
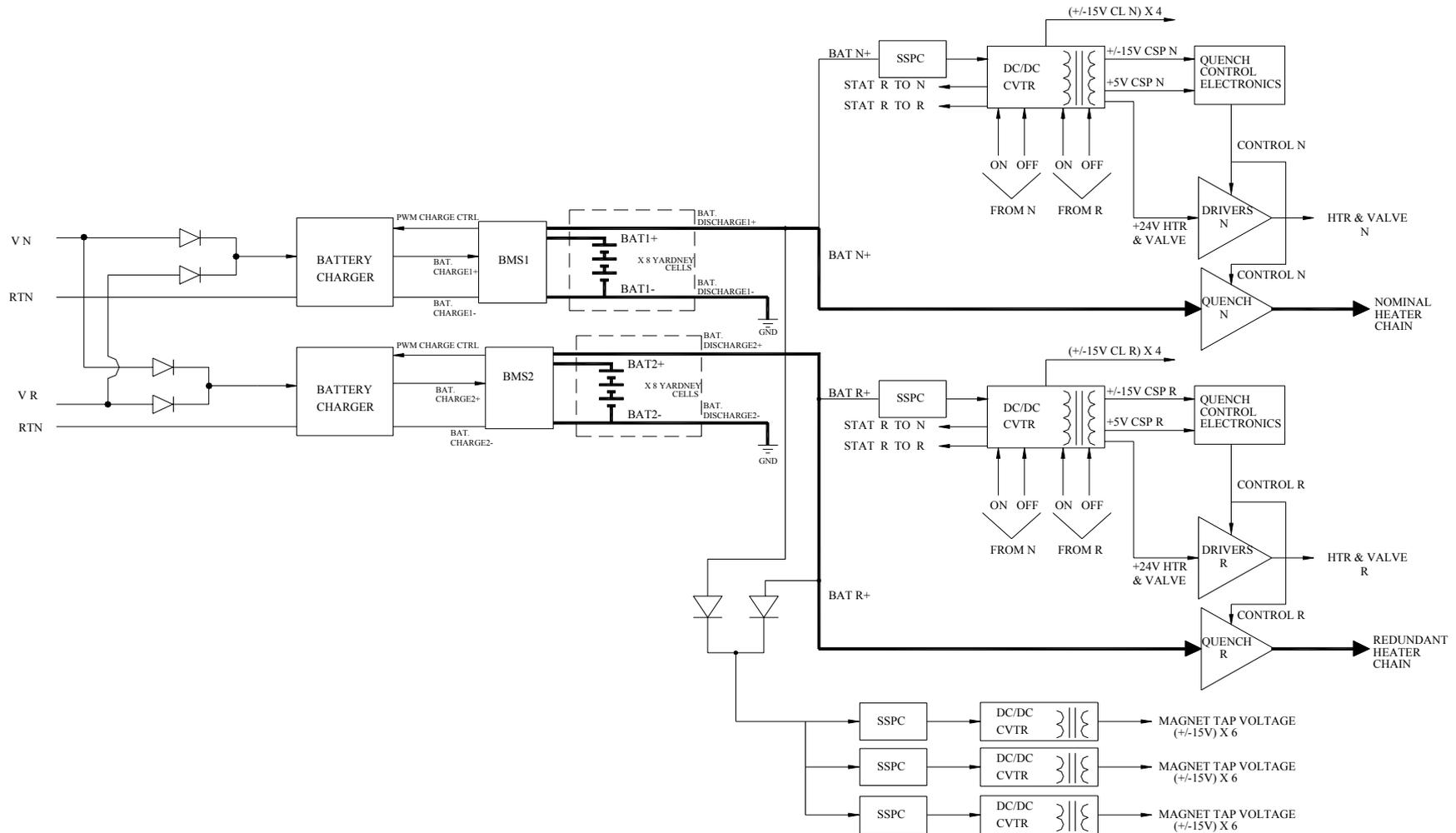
L O C K H E E D   M A R T I N
Space Operations

Uninterruptible Power Source (UPS)

- The UPS will consist of a redundant set of batteries
  - Battery will provide control power during loss of ISS power or communication to payload for mission success
    - Watch-dog timer/control circuit
    - Normal Ramp down function
    - Quench monitoring
    - Initiation of quench, 45A pulse
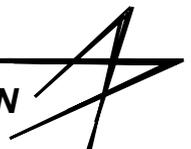
UPS (Continued)

– Battery will be designed to meet NSTS 1700.7B, "Safety Policy and Requirements For Payloads Using the Space Transportation System", NSTS 1700.7B ISS Addendum, "Safety Policy and Requirements For Payloads Using the International Space Station", and JSC 20793, "Manned Space Vehicle Battery Safety Handbook" and will be sized for a minimum of 8 hours of operation, plus ramp-down time

L O C K H E E D   M A R T I N
Space Operations
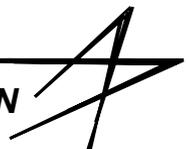
Cell Characteristics

- Manufactured by Yardney/Lithion

  - Prismatic cell

  - Dimensions: 95mm (3.74") X 27.84mm (1.096") X 139.7mm (5.500")

  - Weight: 900g (1.982 lbs)

  - Operational Temperature Range: -30 degC to +50 degC

LOCKHEED MARTIN
Space Operations
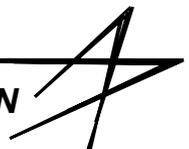
Battery Configuration
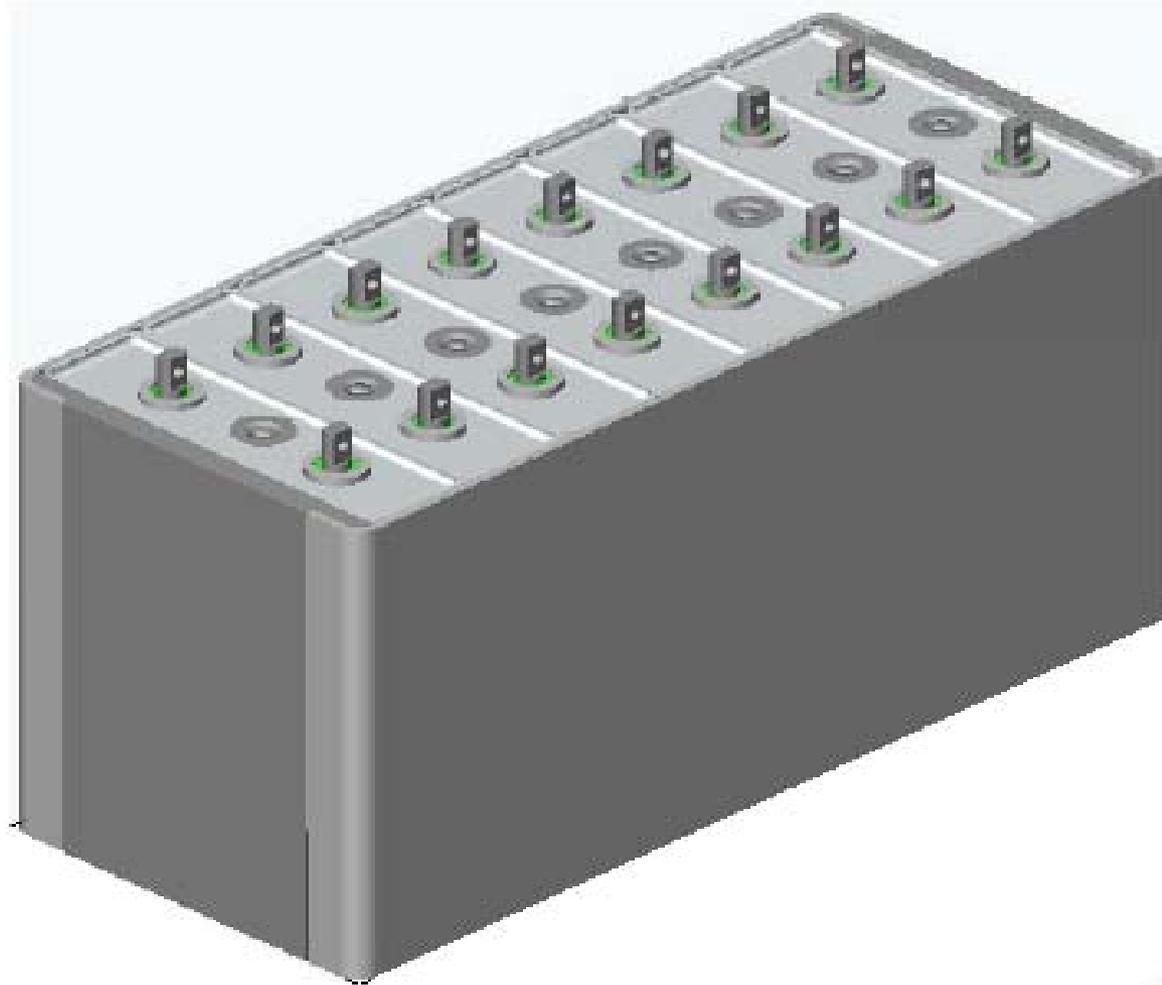
L O C K H E E D   M A R T I N
Space Operations

BMS Safety Inhibit Settings

Parameter	Software Limit	Software Delay	Hardware Limit	Hardware Delay
Over-charge	4.2V/cell	2-3 seconds	4.3V/cell	100 μsec
Over-discharge	2.5V/cell	3-4 seconds	2.15V/cell	200 μsec
Over Temperature	80 degC	3-4 seconds	None	None
Over Current	80A	2-3 seconds	170A	100 μsec

L O C K H E E D   M A R T I N
Space Operations
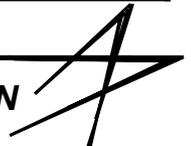
CAB and UPS Mounting Locations

UPS

CAB
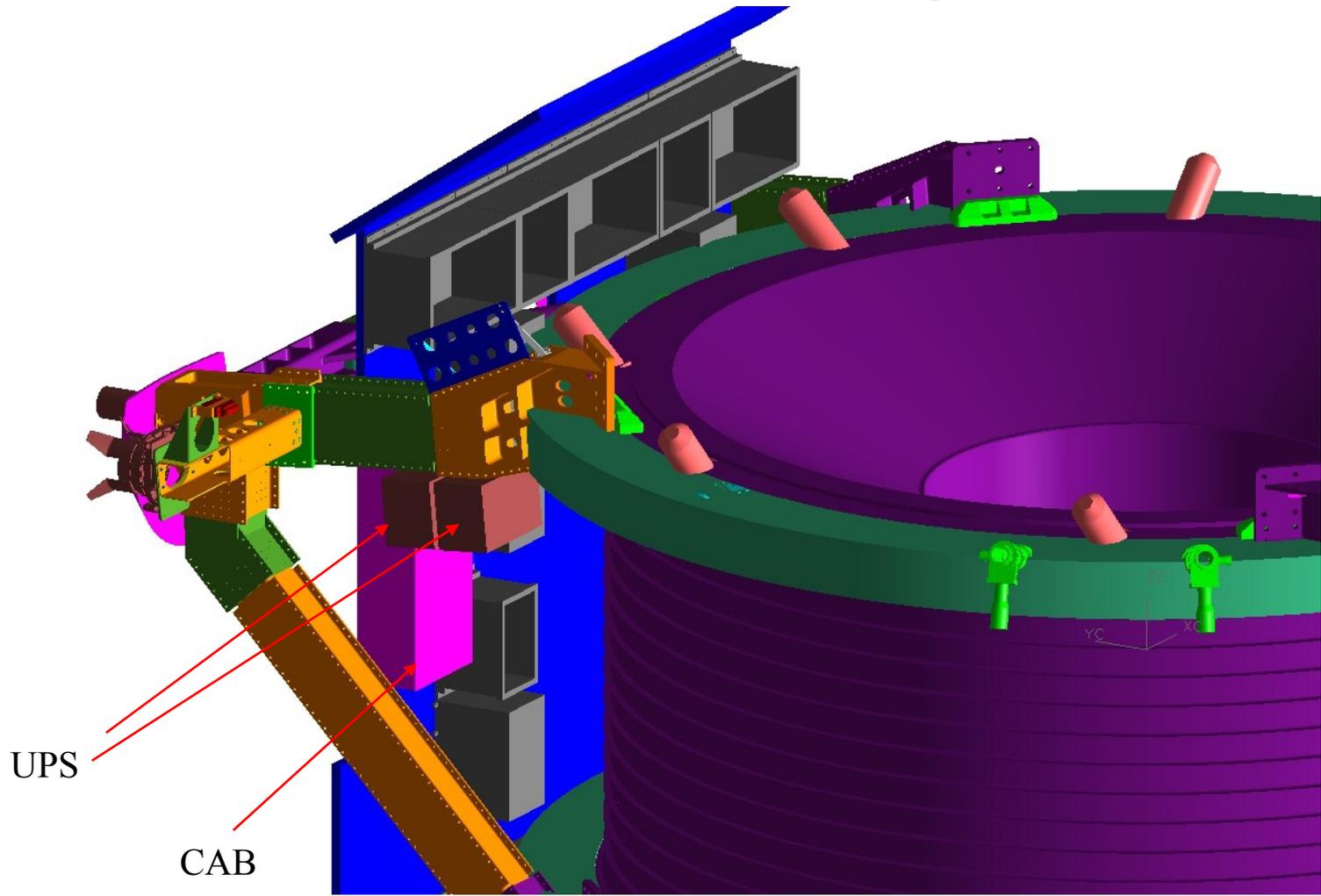
L O C K H E E D   M A R T I N
Space Operations
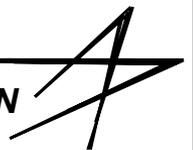
AMS-02

Pad & STS Interfaces Interconnect Diagram

L O C K H E E D   M A R T I N
Space Operations

AMS-02

J-Crate

JLIF

| EBCS | | PDB |

J1553-Y (1553) J1553-Z (1553)

JFOM-A   JFOM-B

P12 J12
J9 P9 P102 J102

To BCS Heaters

J8 J11 J10 J13
P8 P11 P10 P13

Y_J1 Y_J2 Y_J3   Z_J1 Z_J2 Z_J3

JPD
J75   J76
P13   P14

3 wire, 12 awg
Pwr/Rtn/Gnd

J100
P100

1 TSP
22awg
Stub B

1 TSP
22awg
Stub B

Tx, Rx   Tx, Rx

3 wire, 8 awg
Pwr/Rtn/Gnd

3 wire, 8 awg
Pwr/Rtn/Gnd

P122 P121

1 TSP
22 awg
Stub A

6 TSP
22awg
Address/
Parity

6 TSP
22awg
Address/
Parity

1 TSP
22 awg
Stub A

HRDL
Fiber-Optic
Pair

4 TSP*
16 awg

4 TSP*
16 awg

HRDL
Fiber-Optic
Pair

P132
P131 J132 J122
J131 J112 J121

EVA I/F Panel

J111 P111 J103 J104   J101A   J101B
P112 P103   P101

8 TSP
22awg

HRDL
Fiber-Optic
Pair

EVA
Replaceable

3 wire, 8 awg
Pwr/Rtn/Gnd

3 wire, 8 awg
Pwr/Rtn/Gnd

Bus Stub A,B/
Address/Parity

PVGF

UMA

J1
P19

SSRMS

120 Vdc

Bus A
RPCM-II   Bus B
RPCM-II

BC

ISS 1553

HRDL

Ku-Band   APS   ACOP

** Loopbacks determine which module is powered.

ISS Interfaces Interconnect Diagram

L O C K H E E D   M A R T I N
Space Operations

Data System Components

- Crate – Electronics Box

- J-Crate – Performs Top Level DAQ, contains JMDCs, JLIF, and JHIF

- JMDC – Main Data Computer – Combines Housekeeping data and Science data for distribution, performs minor processing , combines pieces of event data into complete event, converts CAN and AMS Wire to 1553, RS422, and Fiber, also TRD Gas control and TTCS control.

- JBU – Buffer Unit – Contained within JMDC, 2GB buffer (1GB/hr)

- JLIF – Low-rate data Interface – Transceivers for 1553

- JHIF – High-rate data Interface – Fiber Interface and Transceivers for RS422

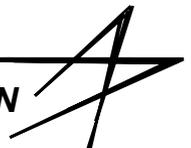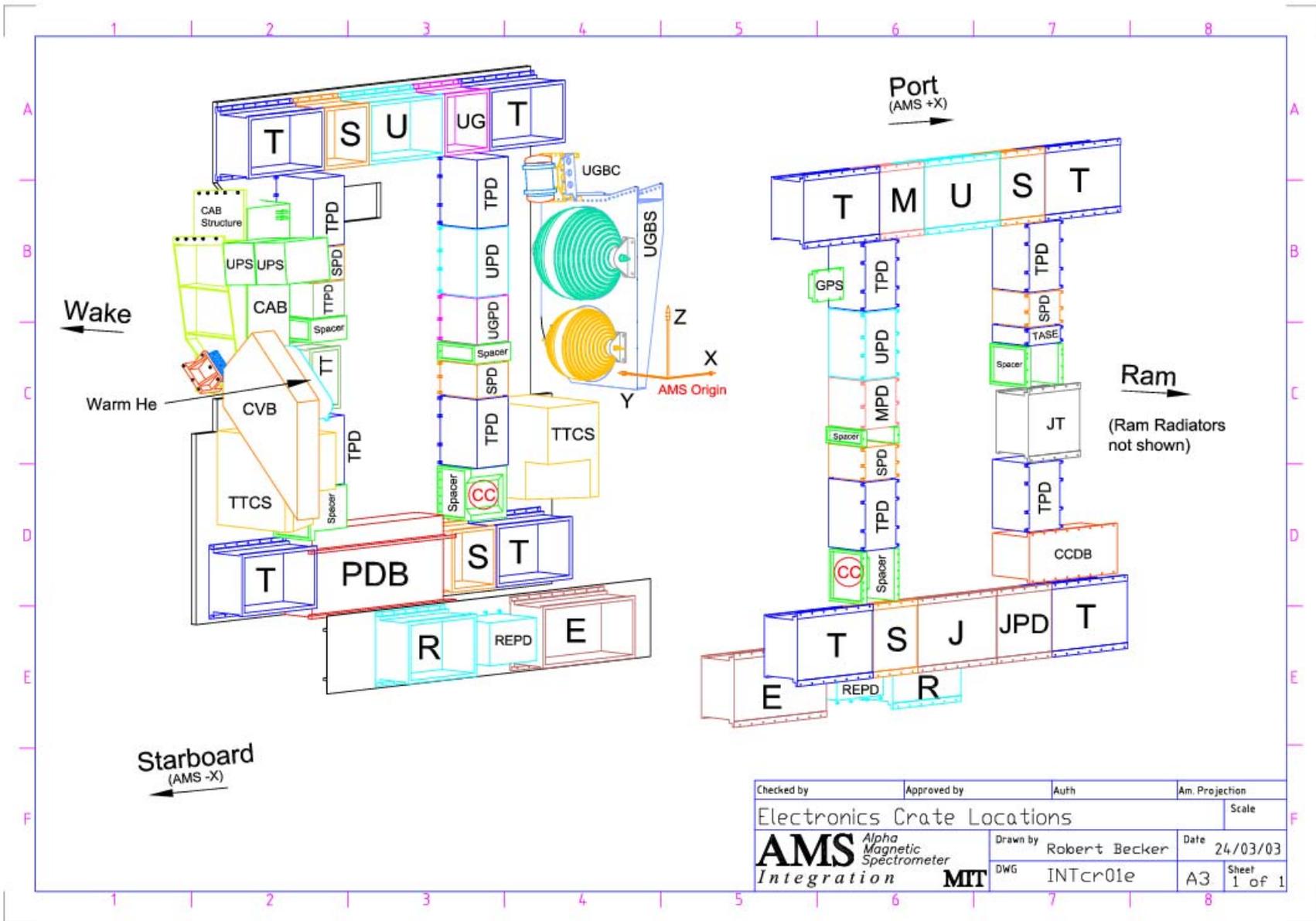- USCM – Universal Slow Control Module – 8051 based CPU and O/S with processing s/w (data gathering and blocking into types)

- CDP – Common Digital Part – Gate Array, DSP, Memory,s/w code to communicate on AMS Wire – performs digitizing, blocking and compression

- CDDC – Command Distributor/Data Concentrator – Reads CDP queue/combines pieces of single events, distributes commands to CDPs

- AMS Wire – Hi-performance serial 100Mbps custom wire (similar to ESA Space Wire)

- LVDS – Low Voltage differential signal

- JPD – J-Crate Power Distribution Box

L O C K H E E D   M A R T I N
Space Operations

Electronics Crate Locations

Checked by	Approved by	Auth	Am. Projection	
Electronics Crate Locations				Scale
AMS *Alpha Magnetic Spectrometer* *Integration* **MIT**	Drawn by Robert Becker		Date 24/03/03	
	DWG INTcr01e		A3	Sheet 1 of 1

Space Operations

Housekeeping Data Overview (equivalent to NASA H&S Data)

CAN Bus

Bus A   Bus B

Dallas Temp Sensor Bus

USCM — LVDS (Digital Bus)

Analog In

Sensors

USCM

USCM

USCM

JMDC

USCM

1553 (STS)

1553 (ISS)   JLIF   JMDC   USCM

USCM

RS422 (STS)

HRDL (ISS)   JHIF   JMDC   USCM

USCM

JMDC   USCM

USCM

Contained in J-Crate

USCM

USCM

Sensors

Data   Commands   Individual Experiment/   V, I, T, P, etc. from
                     Subsystem Crates   detectors/crates
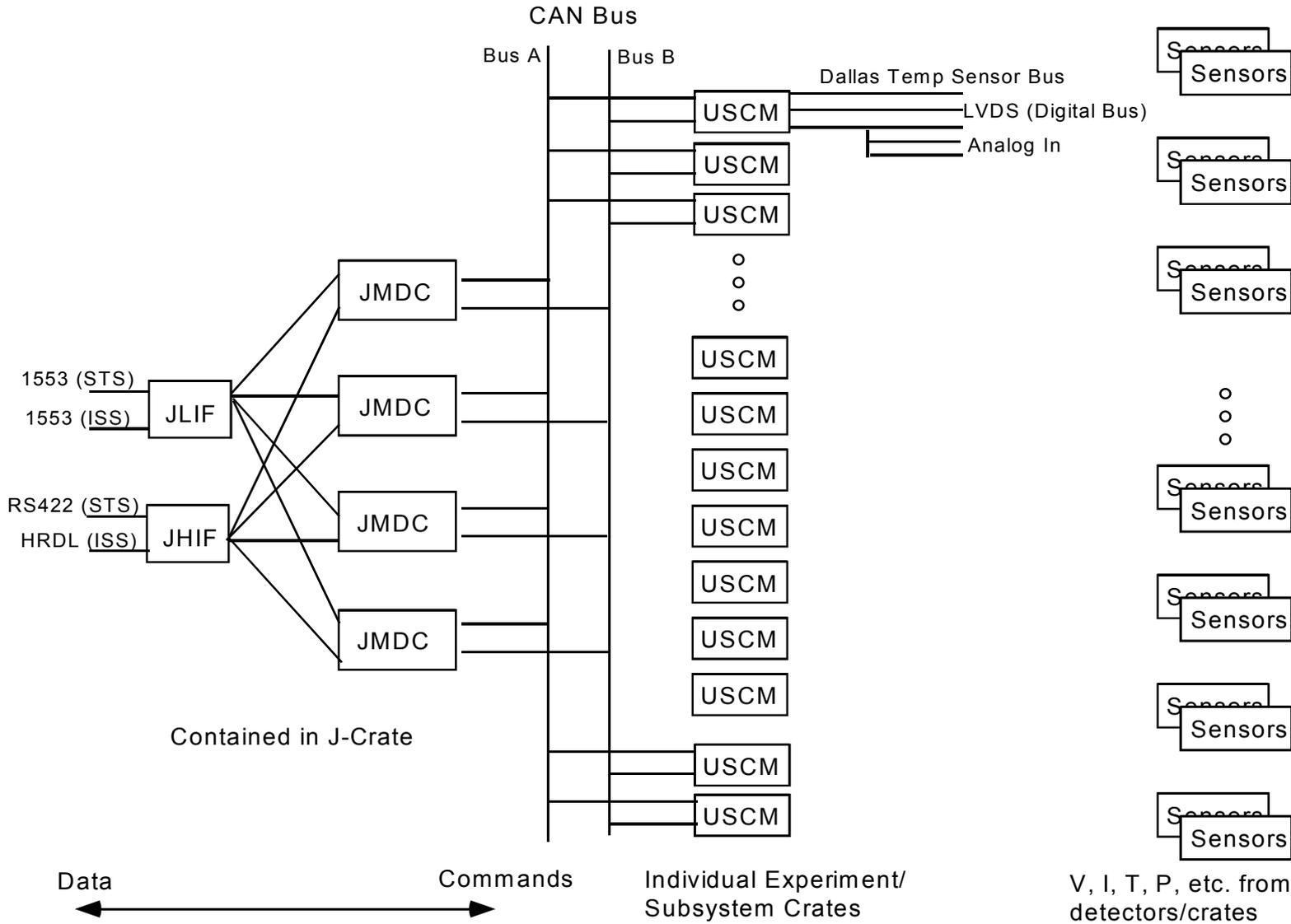
L O C K H E E D   M A R T I N
Space Operations

Science Data

Level 1 Trigger (hardware)

AMS Wire (Hi-performance serial 100Mbps custom wire)

Level 3 Trigger (software)

CDP

CDDC

JBU
JMDC

JLIF — 1553

AMS Blocks

AMS Blocks

CDDC

JHIF — Fiber to ISS / RS422 to STS

JMDC
JBU

Command ⟷ Data

Primary CMD destination for sensor adjustment (remove biases, adjust hresholds, etc., by selecting node address)

Individual Experiment/ Subsystem Boxes

Contained in J-Crate

Detectors

LOCKHEED MARTIN
Space Operations
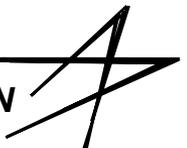
AMS Resource Requirements

- Power
  - Average 2 kW
  - Max 2.3 kW

- Data
  - Science Data: 2 Mbps (avg)
  - Housekeeping Data: 2 kbps
  - Critical Health Data: 10 Bps

*L O C K H E E D   M A R T I N*
Space Operations

Data Compatibility Testing

- STEP Testing (May 2003)

- Taxiscope testing (June 2003)

- 1553 RT Validation testing (June 2003)

- APS testing at ISIL

- OIU Lab Testing

- ESTL testing – RS-422

- PRCU testing at JSC

- PTCS testing at KSC (during on-line processing)

- Orbiter End to End Test

L O C K H E E D   M A R T I N
Space Operations
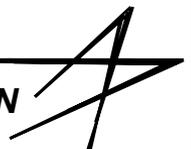
Power Compatibility Testing

- Electrical Power Systems Laboratory (EPSL)
  - Line-to-Ground Resistance & Independent Source Isolation
    - Inrush, Surge, Reverse, and Leakage Currents
    - Steady State Power
  - Current Transients & Steady-state Levels
  - Compatibility with Flight Hardware or Emulators
    - Soft Start/Stop
    - Current Limiting RPC
  - Voltage Range & Transients
    - Normal/Abnormal
    - Ripple Voltage
  - Large Signal Stability
  - Input Impedance / Gain & Phase Margins
  - Common Mode & Input Isolation

L O C K H E E D   M A R T I N
Space Operations
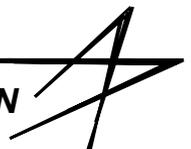
EMC Testing

- Conducted Emissions
  - SSP 30237, Rev F
    - CE01, CE03, CE07

- Conducted Susceptibility
  - SSP 30237, Rev F and SSP 30237 SSCN 3282 D.2
    - CS01, CS02, and CS06

- Radiated Emissions
  - SSP 30237, Rev F, RE02

- Radiated Susceptibility
  - SSP 30237, Rev F
    - RS02 and RS03PL (SSCN 3282 PIRN 57003-NA-0023)

L O C K H E E D   M A R T I N
Space Operations