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ACOP

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AAA	Avionics Air Assembly
ABCL	As-Built Configuration data List
ACOP	AMS-02 Crew Operation Post
ACOP-SW	ACOP Flight Software
ADP	Acceptance Data Package
AMS-02	Alpha Magnetic Spectrometer 02
APS	Automatic Payload Switch
AR	Acceptance Review
ASI	Agenzia Spaziale Italiana *(Italian Space Agency)*
ATP	Authorization To Proceed
B	
BC	Bus Coupler
BDC	Baseline Data Collection
BDCM	Baseline Data Collection Model
C	
CAD	Computer Aided Design
CCB	Configuration Control Board
CCSDS	Consultative Committee on Space Data Standards (standard format for data transmission)
C&DH	Command & Data Handling
CDR	Critical Design Review
CGS	Carlo Gavazzi Space
CI	Configuration Item
CIDL	Configuration Item data List
CM	Configuration Management
COTS	Commercial Off The Shelf
cPCI	CompactPCI (Euro Card sized standard interface to the PCI)
CSCI	Computer Software Configuration Item
CSIST	Chung Shan Institute of Science and Technology
D	
DCL	Declared Components List
DIL	Deliverable Items List
DIO	Digital Input / Output
DML	Declared Materials List
DMPL	Declared Mechanical Parts List
DPL	Declared Processes List
DRB	Delivery Review Board
DRD	Document Requirements Description
E	
EEE	Electrical, Electronic & Electromechanical
EGSE	Electrical Ground Support Equipment
EM	Engineering Model
ER	EXPRESS Rack
ERL	EXPRESS Rack Laptop
ERLC	EXPRESS Rack Laptop Computer
ERLS	EXPRESS Rack Laptop Software
EMC	Electro-Magnetic Compatibility
ESA	European Space Agency
EXPRESS	EXpedite the PRocessing of Experiments to Space Station
F	
FEM	Finite Element Model
FFMAR	Final Flight Model Acceptance Review

FLASH	Rewriteable persistent computer memory
FM	Flight Model
FMECA	Failure Modes, Effects & Criticalities Analysis
FPGA	Field Programmable Gate Array
FSM	Flight Spare Model

G

GIDEP	Government Industry Data Exchange Program
GSE	Ground Support Equipment

H

HCOR	HRDL Communications Outage Recorder
HD	Hard Drive
HDD	Hard Disk Drive
HRDL	High Rate Data Link
HRFM	High Rate Frame Multiplexer
HW	Hardware

I

ICD	Interface Control Document
I/F	Interface
IRD	Interface Requirements Document
ISPR	International Space-station Payload Rack
ISS	International Space Station

J

JSC	Johnson Space Center

K

KIP	Key Inspection Point
KSC	Kennedy Space Center
KU-Band	High rate space to ground radio link

L

LAN	Local Area Network
LCD	Liquid Crystal Display
LFM	Low Fidelity Model
LRDL	Low Rate Data Link

M

MDL	Mid-Deck Locker
MGSE	Mechanical Ground Support Equipment
MIP	Mandatory Inspection Point
MMI	Man Machine Interface
MPLM	Multi-Purpose Logistic Module
MRDL	Medium Rate Data Link

N

NA	Not Applicable
NASA	National Aeronautics and Space Administration
NCR	Non Conformance Report
NDI	Non Destructive Inspection
NRB	Non-conformance Review Board
NSTS	National Space Transportation System (Shuttle)

O

OLED	Organic Light-Emitting Diode
ORU	Orbital Replacement Unit

P

PA	Product Assurance
PCB	Printed Circuit Board
PCI	Peripheral Component Interconnect (personal computer bus)

PCS	Personal Computer System
PDR	Preliminary Design Review
PEHB	Payload Ethernet Hub Bridge
PEHG	Payload Ethernet Hub Gateway
PFMAR	Preliminary Flight Model Acceptance Review
PLMDM	Payload Multiplexer De-Multiplexer
PMC	PCI (Peripheral Component Interconnect) Mezzanine Card
PMP	Parts, Materials & Processes
PROM	Programmable Read Only Memory
PS	Power Supply

Q

QM	Qualification Model

R

RFA	Request For Approval
RFD	Request For Deviation
RFW	Request For Waiver
RIC	Rack Interface Controller
ROD	Review Of Design
ROM	Read Only Memory
RX	Reception

S

SATA	Serial Advanced Transfer Architecture (disk interface)
S-Band	Space to ground radio link
SBC	Single Board Computer
SC MDM	Station Control Multiplexer De-Multiplexer
ScS	Suitcase Simulator
SDD	Solid-state Disk Drive
SIM	Similarity Assessment
SIO	Serial Input Output
SOW	Statement Of Work
SPF	Single Point Failure
SRD	Software Requirements Document
STS	Space Transportation System (Shuttle)
SW	Software

T

TBC	To Be Confirmed
TBD	To Be Defined
TBDCM	Training & Baseline Data Collection Model
TBDCMAR	TBDCM Acceptance Review
TBP	To Be Provided
TCP/IP	Transmission Control Protocol / Internet Protocol
TFT	Thin Film Transistor
TM	Telemetry
TRB	Test Review Board
TRR	Test Readiness Review
TRM	Training Model
TX	Transmission

U

UIP	Utility Interface Panel
UMA	Universal Mating Assembly
USB	Universal Serial Bus

#

100bt	Ethernet 100Mbit Specification
1553	Reliable serial communications bus

1. INTRODUCTION

1.1 PURPOSE

This document contains the Phase 0/I flight safety assessment performed on the ACOP Design. The data presented in this document has been prepared based on the requirements for a Phase 0/I Safety Review as detailed in NSTS/ISS 13830C, "Payload safety Review and Data Submittal Requirements For Payloads Using the: -Space Shuttle - International Space Station".

This package also documents compliance to the requirements of NSTS 1700.7B, "Safety Policy and Requirements for Payloads Using the Space Transportation System (NSTS)" and its International Space Station (ISS) Addendum.

This document contains only the safety assessment and hazard reports related to flight hardware and operations.

This analysis has been developed in the frame of Preliminary Design Review (PDR).

1.2 SCOPE

This document has been prepared during the design development phase till PDR of the ACOP Unit and is in accordance with [ADNASA 1 ÷ ADNASA 5].

The Safety Data Package addresses only the flight hardware and operations safety for the ACOP at Phase 0/I. The flight hardware covered by this safety analysis is new series, no re-flown hardware is foreseen.

2. DOCUMENTS

2.1 NASA APPLICABLE DOCUMENTS

AD NASA	Doc. Number	Issue / Date	Rev.	Title / Applicability
1	NSTS 13830, Rev. C+ existing CNs	Issue date of last CN	C	Implementation Procedures for Payloads System Safety Requirements – For Payloads Using the STS & ISS.
2	NSTS 1700.7B + existing CPs	Issue date of last CP	B	Safety Policy and Requirements for Payloads using the Space Transportation System
3	NSTS 1700.7B, ISS Addendum + existing CPs	Issue date of last CP	B	Safety Policy and Requirements for Payloads using the International Space Station
4	NSTS 18798B+ existing CPs	Issue date of last CP	B	Interpretation of NSTS Payload Safety Requirements
5	KHB 1700.7C	00/8/99	C	Space Shuttle Payload Ground Safety Handbook

2.2 PROJECT DOCUMENTS

AD	Doc. Number	Issue / Date	Rev.	Title / Applicability
1	SSP 52000-IDD-ERP	D / 6/08/03		EXpedite the PRocessing of Experiments to Space Station (EXPRESS) Rack Payloads Interface Definition Document
2	NSTS/ISS 13830	C / 01/12/1996		Implementation Procedures for Payloads System Safety Requirements – For Payloads Using the STS & ISS.
3	JSC 26493	17/02/1995		Guidelines for the preparation of payload flight safety data packages and hazard reports.
4	SSP 50004	April 1994		Ground Support Equipment Design requirements
5	SSP-52000-PDS	March 1999	B	Payload Data Set Blank Book
6	SSP 52000-EIA-ERP	Feb. 2001	A	Express Rack Integration Agreement blank book for Express Rack payload
7	GD-PL-CGS-001	3 / 17/03/99		PRODUCT ASSURANCE & RAMS PLAN
8	SSP 52000 PAH ERP	Nov. 1997		Payload Accommodation Handbook for EXPRESS Rack
9	SSP 50184	D / Feb. 1996		Physical Media, Physical Signaling & link-level Protocol Specification for ensuring Interoperability of High Rate Data Link Stations on the International Space Program
10	SSP 52050	D / 08/06/01		S/W Interface Control Document for ISPR ***ONLY FOR HRDL, SECTION 3.4 ***
11	ECSS-E-40	A / April 1999	13	Software Engineering Standard
12	AMS02-CAT-ICD-R04	29/08/2003	04	AMS02 Command and Telemetry Interface Control document. Section AMS-ACOP Interfaces
13	SSP 52000-PVP-ERP	Sept. 18, 2002	D	Generic Payload Verification Plan EXpedite the PRocessing of Experiments to Space Station (EXPRESS) Rack Payloads
14	NSTS 1700.7B	Rev. B Change Packet 8 / 22.08.00		Safety Policy and Requirements for Payloads using the STS
15	NSTS 1700.7B Addendum	Rev. B Change Packet 1 01.09.00		Safety Policy and Requirements for Payloads using the International Space Station
16	SSP 52005	Dec. 10, 1998		Payload Flight equipment requirements and guidelines for safety critical structures
17	NSTS 18798B	Change Packet 7 10.00		Interpretation of NSTS Payload Safety Requirements
18	MSFC-HDBK-527	15/11/86	E	Materials selection list for space hardware systems Materials selection list data
19	GD-PL-CGS-002	1/ 12-02-99		CADM Plan
20	GD-PL-CGS-004	2/07-04-03		SW Product Assurance Plan
21	GD-PL-CGS-005	2/09-05-03		SW CADM Plan

2.3 REFERENCE DOCUMENTS

RD	Doc. Number	Issue / Date	Rev.	Title
1	GPQ-MAN-02	1		Commercial, Aviation and Military (CAM) Equipment Evaluation Guidelines for ISS Payloads Use
2	BSSC (96)2	1 / May 96		Guide to applying the ESA software engineering standards to small software projects
3	GPQ-MAN-01	2 / Dec. 98		Documentation Standard for ESA Microgravity Projects
4	MS-ESA-RQ-108	1 / 28-Sep-2000		Documentation Requirements For Small And Medium Sized MSM Projects
5	PSS-05			Software Engineering Standards
6	GPQ-010	1 / May 95	A	Product Assurance Requirements for ESA Microgravity Payload. Including CN 01.
7	GPQ-010-PSA-101	1		Safety and Material Requirements for ESA Microgravity Payloads
8	GPQ-010-PSA-102	1		Reliability and Maintainability for ESA Microgravity Facilities (ISSA). Including CN 01
10	ACP-RP-CGS-003	1/Jan. 05		ACOP Design Report
11	ACP-RP-CGS-004	1/Jan. 05		Electrical Analysis and Design Report
12	ACP-RP-CGS-002	1/Jan. 05		Operational Analysis Report
13	ACP-RP-CGS-005	1/Jan. 05		Structural Analysis and Design Report
14	ACP-RP-CGS-006	1/Jan. 05		Thermal Analysis and Design Report
15	ACP-PL-CGS-002	1/Jan. 05		PA Plan
16	ACP-TN-CGS-001	1/Jan. 05		FMECA and SPF List
17	ECSS-Q-60-11A	/ Sept. 2004	A	Derating and end-of-life parameter difts –EEE Components

3. ACOP SYSTEM DESCRIPTION

3.1 INTRODUCTION

The ACOP System is intended to fly on the International Space Station (ISS) as a payload installed into a ISPR on the NASA laboratory. The main objective of ACOP is to provide an ISS Internal Facility capable of supporting AMS-02 experiment, performing the recording of Science data. In particular, ACOP shall allow a more flexible and efficient use of ISS TM downlink, providing a temporary backup of data generated by AMS-02 and preventing, in this way, possible losses of valuable data. In addition, ACOP is the operational interface to on board crew in order to control and monitor AMS-02 inside from ISS and to permit files and SW upload into the supported payloads.
ACOP system shall be installed in the U.S. Laboratory Module, on the ISS, in one EXPRESS rack (see, for reference, Figure 3-1).

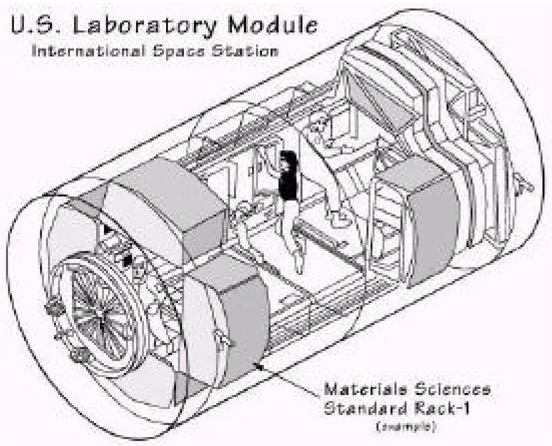

Figure 3-1 US-LAB

The standard configuration of an EXPRESS Rack is commonly known as 8/2. This means that it can accommodate eight ISS locker/Middeck Locker (MDL) and two International Subrack Interface Standard (ISIS), as shown in Figure 3-2. On-Board Spare parts shall be accommodated in a standard soft bag.

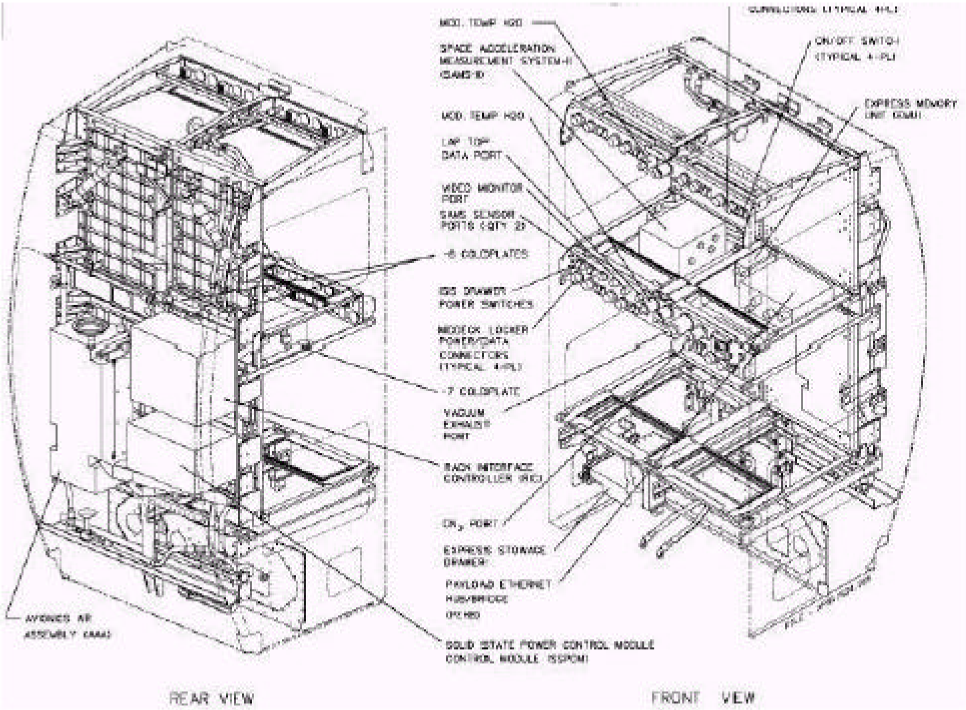

Figure 3-2: Example of Express Rack

3.2 ACCOP SYSTEM OVERVIEW

ACOP is reliable special purpose computer to be launched to the International Space Station (ISS) to assist the operations of large science experiment projects. ACOP provides these services:

1. On-orbit recording mechanism for large volumes of data at high rates
2. Play back for downlink of the recorded data at high rates
3. A crew interface for complex experiments
4. General computing facilities
5. Alternate bi-directional commanding path via the HRDL interface

ACOP will initially support a state-of-the-art particle physics detector experiment Alpha Magnetic Spectrometer (AMS-02), which uses the unique environment of space to study the properties and origin of cosmic particles and nuclei including antimatter and dark matter, to study the actual origin of the universe and potentially to discover antimatter stars and galaxies.

After the AMS-02 experiment, ACOP will stay permanently in the US module as the only computer for large science experiment projects on the International Space Station for astronaut crew's use for recording and management of science data, monitoring and control of experiment, as well as improving the data communication between the earth and the space station.

In addition to the ACOP system there will be stowage bag sent to ISS that will contain additional hard drives that can be exchanged with the hard drives in ACOP. From time to time the astronauts will perform this exchange enabling ACOP to record all of AMS-02's data onto fresh hard drives. Once recorded, the data will not be overwritten; rather it will be transported to the ground as a permanent archive (TBC).

3.2.1 FUNCTION AND PURPOSE OF ACOP

ACOP must meet the following requirements of the AMS-02 program:

1. Operate effectively in the ISS space environment.
2. Create an on-orbit recording of all AMS-02 science data on removable[1] media - explicitly hard drives, preferably SATA based.
3. Provide not less than 20 days of recording capacity without crew intervention (based on 2Mbit/second rates), longer would be better.
4. Provide not less than 120 days of recording media capacity within a single mid deck locker equivalent storage unit, longer would be better.
5. Recorded data is an archive. Disks must be provided for the entire 3+ year mission without overwriting (a total of ~23 TByte)[2].
6. For recording ACOP must support an orbital average data rate of not less then 4Mbit/second with bursts of up to 20 Mbit/second.
7. Provide a continuous operations display of ad hoc AMS-02 data for the ISS crew to monitor[3].
8. Provide a continuous means for the ISS crew to issue ad hoc predefined commands without external equipment[4].
9. Provide, as needed, an exhaustive diagnostic, monitoring and operations environment via the EXPRESS laptop computer.
10. Support the playback of recorded data to ground systems at selectable data rates up to at least 20Mbits/second sustained while simultaneously recording at prescribed rates.
11. Support ACOP to AMS-02 commanding at selectable data rates up to at least 20Mbits/second sustained (No requirement for simultaneous recording or playback operations at higher rates.)
12. Support an alternate AMS-02 ground commanding and housekeeping report path via the HRDL interface.
13. CompactPCI based. Preferably 6U form factor.
14. Crew serviceable for upgrades and repairs - hardware and software.
15. Provide for upgrades and expansion to ACOP using COTS subsystems.
16. Provide support of ISS system upgrades (100bt MRDL follow on systems)[5].
17. ACOP will be housed in an EXPRESS Rack Locker.
18. The mass budget for ACOP is 35.5 kg for the EXPRESS Rack Locker and 35.5 kg for the soft stowage bag.
19. The power allocated to ACOP is 200 watts

3.2.2 UTILIZATION CONCEPT

The following are the key points of the ACOP operational concept as it pertains to the AMS-02 mission:

- ACOP is principally a ground operated payload.
- ACOP is powered and active whenever AMS-02 is active. Only short (<8hrs) outages.
- ACOP maintains an active bi-directional connection via the HRDL interface to AMS-02 at all times.
- The AMS-02 TX connection may be tee'd by the APS to the HRFM/KU for direct downlink.
- ACOP provides the mechanism for the crew to monitor and control AMS-02. Both front panel and ERL based interfaces are supported.
- As KU access is available, ACOP will be commanded to use its additional TX connection to down link data. ACOP will have the ability to burst this transmission (~20Mbits/sec).
- All data transmitted by AMS-02 is recorded onto ACOP's hard drives as a master copy of the AMS-02 science data.
- When ACOP has acknowledged that the data is recorded, AMS-02 can release that data from its buffers.
- The four hard drives installed in ACOP provide an estimated 20 days of recording (Note: Dependent on event

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[1] Hot swap software not required but performing a hardware hot swap must not permanently damage the system
[2] The current contract ASI N. I/044/04/0 foresees the provision of 14 nominal hard drives plus 2 hard drives as spare parts. The individual hard disk capacity is 200 – 250 GB (TBC).
[3] The design presented in this report foresees the presence of a LCD monitor, not foreseen in the contract ASI N. I/044/04/0
[4] The design presented in this report foresees the presence of a LCD monitor, not foreseen in the contract ASI N. I/044/04/0
[5] Not foreseen in the contract ASI N. I/044/04/0

rate and size.)

- The four installed hard drives will require periodic replacement by the ISS crew from the onboard stock of empty drives (30 minute operation about every 20 days)
- A batch of 20 hard drives provides 150 days of recording capacity.
- New batches of hard drives will be delivered by STS and the original master copies of the AMS-02 data will be returned to earth by STS.

3.3 MECHANICAL STRUCTURE

ACOP is installed in the location of MDL of EXPRESS Rack as shown in the following figure and should blind mate with the back plate of the rack.

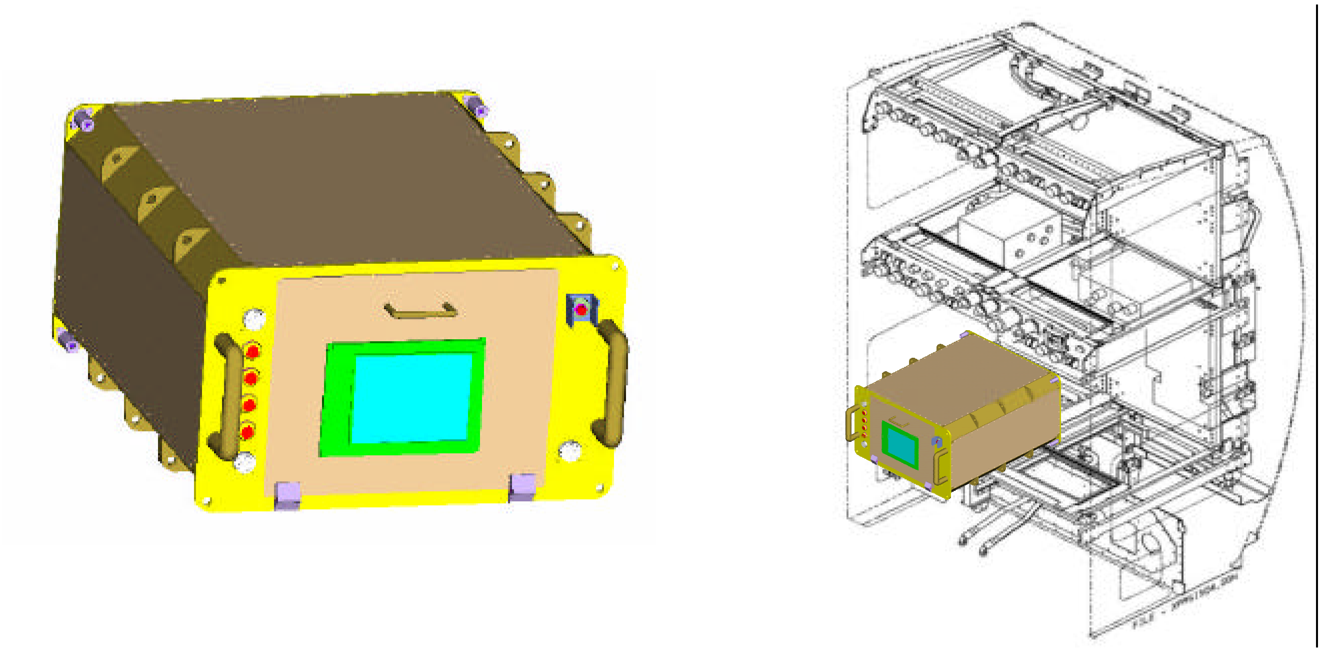

Figure 3-3 Location and configuration of ACOP

Mechanical structure of ACOP is mainly constructed by an outer structure (LOCKER) and an inner structure (CHASSIS The locker will be mounted to the back-plate of the EXPRESS Rack and the chassis will support the electrical components..

The main mechanical parts of ACOP are listed below:

Item	Function	Quantity	Note
LOCKER	Outer structure (shell) of ACOP. Structure interface to back plate of RACK	1 set	Assembly of 6 plates and 4 beams, Integrated by flat head #4 screws
FRONT PANEL (Fixed)	Part of LOCKER Supporter of all IO connectors	1 piece	
FRONT PANEL (Opening)	Access for HARD DRIVE replacement Location of LCD (TBC)	1 piece	Opened with friction hinge, closed by 1/4 Turn fasteners
CHASSIS	Inner structure of ACOP Supporter of electric components Fins for heat dissipation	1 piece	Produced by wire cutting, all in one piece. It will be fixed to the locker by means of flat head screws size # 6 or #8 (TBC).
SIDE PLATE	Enclose airflow inside the fin channel Prevent occurrence of turbulence in front space.	2 pieces	Fixed with CHASSIS by #4 flat head screws

Item	**Function**	**Quantity**	**Note**
BP FRAME	Frame for Back Plane Resist the force when connector plug in	1 piece	Integrated with Back Plane by screws
DUCT	Air duct for air inlet and outlet Airflow channels between CHASSIS and LOCKER	2 sets	Made from metal plate, integrated with CHASSIS and LOCKER by #4 flat head screws
CADDY	Frame for HD Heat sink and path of HD	4 pieces	
AIR FILTER	Filter for airflow	2 pieces	Mounted from outside of LOCKER back plate

Table 3-1 Main Mechanical Parts

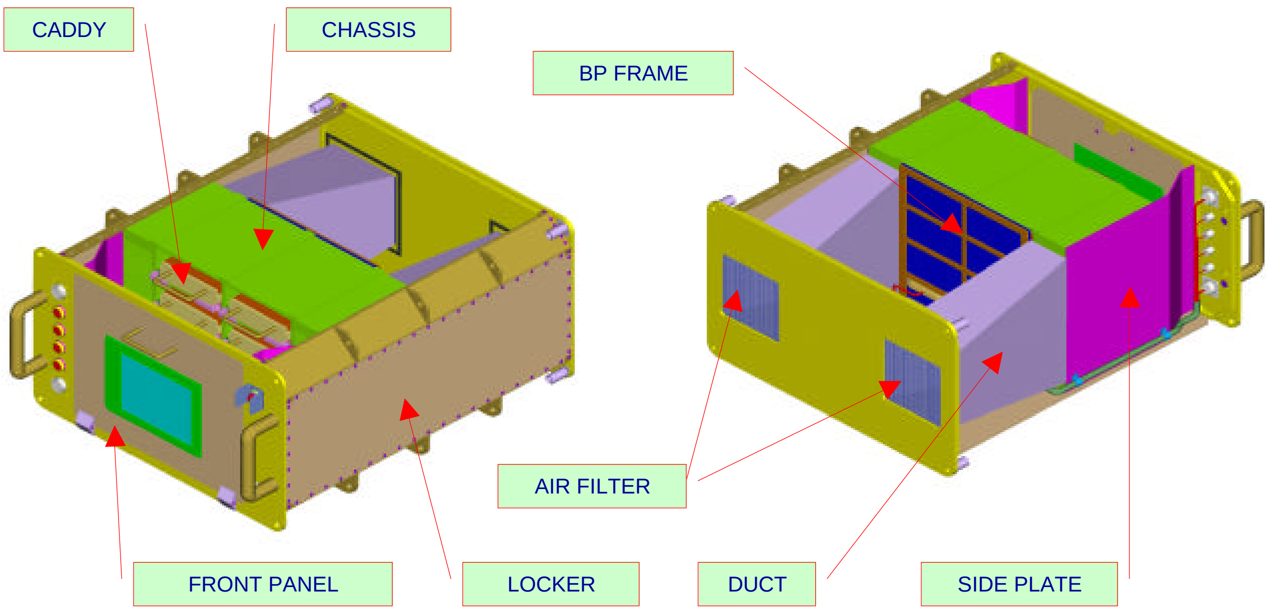

Figure 3-4 Mechanical Main parts of ACOP

There are 4 HARD DRIVEs installed in the upper part of the Chassis and 5 PCI with 1 power supply installed in the lower part of the Chassis as shown in the Figure 3-5.

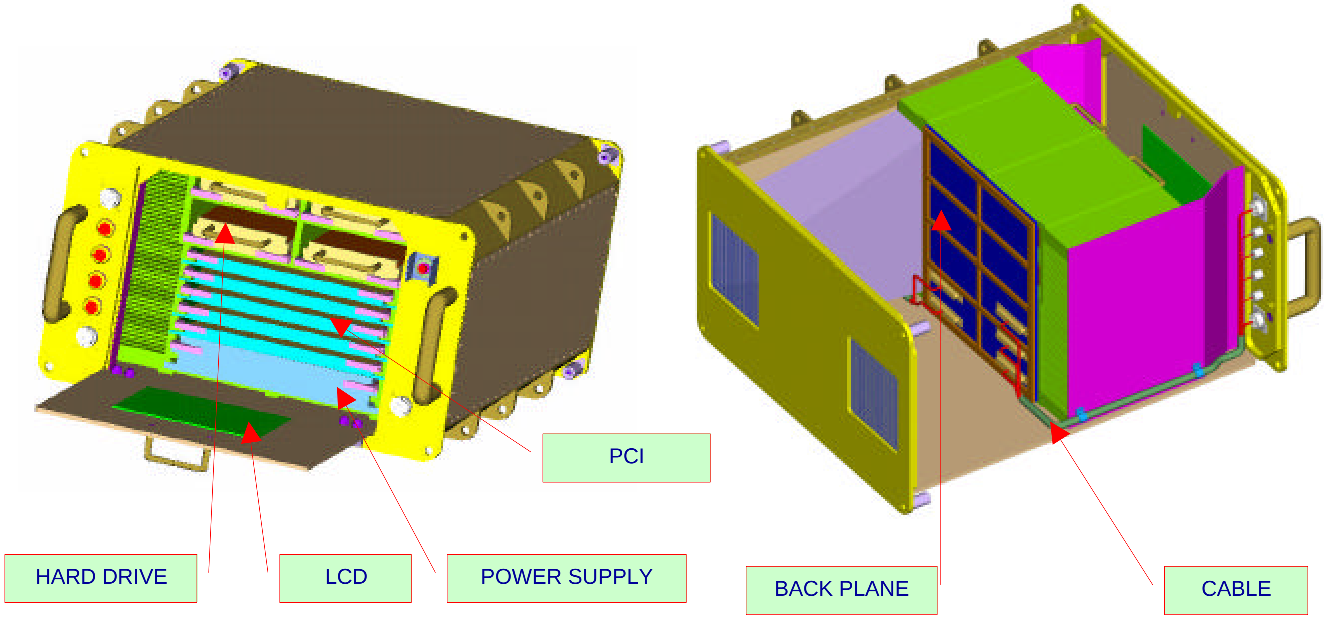

Figure 3-5 Electric Main parts of ACOP

At moment the hard drives are under selection so the final choice is TBC. All CompactPCI, Hard Drives, and the Power Supply are fixed and extracted by hand operated card locks as shown in the Figure 3-6. No special tools are required.

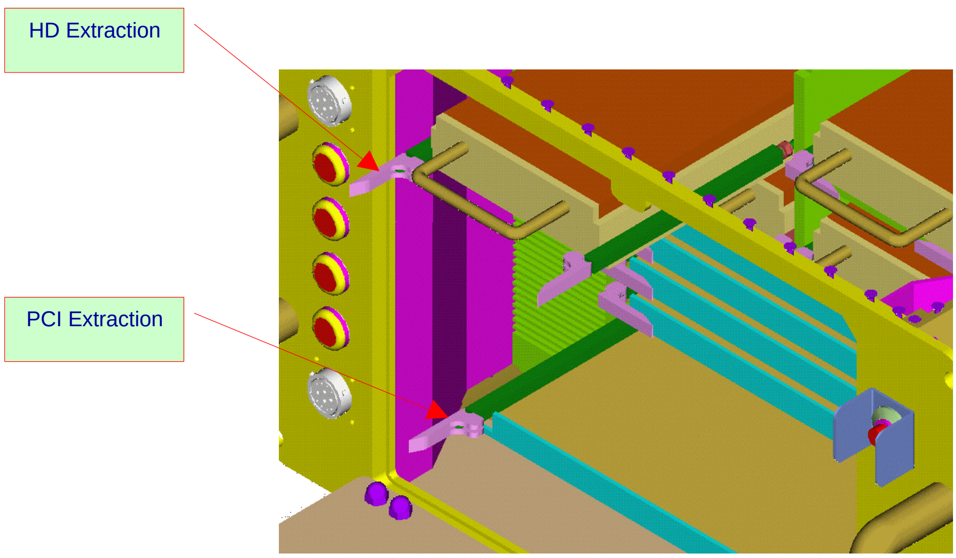

Figure 3-6 Card Locks

The most important matters concerned for hard drive installation and replacement are reliability and human factor. The connectors will be put on the rear side of the CADDY of the Hard Drive and plugged into the corresponding connector on the Backplane.as shown in the Figure 3-7. The force to plug in or out the connector is tested to be 5 kg for a 26 pin D-Sub type connector .

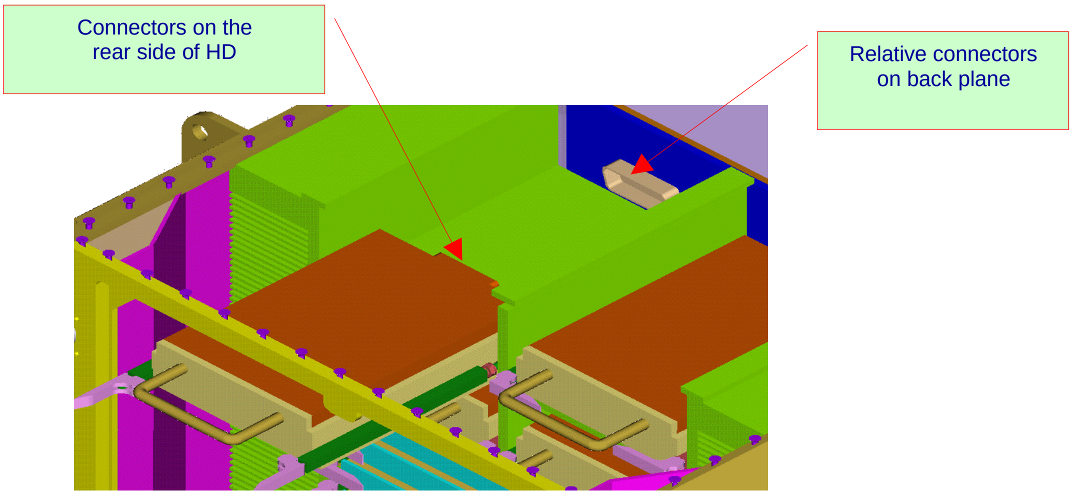

Figure 3-7 HARD DRIVE installation

All external connectors, push buttons, circuit breaker, and LCD (TBC) are mounted on the Front Panel as shown in the Figure 3-8.

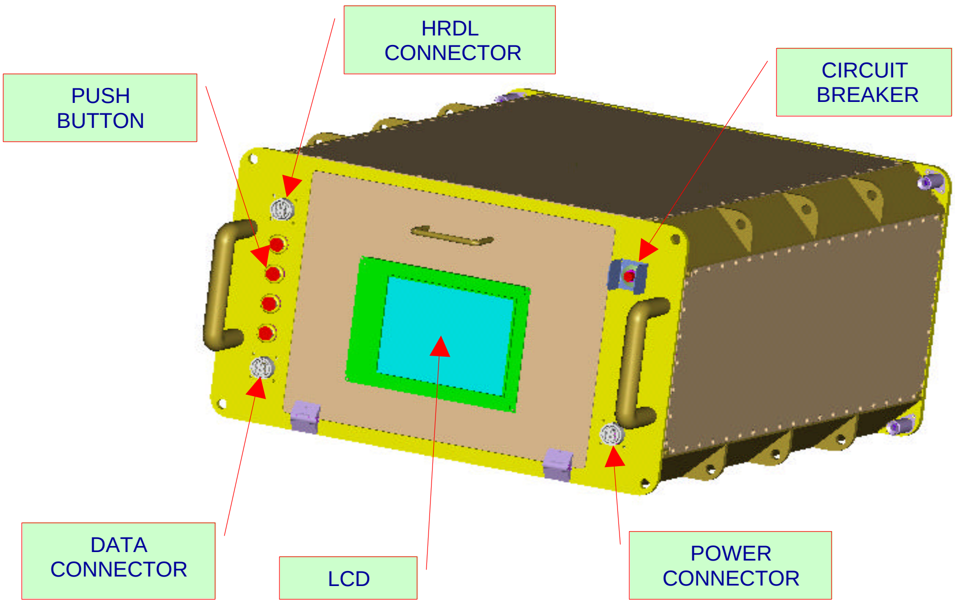

Figure 3-8 Layout on Front Panel

Main front Panel shall be mounted with LCD Panel (TBC) and can be opened with friction hinge. It is locked by four 1/4 fasteners and one magnetic latch.
LCD display is covered by plastic covering to avoid potential shatterable material hazard.

Following components are mounted in the Front Panel:

- Four Momentary Press Buttons
- One Circuit Breaker On/Off Switch
- One HRDL Connector
- One Power Connector
- One MRDL Connector with expansion 100bt and RS422

3.3.1 CABLE HARNESS

Cable that come from the Back Plane will pass through the space between CHASSIS and LOCKER on both sides and go to the Front Panel.

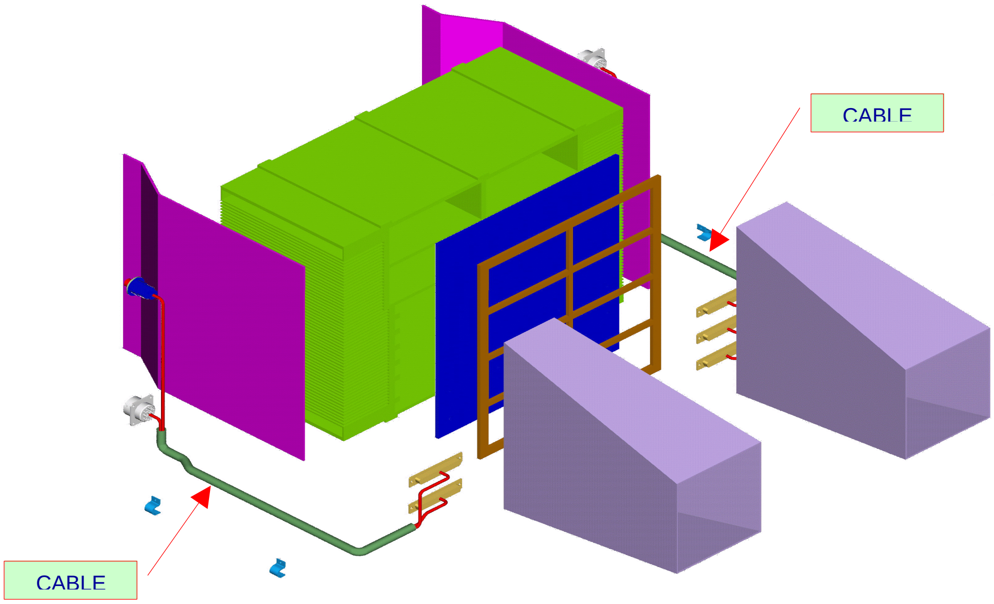

Figure 3-9 Layout of cable (rear view)

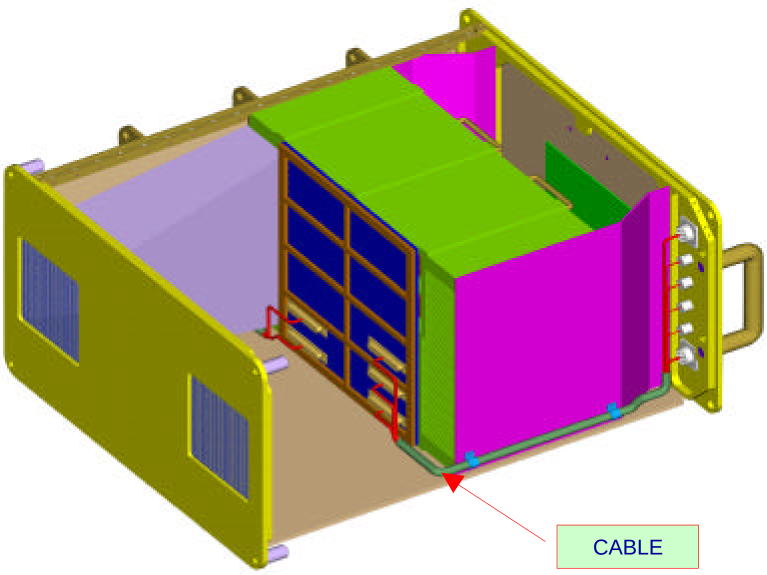

Figure 3-10 Layout of cable (side view)

3.3.2 MATERIALS AND PROCESSES

The material aluminium alloy AL 7075-T7351 is used for the entire structure; the material FR4 is used for electronic boards. Mechanical properties of AL 7075-T7351 and FR4 are list in the Table 3-2 and Table 3-3. Electronic boards and LCD module are not available now. Here, assume reasonable material properties of these parts referring to AMS02 E-crate structural analysis report.

AL 7075		
source	MIL-HDBK-5G	
Specification	AMS 4078 and QQ-A-250/12	
Form	Plate	
Temper	T7351	
Thickness	0.5~1.0 in	
basisi	A	
	ksi	**$x10^6$ N/m^2**
Ftu	68	468.9
Fty	57	393
Fsu	38	262
Fbru(e/D=1.5)	103	710.2
Fbry (e/D=1.5)	81	558.49
E	10.3	71020.
	lb/in^3	**kg/m^3**
Density	0.101	2.79E+3
Poisson Ratio	0.33	

Table 3-2: Mechanical and physical properties of AL 7075

Material	**Specification**	
FR4		
	ksi	**N/m^2**
Ftu	29	2.00E+08
Fty	N/A	N/A
Fcu	50.7	3.497E+8
Fcy	N/A	N/A
Fbru(e/D=1.5)	--	--
Fbry(e/D=1.5)	N/A	N/A
E	2.61E+3	1.80E+10
	lb/in^3	**kg/m^3**
Density	6.5E-02	1.799E+3
Poisson Ratio	0.3	
Reference	Vonroll Isola catalogue	01/06/1995

Table 3-3: Mechanical and physical properties of FR4

Both Locker and Chassis will be assembled by several parts which are mainly produced by machine milling. Assembly are integrated by stainless fastener according to MIL-SPEC.
Surface treatments will be either Clear Anodizing according to Spec.MIL-A-8625 TYPE II CLASS 1 or Anodyne 1200 according to Spec.MIL-C-5541 CLASS 3.

3.3.3 STRUCTURAL ANALYSIS RESULTS SUMMARY

Basic on 3D mechanical design drawing and mass budge of ACOP engineering model, the finite element model was built to verify structural safety.
MSC/NASTRAN v2004 software is used for analysis, including model check, natural modal analysis, and static stress analysis.
EDS/I-DEAS 10m2 software is used for Pre/Post processing, including FE model construction, results plotting.

3.3.3.1 SAFETY FACTORS

The structural factors of safety Table 3-4shall be applied to the EXPRESS Rack load factors during the payload analysis. In this report, we conservatively use factor of safety 1.25 for yield and 2.0 for ultimate.

CATEGORY		FACTOR OF SAFETY	
		YIELD	ULTIMATE
Metallic Structures	Untested Shuttle (analysis only)	1.25	2.0
	Untested On-Orbit (analysis only)	1.25	2.0
	Tested Shuttle (analysis and test)	1.0	1.4
	Tested On-Orbit (analysis and test)	1.1	1.5

Table 3-4: Factors Of Safety For Express Rack Payload Analysis

The structural factors of safety in
Table 3-5 shall be applied to the middeck load factors during the payload analysis.

ANALYSIS	ULTIMATE FACTOR OF SAFETY
Payload Structure	1.4

Table 3-5: Factors Of Safety For Middeck Payload Analysis

3.3.3.2 MOS SUMMARY FOR STRESS ANALYSIS

The following table presents the summary of the margins of safety of the entire ACOP crate. In the table the values of Fty and Ftu have degraded by a factor of 0.97 .

MARGINS OF SAFETY FOR STRESS ANALYSIS										
ITEM	**LC**	**NID EID**	**MATERIAL**	**Fty**	**Ftu**	**Limit stress [Mpa]**	**$S.F._Y$**	**$S.F._U$**	**MoS_Y**	**MoS_U**
Chassis	20	N59029	AL 7075 T7351	381.2	454.8	1.475E+02	1.25	2.0	1.068	0.542
Ducts	17	E22008	AL 7075 T7351	381.2	454.8	4.104E+01	1.25	2.0	6.431	4.541
Front Panel + LCD	12	N63655	AL 7075 T7351	381.2	454.8	1.937E+01	1.25	2.0	14.744	10.741

MARGINS OF SAFETY FOR STRESS ANALYSIS										
ITEM	**LC**	**NID EID**	**MATERIAL**	**Fty**	**Ftu**	**Limit stress [Mpa]**	**S.F.$_Y$**	**S.F.$_U$**	**MoS$_Y$**	**MoS$_U$**
Locker	20	N76999	AL 7075 T7351	381.2	454.8	1.639E+02	1.25	2.0	0.861	0.388
PCB	17	N18379	FR4	NA	200	1.349E+01	NA	2.0	NA	6.191

Table 3-6:MOS FOR STRESS ANALYSIS FOR THE ENTIRE MODEL

All MoS are positive for the worst loading case. The minimum MoS is 0.388 occurred at a fastener hole of locker backplate for ultimate stress.

3.3.3.3 MOS SUMMARY FOR JOINT ANALYSIS

The following table presents the summary of the MoS of bolts in the ACOP crate.

MoS Type	MoS Value	Joint ID
MoS sep	0.518	2, 3
MoS combU	0.386	1, 4
MoS bry	5.88	1, 4
MoS bru	4.47	1, 4
MoS lug ty	10.74	1, 4
MoS lug tu	7.75	1, 4
MoS lug sy	3.509	1, 4
MoS lug su	3.89	1, 4
MoSinsert	-0.183	4

Table 3-7: MoS for bolt analysis

The MoS are positive for all applied loads and compliant with the structural requirement except for the insert analysis.
The ACOP interface is made using the configuration A defined in AD1 (section 3.4.3.6.2.1). In this configuration the attachment point is as the Figure 3-11 shows.

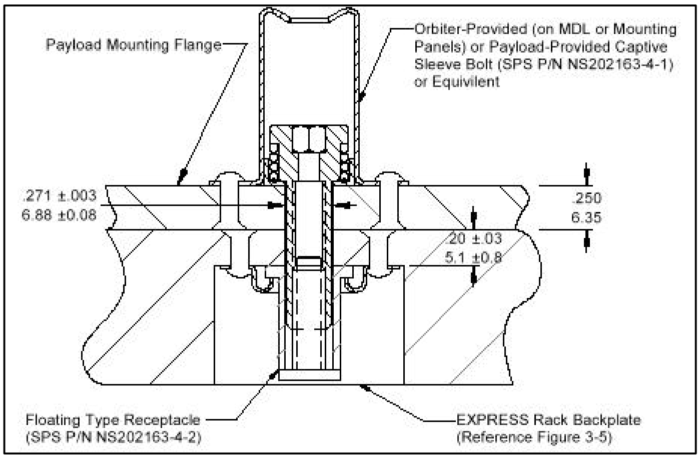

Figure 3-11: EXPRESS Rack backplate attachment point details.(from AD1)

And the allowable forces of Type A joint are shown as the following table.

BACK PLATE INTERFACE	INTERFACE CONFIGURATION	ULTIMATE FORCE ALLOWABLES	
		TENSILE (lbf)	SHEAR (lbf)
Type A	Sleeve Bolt Receptacle P/N SPS 202163-4-2	2500[1]	1660[1]
Type B	Threaded Insert P/N MS51831CA-202	8900[2]	19600[2]

Notes:
1. Sleeve bolt limits based on manufacturer's specification SPS NS202163-4.
2. Insert limits exceed 160ksi bolt strength.

Table 3-8: EXPRESS rack backplate inerface force allowables

After calculating like bolt analysis, MoS (-0.183) for insert is negative.

To avoid this problem the following solutions are under investigation:

- Modification of the joint type: from A to B. In this case the hole pattern in the I/F panel are different. Either
    - modify the mechanics to comply also with B hole pattern (with particular attention to integration of chassis, cabling and manufacturing) or
    - evaluate the possibility of using an adapter (TBC after PDR).
- Reduce mass with current joints or/and
- Move the chassis toward the back of the locker to increase the margin of safety.

3.4 ELECTRICAL

3.4.1 ISS AVIONICS ARCHITECTURE

The ISS Command & Data Handling (C&DH) of the ACOP and AMS-02 system is shown as Figure 3-12.

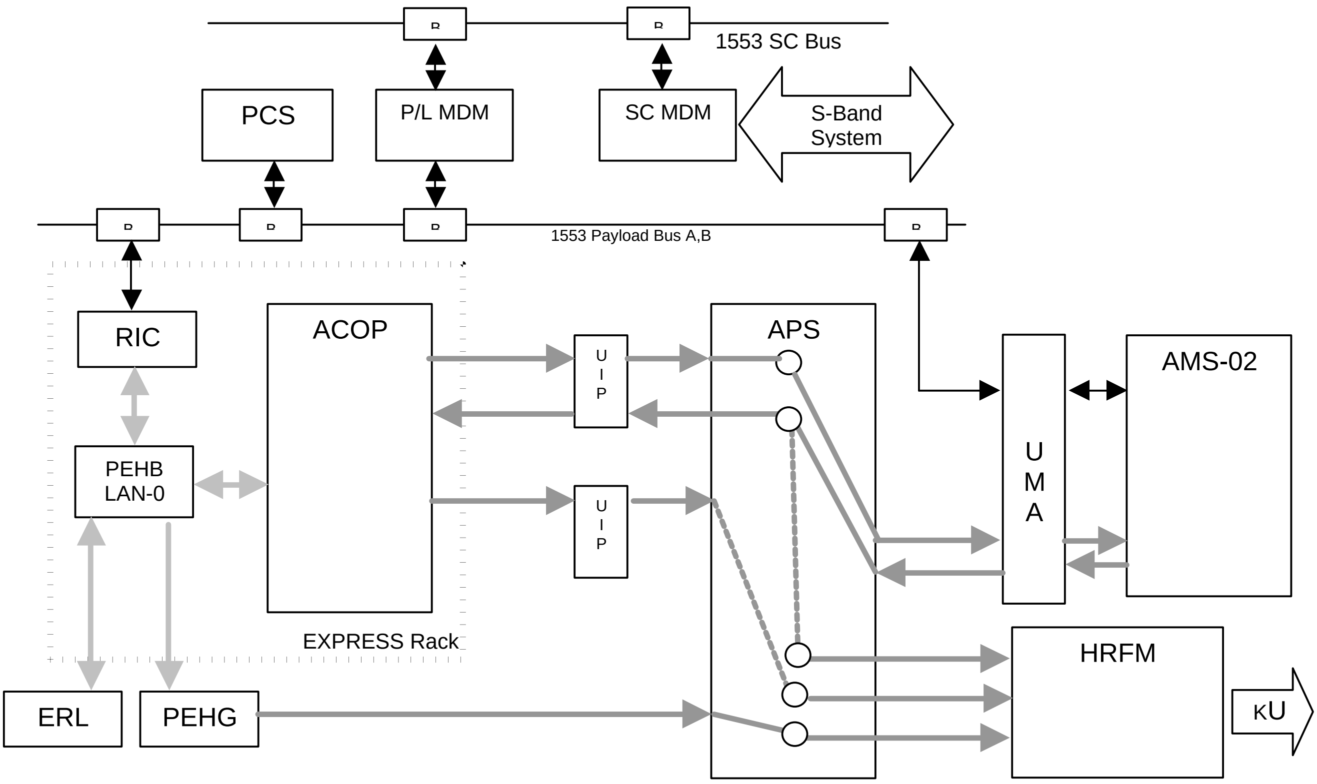

Figure 3-12 AMS-02 Avionic Architecture

Commanding and housekeeping data for ACOP is handled via the EXPRESS Rack Interface Controller (RIC). ACOP communicates with the RIC software on an Ethernet connection via the Payload Ethernet Hub Bridge (PEHB) using the Transmission Control Protocol/Internet Protocol (TCP/IP).

All ISS HRDL fibers are connected to the Automated Payload Switch (APS). This device provides cross bar switching among the fiber systems of ISS. ACOP has two prime targets for HRDL transfers. The first is the High Rate Frame Multiplexer (HRFM - via the High-Rate Communications Outage Recorder (HCOR). The HRFM interleaves data to the KU-Band transmission system for downlink. The second target is the AMS-02 payload. The APS can be configured to tee data transmitted by AMS-02 to both the HRFM and ACOP.

ACOP maintains an active bi-directional connection via the HRDL interface to AMS-02 at all times. As KU access is available, ACOP will be commanded to use its' additional TX connection to down link data. ACOP will have the ability to burst this transmission (~20Mbits/sec). All data transmitted by AMS-02 is recorded onto ACOP's hard drives as a master copy of the AMS-02 science data. When ACOP has acknowledged that the data is recorded, AMS-02 can release that data from its buffers.

3.4.2 ACOP AVIONICS ARCHITECTURE

The ACOP system is based on CompactPCI systems. It contains a single board computer and several custom developed interface boards (including HRDL fiber interface, Ethernet interfaces, two USB interface to upgrade the operating system and programs, and digital input-output and video interface). ACOP will also contain four exchangeable hard disks used to archive the data and the necessary interfaces. Other parts of ACOP are a flight qualified LCD (TBC) screen and a simple push button interface, connected via peripheral cards.

In the main chassis and front panel are the electrical parts which include a set of digital computer hardware and software, the functional block diagram of electrical parts is shown as Figure 3-13.

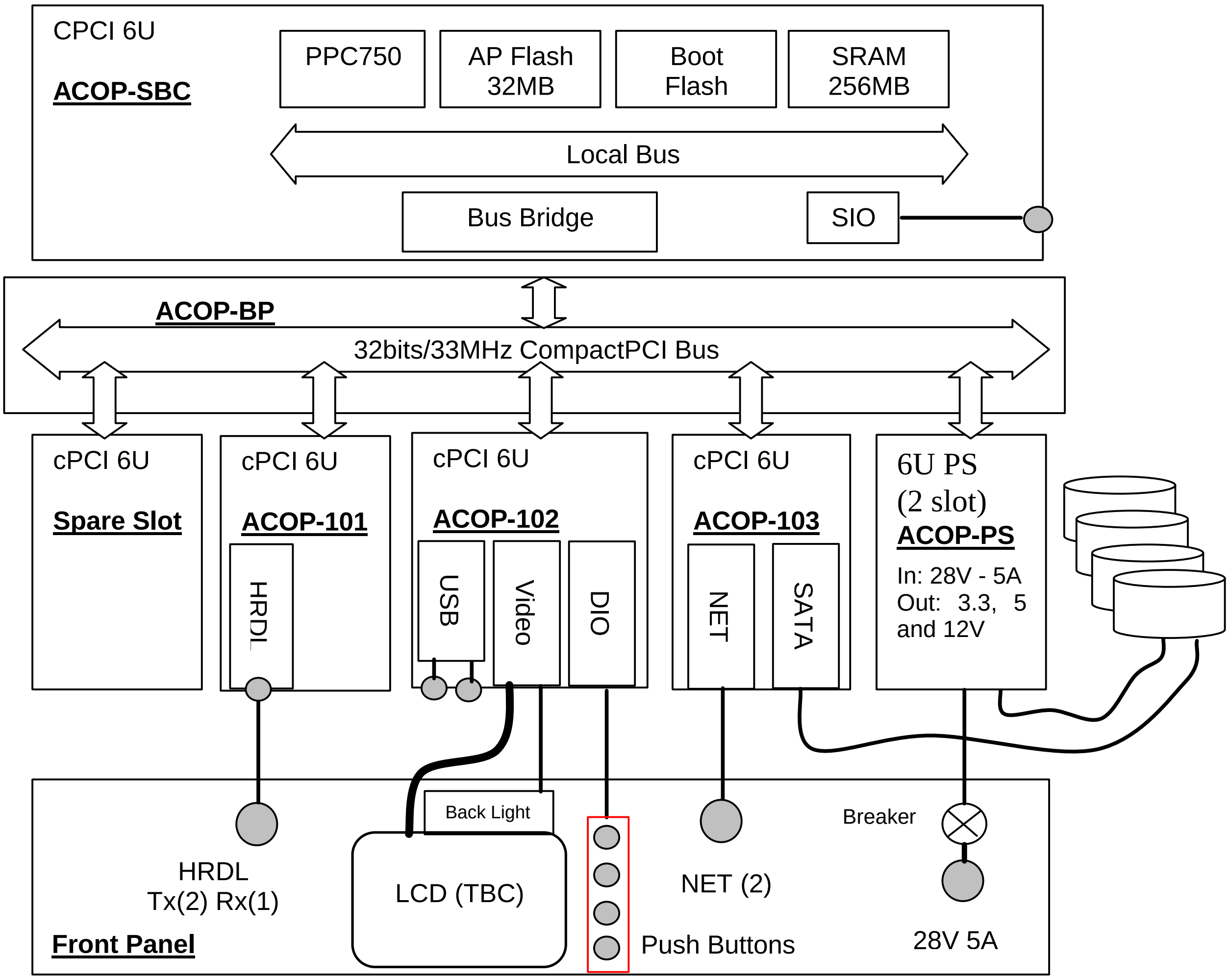

Figure 3-13 ACOP Electrical Block Diagram

The ACOP chassis includes the following modules:

- ACOP-SBC: Single board computer, based on the IBM PPC 750, which provides 400Mhz speed as well as standard CompactPCI bus interfaces and acts as CompactPCI system slot.
- ACOP-T101: Provides 2 fiber optic TX and 1 fiber optic RX interfaces.
- ACOP-T102: Provides video output interface (TBC), 2 USB 1.1 interfaces and a DIO interface.
- ACOP-T103: Provides 2 Ethernet ports and 4 SATA ports.
- Spare Slot: for future expansion purpose
- ACOP-PS: Double height power supply.
- 4 hot swappable HDD (Hard Disk Drive)

The ACOP front panel will be mounted with:

- Four Momentary Press Buttons
- One Circuit Breaker On/Off Switch
- One HRDL Connector
- One Power Connector
- One MRDL Connector with 10/100 base Ethernet
- One LCD screen with backlight (TBC)

During the engineering development stage, the I/O configuration will be tailored with PMC mezzanine modules and all modules integrate in an industry standard CompactPCI backplane. The design is scaleable and expandable, with a clear and built-in path for technology upgrades and insertion. A well-defined avionics Application Programming Architecture abstracts the application software from the underlying hardware, affording system evolution to ever-increasing performance standards, while effectively managing obsolescence. The Ethernet interface and USB interface can also supports software development and system maintenance during development.

3.4.2.1 POWER DISTRIBUTION AND POWER FEEDERS PROTECTIONS

ACOP is supplied by the +28Vdc standard power feeder provided by the EXPRESS Rack. A circuit breaker with a switch mounted on the front panel provides the On/Off switching capability. When the switch is moved to the on position power is provided to the system. During power stabilization the ACOP single board computer CPU is held in reset; once power is stable reset is released and the system begins the boot phase.

The circuit breaker is used also to protect wirings and downstream circuits from thermal damage that occurs during an over-current situation and as the first step of defense against electrical hazards. Circuit breaker's features include fail-safe operation, ambient temperature compensation and load protection function.

The circuit breaker's output supplies the ACOP Power Distribution module (ACOP-PS), which is based on power DC/DC converter implemented with hybrid integrated circuits. Each one incorporates two filters designed with output common mode filter chokes and low ESR capacitors, as shown in Figure 3-14.

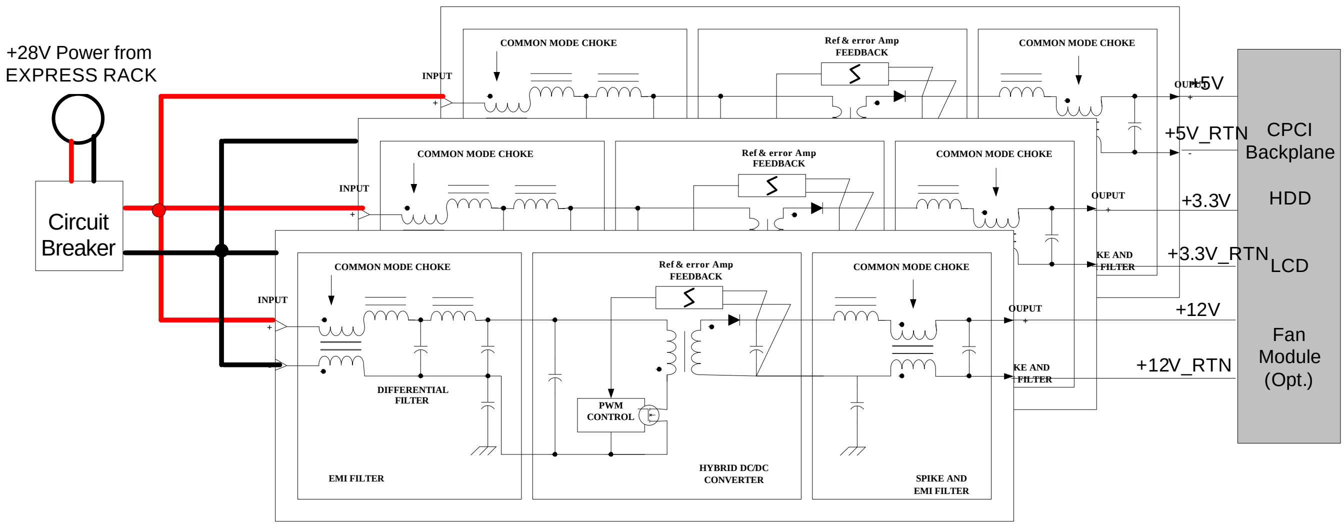

Figure 3-14 ACOP Power Distribution Diagram

On the power input side of the ACOP-PS, for each DC/DC converter the common mode currents are interrupted by a high inductance common mode choke. A shunt capacitor connected to the hybrid integrated circuit case allows the common mode input currents to be localized, instead of flowing out to the input leads.
Two stages of LC differential filtering are used to reduce ripple current levels. By using two cascaded higher frequency stages, each stage is physically smaller than a larger, lower frequency single stage.

On the output side of the ACOP-PS, for each DC/DC converter a common mode choke and a shunt capacitor to the hybrid integrated circuit case completely tame the common mode spikes. A small differential filter adds the final bit of filtering to the output leads. At above approximately 10 MHz, the output filters within the hybrid can become capacitive: external ferrite leads and small capacitors may be used to tame the residual high frequency spikes.

Three different voltages, 3.3V, 5V and 12V, are distributed from ACOP–PS to CompactPCI backplane and other stand-alone devices. The ACOP-SBC board will provide a power monitor circuit for both the 3.3V and 5V supplies: during power up, the 3.3V power monitor circuit will hold the ACOP in reset until the power is stable. The 5V power monitor signal will be latched when activated and the latched results will be provided as input to the CPU for software reading.

3.4.3 AVIONICS DESIGN DETAIL

The mechanical design of ACOP card cage assembly is shown as Figure 3-15.

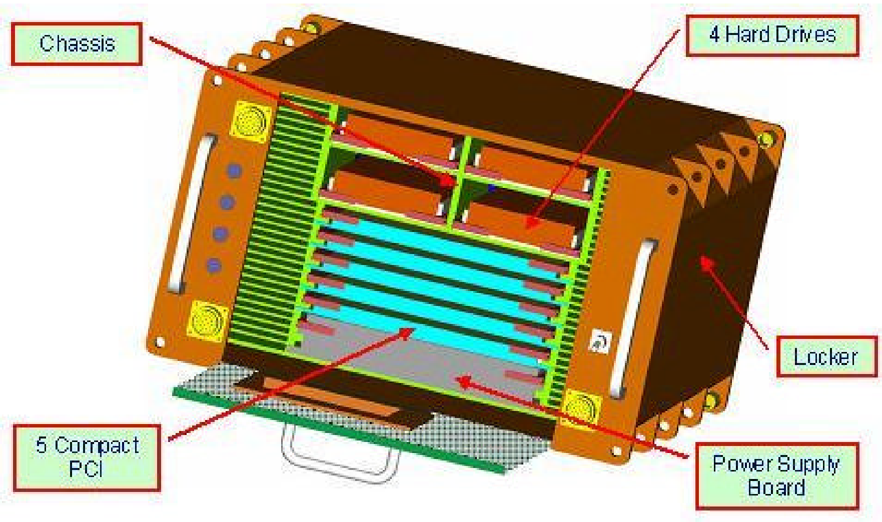

Figure 3-15 ACOP Main Components

The main characteristics of the ACOP card cage assembly are:

- 6U card cage for 5 double Eurocard CompactPCI boards in a CompactPCI chassis.
- Conduction cooling and wedge-locks for CompactPCI boards and power supply board.
- Double height power supply slot.
- Mounting provisions for CompactPCI backplane.
- 4 hard drives with caddies that can be removed from the chassis

The CompactPCI bus combines the performance advantages of the PCI desktop architecture with the ruggedness of the Eurocard form factor, a widely used standard within the industry for over 20 years. The Eurocard boards provides more secure connectors and more available space for professional embedded platforms than the PCI cards in desktop computers. The CompactPCI standard has widely been accepted for a large spectrum of applications.

In ACOP card design is based on the "IEEE 1101.2- Mechanical Core Specification for Conduction Cooled Eurocards" specification and the board layout is shown in Figure 3-16:

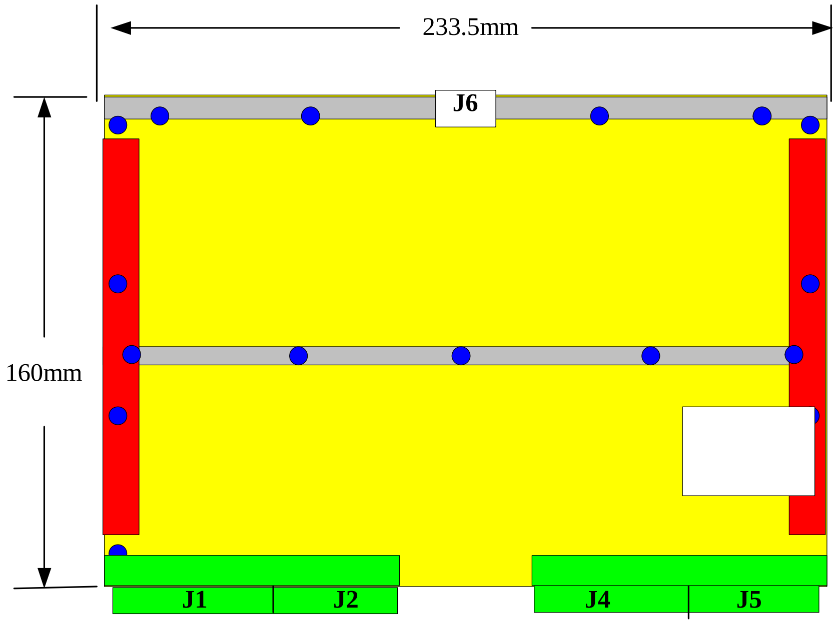

Figure 3-16 IEEE 1101.2- Mechanical Core Specification for Conduction Cooled Euro cards

To allow the ACOP to operate in the ISS, the circuit card design incorporate the following techniques:

- Buried thermal layers within the PCB
- Heat sink for high power components
- Stiffening ribs cross the board
- Expandable wedge lock on both sides

3.4.3.1 ACOP-SBC

The ACOP-SBC is a single slot 6U CompactPCI form-factor board that fits into a system slot of a standard CompactPCI backplane. It consists of an IBM PowerPC750 CPU with system memory, several peripherals and the CompactPCI interface.. Figure 3-17 shows the main functional blocks that make up the ACOP-SBC board. There are two bus sections in the ACOP-SBC board design: the CPU bus provides connections to the North PCI Bus Bridge chip, which provides the connections to the processor memory.
The processor memory includes read only boot PROM, FLASH memory and SDRAM. The system allows the operational memory configuration to be customized to the specific application.

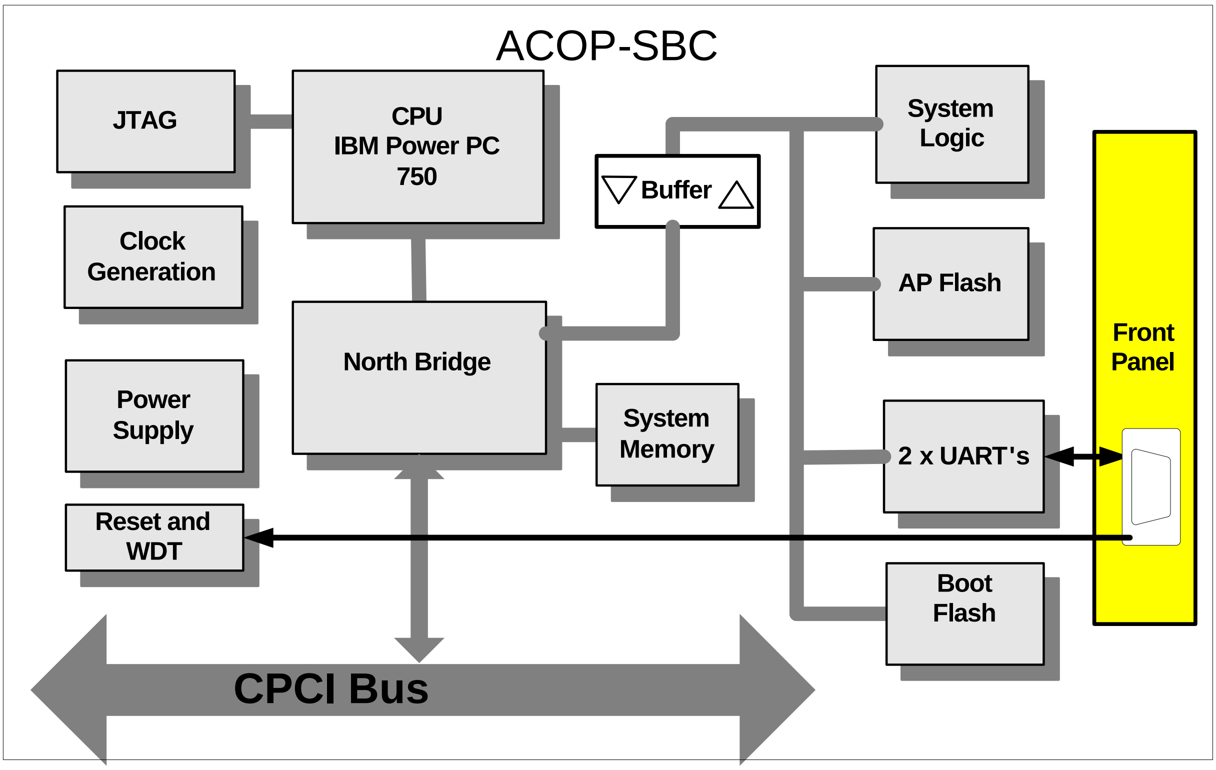

Figure 3-17 ACOP-SBC Functional Block Diagram

The following is a list of the hardware features for the ACOP-SBC:

- Microprocessor:
  - IBM PowerPC750 running at 400 MHz, On-chip Cache (I/D): 32K/32K
- CPU to PCI Bridge:
  - The CompactPCI backplane bus is 33MHz / 32-bit PCI
  - Up to 75MHz CPU bus frequency
  - CPU to SDRAM bridge
  - CPU to PCI bridge
  - PCI to DRAM bridge
  - Compatible to PCI rev 2.1
- Main Memory:
  - Synchronous Dynamic RAM (66MHz)
  - 64 bit DRAM data path interface
  - 256Mbyte Synchronous DRAM supported
- On-board Flash Memory:
  - 32 bit Flash data path
  - 4Mbyte (1M x 32) standard configuration
  - 8Mbyte (2M x 32) optional configuration
- One 32 Pin JEDEC standard EPROM PLCC socket:
  - 8-bit EPROM data path interface
  - Up to 512KB EPROM supported
- Dual serial interface ports:
  - 16552D (16550A compatible)
  - RS422 Interface
- General Purpose Registers
- Reset Generation

- Thermal sensor input
- 32bits /33Mhz CompactPCI system slot, PICMG 2.0 compliant

3.4.3.2 ACOP-T101

The ACOP-T101 module provides two transmit and one receive fiber optic interfaces meeting the ISS HRDL CCSDS packet mode standards. The hardware structure of ACOP-T101 board is shown in Figure 3-18. Two ZBT SRAM chips are used as buffer between System slot and the FPGA chip. The PCI agent chip (Actel A54SX72A) includes two main functions:

1) translator between the PCI bus and interface back-end bus
2) handling of the read/write operations (PCI memory space access) on the left port of the DPM buffer

The FPGA chip accesses the DPM buffer though its right port. It also has a 5 bit parallel data interface with physical data transmitter (AM79865) and receiver (AM79866A) for HRDL.

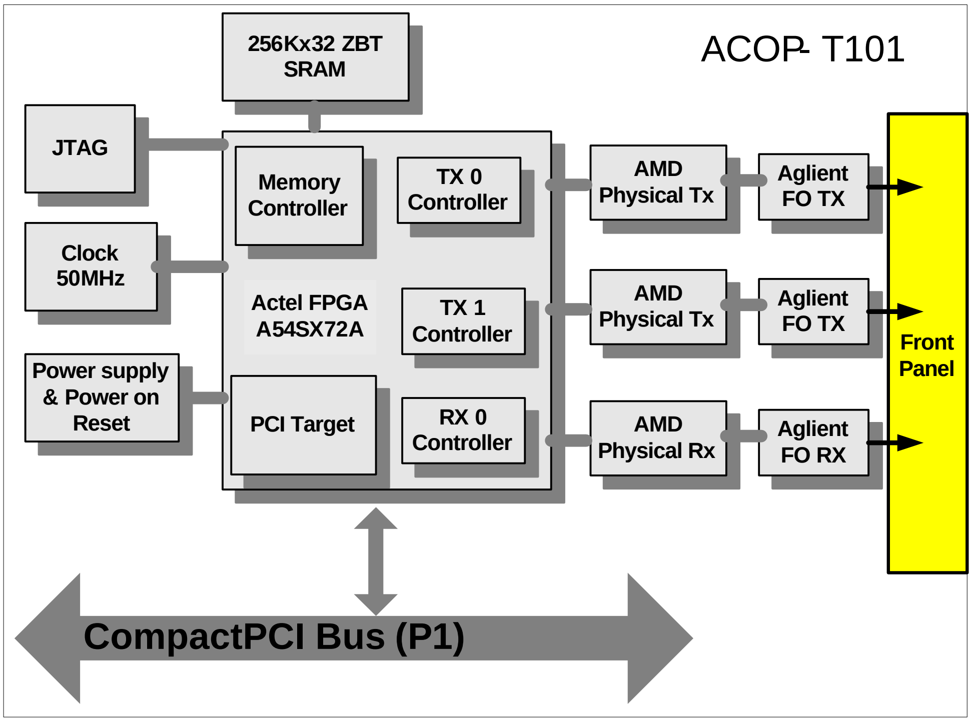

Figure 3-18 ACOP-T101 Functional Block Diagram

The following is a list of the hardware features for the ACOP-T101:

- Include two transmit and one receive fiber optic interfaces meeting the ISS HRDL CCSDS packet mode standards
- The interface provides intelligent reception and transmission of variable length CCSDS packets referred to as frames
- Ram data is received into and transmitted out of a buffer memory of 1MB contained on board. The configuration of FIFOs to manage the data is done by software allowing support for varying operational modes.
- Software configurable sync-symbol insertion parsing in terms of a data-symbol to sync-symbol ratio as well as specifying the number of sync-symbols between frames.
- The interface removes all sync-symbols on reception.
- The interface provides a means to transmit test patterns of symbols, including both valid and invalid symbols
- Transmitter capable to transmit frame from 1 to 4096 bytes length
- Data symbols can be interleaved with sync symbols d:s where d=0:20 s=0:20 where d is the number of consecutive data symbols and s is the number of consecutive sync symbols. Either s or d being zero means no syncs are inserted

- The number of sync symbols in the gap between frames can be specified between 1 and 2 ** 23 –1 inclusively
- Receiver can receive frames from 0 to 4096 symbols with all sync symbols removed.
- 32bits /33Mhz CompactPCI peripheral slot, PICMG 2.0 compliant

3.4.3.3 ACOP-T102

The block diagram in Figure 3-19 shows the major systems that make up the ACOP-T102 board. An ACTEL A54SX72A FPGA is used to implement the PCI agent and VGA controller function. It is compliant with the PCI 2.2 specification and provides 33MHz performance. Two ZBT SRAM chips are used as video memory and buffer between system slot and the FPGA chip.

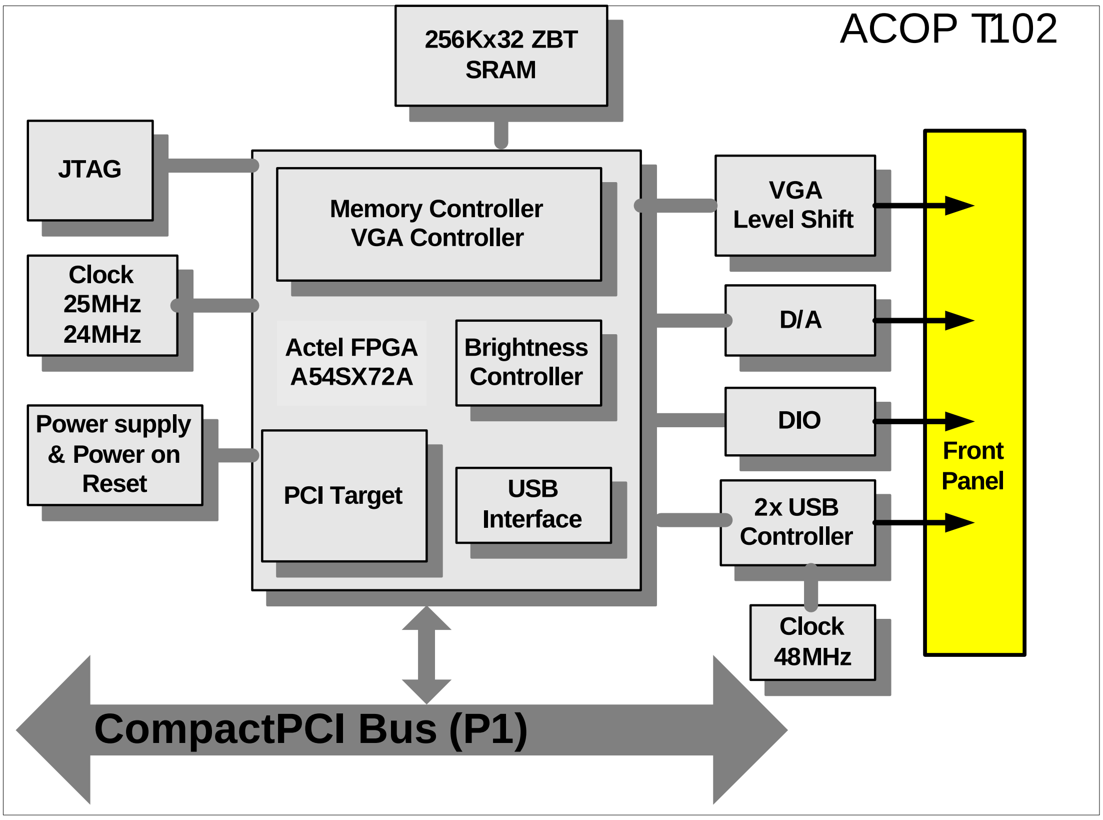

Figure 3-19 ACOP-T102 Functional Block Diagram

The following is a list of the hardware features for the ACOP-T102:

- LCD Graphic Function (TBC):
  - Only graphic mode supported.
  - Resolutions: 640x480 and 320x240
  - Color: 5 bits (bit1 to bit 5) for R, G, B. The value of bit 0 of each color is fixed to zero.
  - Clock frequency: 25MHz
  - Vertical frequency: ~ 60Hz
  - Video SRAM: 256K x 32bit
- D/A converter with analog output to adjust the brightness of the LCD backlight (TBC)
- USB interface:
  - Supports USB Specification 1.1 (1.5Mb/s) devices
  - Allow one PCI transaction to access both SL811HS controllers.

- o Support burst R/W by using backend throttling

- 32bits /33Mhz CompactPCI peripheral slot, PICMG 2.0 compliant

3.4.3.4 ACOP-T103

The ACOP-T103 provides four (4) separate SATA channels to access storage media such as hard disk drive. It uses a PCI-to-Quad-SATA Controller that supports a 32-bit, 66 or 33MHz PCI bus. It accepts host commands through the PCI bus, processes them and transfers data between the host and Serial ATA devices.
It can be used to control four independent Serial ATA channels: each channel has its own Serial ATA bus and will support one Serial ATA device with a transfer rate of 1.5 Gbits/sec (150 MBytes/sec).

The ACOP-T103 also provides two independent high-performance Fast Ethernet interface controller ports.

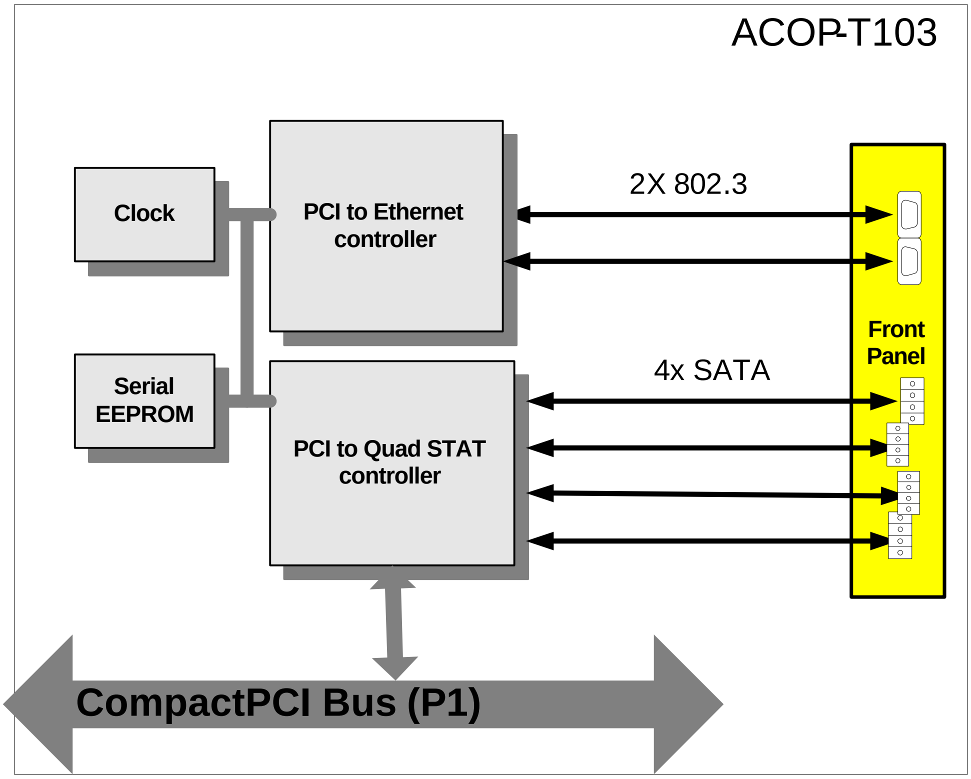

Figure 3-20 ACOP-T103 Functional Block Diagram

The following is a list of the hardware features for the ACOP-T103:

- PCI to 4-port Serial ATA (SATA) host controller
- Serial ATA transfer rate of 1.5Gbit/second
- Spread spectrum receiver and single PLL for all channels
- Independent 256 byte (32-bit by 64) FIFO per channel
- Integrated Serial ATA Link and PHY logic
- Compliant with Serial ATA 1.0 specifications
- Two IEEE802.3 10/100Base Ethernet ports, Both TX and RX supported
- 32bits /33Mhz CompactPCI peripheral slot, PICMG 2.0 compliant

3.4.3.5 ACOP-BP

The ACOP-BP backplane is compliant to the PICMG 2.0 R3.0 standard for backplane, module connectors, mechanical and power interfaces. CompactPCI signals are routed on P1 connector row only. P2 connectors are installed only on the system slot positions. P3 connector row is not used at all.
Each of the CompactPCI segments provides +3.3 VDC signal environment only. All V(I/O) pins of each slot are connected to the corresponding +3.3V power planes. The peripheral interface signals for ACOP specific applications are routed on P4.

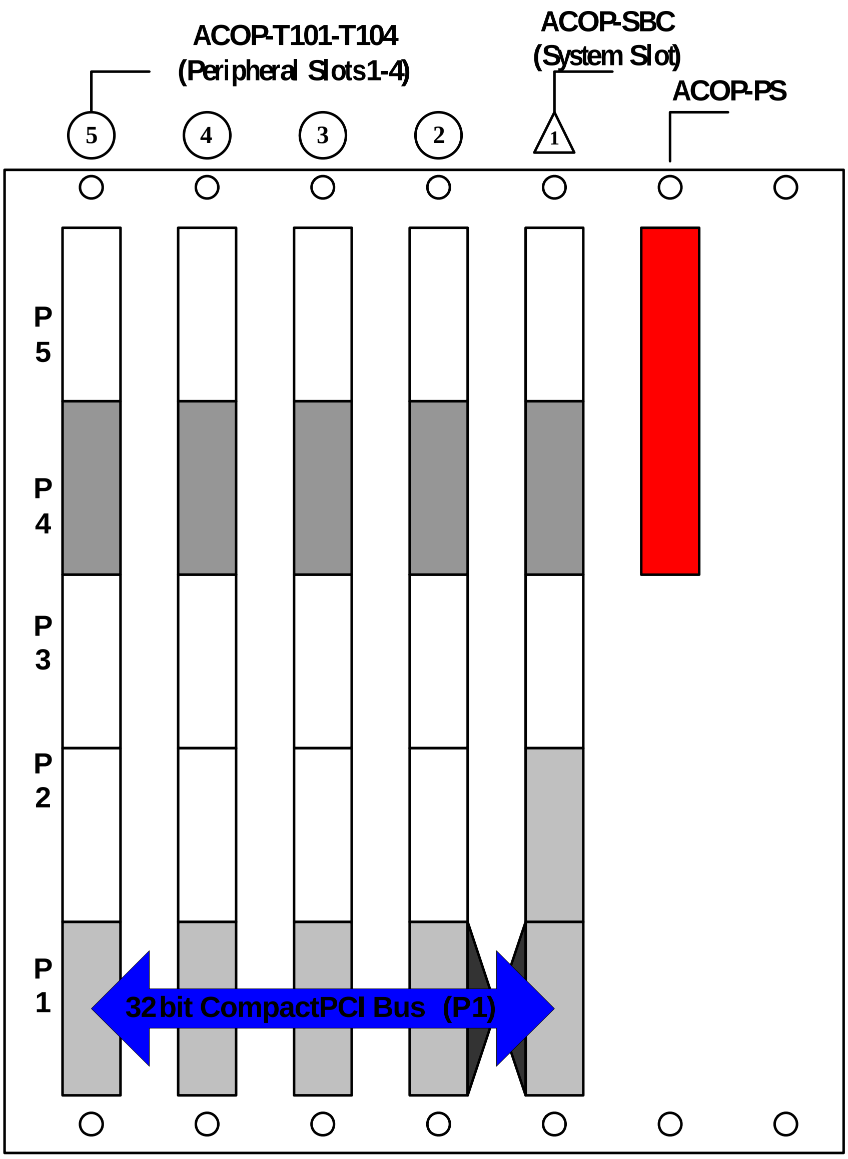

Figure 3-21 ACOP-BP Functional Block Diagram

The following is a list of the hardware features for the ACOP-BP:

- Compliant with the CompactPCI core specification (PICMG 2.0 R3.0), including the external +12V and -12V power lines connectors for ground test only.
- support 32-bit, 33 MHz PCI bus operation
- 3.3V V(I/O) signaling voltage only

- no Hot Swap capability, no Rear I/O capability
- 5-slot wide, one system and four I/O slots
- Standard 47 pins power supply slot
- Position of the AMS-02 specific I/O modules is predefined.

3.4.3.6 ACOP-PS

The ACOP-PS module is CompactPCI form factor and installed in the backplane. The input voltage range is 24 to 32Vdc, compliant with the +28Vdc power feeder voltage range provided by the EXPRESS Rack.

Three outputs (generated by power DC/DC converter implemented with hybrid integrated circuits) provide 3.3Vdc, 5Vdc and 12Vdc power supplies with independent output regulation. The outputs of the ACOP-PS meet the electrical requirements of PICMG specification for CompactPCI systems.

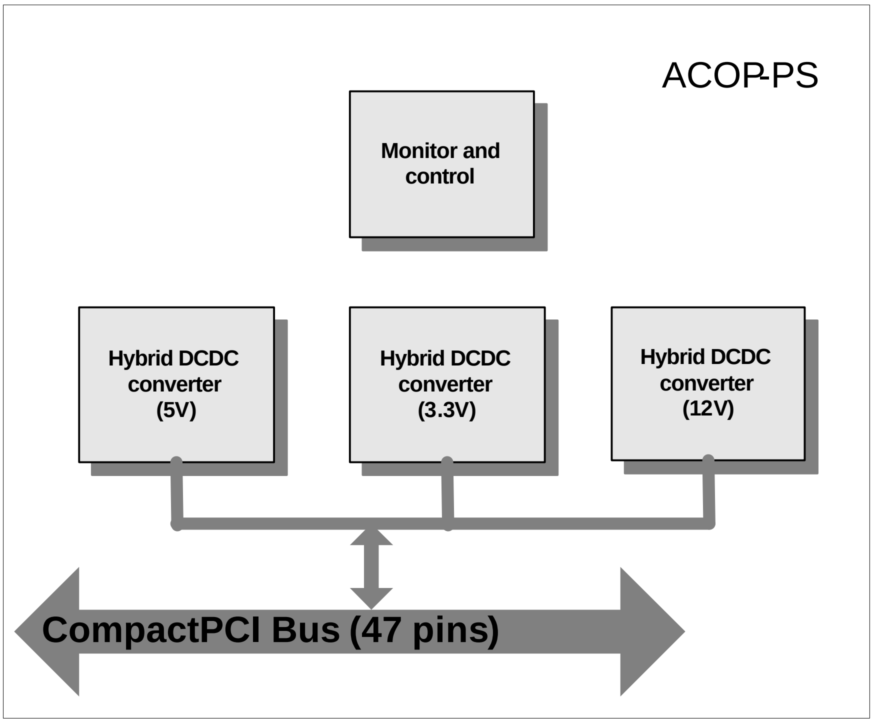

Figure 3-22 ACOP-BP Functional Block Diagram

The following is a list of the hardware features for the ACOP-PS:

- Inrush Current: TBD A peak @ TBD VDC
- Efficiency: > 75% @ full load, nominal line
- Output Power: TBD watts
  +5.06V +/-3% : TBD A
  +3.36V +/-3% : TBD A
  +12.1V +/-5% : TBD A
- Protection : Over voltage, over current, short circuit, over temperature and fault isolation
- Built-in EMI filter
- Backplane power connection via PICMG 2.11 compliant 47-pin power connecter.

3.4.3.7 LCD (TBC) PANEL MONITOR

A Color Active Matrix Liquid Crystal Display (LCD) with an integral Cold Cathode Fluorescent Lamp (CCFL) backlight system will be mounted on the ACOP front panel (TBC). This TFT-LCD has a 6.4 inch diagonally measured active display area with VGA resolution (640 vertical by 480 horizontal pixel array). Each pixel is divided into Red, Green and Blue sub-pixels or dots which are arranged in vertical stripes. A DC/AC inverter is installed inside to provide power for backlight tubes. Backlight tube brightness is adjustable by means of push buttons and software.

The following is a list of the hardware features for the LCD module (TBC).

The following is a list of the hardware features for the LCD module:

- Compatible withVGA-480, VGA-400,VGA-350 and free format.
- Screen size 6.4"
- Display format 640xR,G,B x480
- Display colors: 262,144 colors
- Active area/Outline area =62.3%
- Backlight brightness is adjustable

LCD (TBC) display will be covered with a protection plastic cover (LEXAN) to avoid potential shatterable material hazard.

3.4.3.8 HARD DRIVES AND CARD CAGE ELECTRONICS

There are four hard drives installed in ACOP provide an estimated 20 days of recording. (Note: Dependent on event rate and size) The four installed hard drives will require periodic replacement by the ISS crew from the onboard stock of empty drives. A batch of 20 hard drives provides 150 days of recording capacity. New batches of hard drives will be delivered by STS and the original master copies of the AMS-02 data will be returned to earth by STS. A dedicated HDD Backplane provides blind mate connectors for the hard drives. Cable connectors are provided to bring the power and data to this backplane.

The following is a list of the hardware features for the Hard Disk Drives:

- Serial ATA with 1.5Gb/sec interface speed
- Native Command Queuing
- Build-in 16MB cache buffer
- Capacity 250 GB or Up

3.4.3.9 THERMAL SENSOR NETWORK

The thermal sensor network will consist of Dallas one-wire bus devices attached to a single network. The devices will be mounted where appropriate within the ACOP system. Each ACOP-10x board will have a front panel connector to connect the devices on it. Additionally several sensors will be mounted on the chassis to monitor base plate and hard drive temperatures. The digital I/O (DIO) function will be used to control this bus.

3.4.3.10 INTERNAL HARNESS

Table 3-9 provides a preliminary list of the internal harness of ACOP. All the cables will be selected for what concerns the current rating according to Para. 7.32 of ECSS-Q-60-11A (TBC) [RD17].

Cable	Type /Size	From	To
SATA	SATA 26-28AWG (TBC)	ACOP-T103 Card Front Panel	HDD Backplane

Cable	Type /Size	From	To
Ethernet	CAT5 22AWG (TBC)	ACOP-T103 Card Front Panel	ACOP Front Panel
Fiber Tx1	ISS fiber	ACOP-T101 Card Front Panel	Through ACOP Front Panel to EXPRESS Rack
Fiber Tx2	ISS fiber	ACOP-T101 Card Front Panel	Through ACOP Front Panel to EXPRESS Rack
Fiber Rx	ISS fiber	ACOP-T101 Card Front Panel	Through ACOP Front Panel to EXPRESS Rack
External Power	12 AWG	ACOP Front Panel	ACOP-BP
Push Buttons	20 – 24 AWG (TBC)	ACOP Front Panel	ACOP-T102 Card Front Panel
LCD Ribbon (TBC)	26 – 28 AWG (TBC)	ACOP Front Panel	ACOP-T102 Card Front Panel
LCD Power (TBC)	20 – 24 AWG (TBC)	ACOP Front Panel	ACOP-T102 Card Front Panel
HD Power	20 – 24 AWG (TBC)	ACOP-BP	HDD Backplane

Table 3-9 ACOP Internal Harness

3.4.4 EMC REQUIREMENTS ASSESSMENT AND VERIFICATION APPROACH

This section provides the list of the EMC and bonding-grounding requirements applicable to ACOP and the identification of the verification type to be applied.

The AD1 sections 7.1, 7.3 and 7.4 contains all the requirements that ACOP shall to be compliant with. Sections 7.2, 7.4.1, and 7.4.2 has not to be considered applicable due to the fact ACOP will be transported inside the shuttle in power off condition.

Verification of the applicable requirements given in AD1 will be carried out by test and/or review of design and/or analysis as defined in AD13

3.4.5 GROUNDING AND BONDING

3.4.5.1 GROUNDING & BONDING REQUIREMENTS

ACOP shall meet the grounding and bonding requirements given in section 7.5-7.7 of AD1 and and appropriate bonding provisions for installation of hardware during in-orbit operations, in accordance with NASA letter MA2-99-142, are foreseen (redundant bonding path, adequate bonding surfaces). In particular:

- ACOP shall be inserted and fixed into a Locker location of a Express Rack before being powered on
- ACOP will use the single point ground approach for the internally DC/DC generated secondary power lines (cPCI voltages, Hard Disk drives voltages).
- the Express Rack 28 VDc primary power line will be maintained isolated from the ACOP chassis/structure by a minimum of 1 Mohm in parallel with a capacitance less than 10uF.
- the Express Rack 28 VDc primary power line will be kept isolated from ACOP secondary power voltages by a minimum of 1 Mohm

3.4.5.2 GROUNDING & BONDING VERIFICATION

Verification of the applicable requirements given in AD1 will be carried out by test and/or review of design and/or analysis as defined in AD13

3.4.5.3 GROUNDING/BONDING/ISOLATION

The ACOP electronics is housed in an aluminum box (AL 7075). The parts of the box are electrically connected together in order to offer a low impedance path, therefore the mechanical box will operate as a shield against the internally generated emissions and the externally generated emissions.

The ACOP shall be bonded via the bond path present in the EXPRESS Rack-to-payload power connector (pin D). The ACOP bonding class is R (Radio Frequency Bond-RF).

The bonding path to the Express Rack will allow :

- to conduct electrical faults current without creating thermal or electrical hazard
- to minimize differences in potential between all equipment.

The ACOP internal power lines are derived from the 28Vdc input line. The 28Vdc input line will be kept isolated from ground/structure by at least 1 Mohm (this applies to the alive and return line), in parallel with a capacitance of less than 10uF, according to [AD1] Section 7.6 (Power Circuit Isolation and Grounding). The 28Vdc input line will be also isolated from the ACOP internal DC/DC generated power supplies by at least 1Mohm.

The Ethernet connection with the EXPRESS Rack RIC will be as per [AD1] Section 7.7 (Signal Isolation and Grounding Requirements) for isolation and grounding.

The HRDL interfaces will use optic fiber cables as physical layer, therefore there will not be electrical connections.

One RS 422 Interface will be present only for ground test (TBC).

Two USB 1.1 (TBC) ports will be present to be used by crew in non-nominal scenarios (SW patches) to connect portable devices (USB keys)

3.4.5.4 IN – RUSH CURRENT

In order to limit the in–rush current at the ACOP control electronic "power on" the DC/DC converters connected on the nominal 28 VDC line are equipped with a current limiter which has a two fold function:

- to limit the current drained from the 28 VDC nominal inlet at the power on
- to protect against short circuit occurring in the DC/DC converter during nominal operation.(TBD)

The maximum specified power for ACOP in the operative mode is 70 watt (TBD).

3.4.5.5 CONDUCTED AND RADIATED EMISSION SOURCES

The main sources of conducted/radiated emissions are:

- ACOP DC/DC converters to generate the ACOP internal voltages for the cPCI boards and the HDDs
- cPCI bus traffic running at 33 MHz on the 5 slots ACOP-BP
- ACOP Single Board Computer
- Hard Disk Drives (in particular the disk motor control sections)
- LCD High Voltage Inverter (TBC)

In particular, the following clock frequencies are present in ACOP:

- 50 MHz oscillator for the HRDL board ACOP-T101
- 100-110 KHz (TBC) of the DC/DC converters control logic.
- 50 MHz oscillator (TBC) for the FPGA implementing the SATA interface
- 66 and 33 MHz for the ACOP-SBC board (66 MHz for the Power PC chip and 33 MHz for the cPCI Interface)
- 24-25 MHz oscillator for the FPGA implementing the VGA control logic (TBC)
- 48 MHz for the USB Controller
- 50 MHz oscillator (TBC) for the FPGA implementing the Ethernet Interface

3.4.5.6 GROUNDING PHILOSOPHY

The ACOP avionics, with respect to the overall grounding system, shall be based on the following concepts:

- The primary electrical power shall be isolated from ACOP chassis by a minimum of 1 Mohm in parallel with a capacitance less than 10uF.
- Implementation of a galvanic isolation between the primary power bus and all the secondary internal or distributed powers (greater than 1 Mohm)
- All the secondary power references shall be connected together and to the ACOP structure in a single point represented by an internal bonding stud.
- The metallic shell of all the ACOP external electrical connectors are electrically bonded to the ACOP bulkhead mount connector or the ACOP front panel case, with a DC resistance of less than 2.5 milliohms per joint.

The primary payload bond path for ACOP shall be through the EXPRESS Rack-to-payload power connector interface (pin D, see Table 3-10). Nevertheless a bonding stud will be implemented on the front panel to allow the single point connection of the internal secondary power reference(internal side of the front panel) and eventually to connect an external bonding strap between ACOP and the Express Rack (external side of the front panel).

An internal to the front panel bonding strap will connect the movable part of the front panel to the fixed one (the bonding between the two parts of the front panel will not rely only on the friction hinge)

EXPRESS CABLE CONNECTOR: NB6GE14-4SNT MATING CONNECTOR: NB0E14-4PNT

PIN	FUNCTION	AWG	SIGNAL NAME	COMMENT
A	+28 V Power	12	Power	
B	Not Used	12	N/A	
C	28 V Return	12	Power Return	
D	Ground	12	Ground	

Table 3-10: EXPRESS Power Connector

In Figure 3-23 the ACOP grounding philosophy is shown.

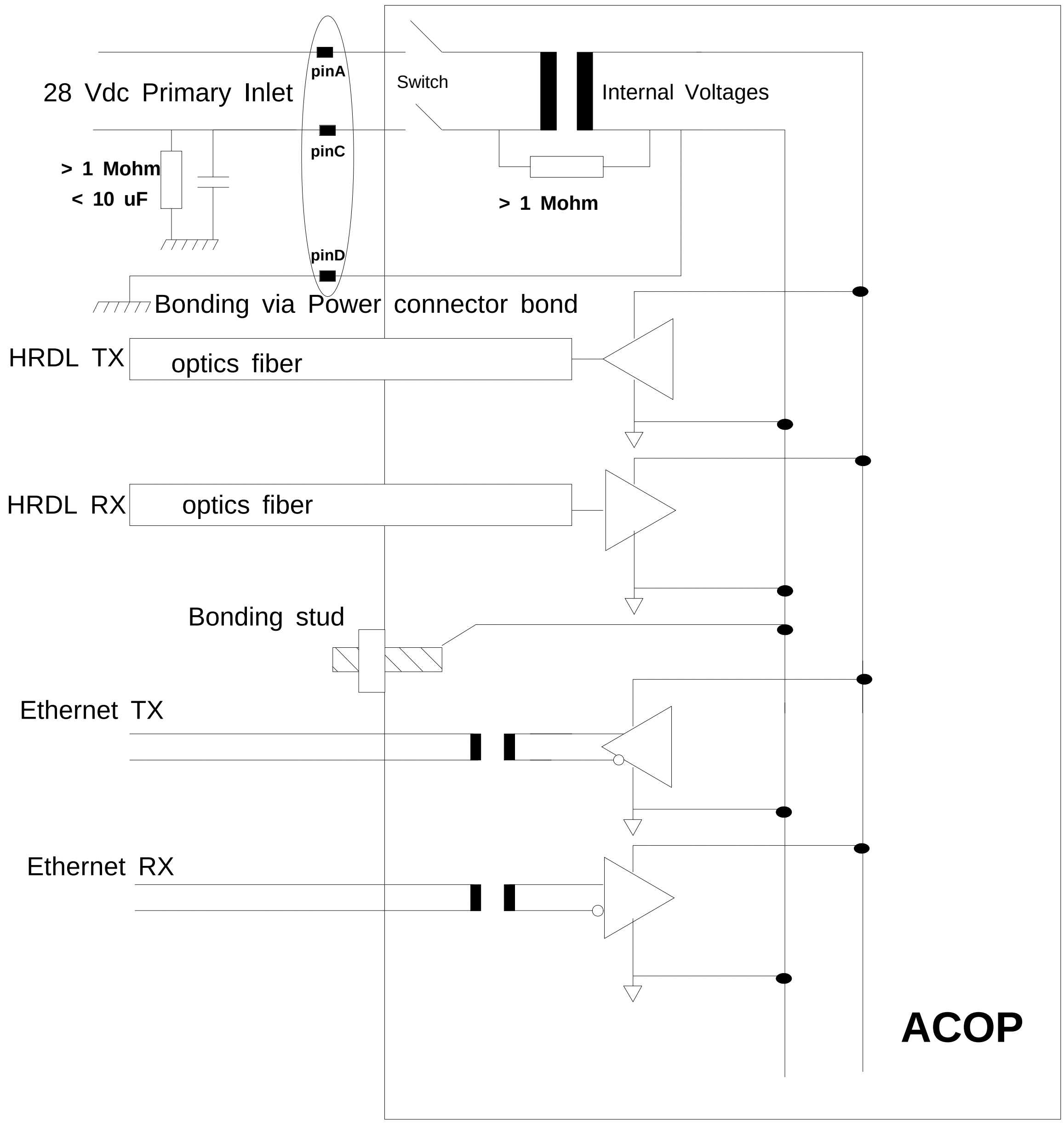

Figure 3-23: ACOP Grounding and Bonding

3.5 ACOP SOFTWARE

ACOP-SW is the entire body of embedded software running on the ACOP hardware. ACOP-SW consists of three components:

1) ACOP-SYS-SW providing low level functionality
2) ACOP-APP-SW providing the mission explicit application software functions on the ACOP hardware
3) ACOP-ERL-SW software developed by the ACOP project but which executes on the EXPRESS Rack Laptop

The S/W does not have any safety control and cannot produce an hazardous command or operation.

3.5.1 ACOP-SYS-SW

Implements the following main functions:

1. BootROM monitor providing boot strapping operations and low level file transfer functions.
2. Initialization of the ACOP hardware.
3. Operations of the ACOP hardware interfaces via device drivers.
4. Exception handling.
5. Diagnostic and system self-tests.
6. Management of data storage devices and file systems.
7. External command processing for system commands.
8. Execution and control of ACOP-APP-SW.

3.5.2 ACOP-ERL-SW

Implements the following main functions:

1. Implements a ISS crew interface on the EXPRESS Rack Laptop.

3.5.3 ACOP-APP-SW

Implements the following main functions:

1. Monitoring of resources and environment relevant to ACOP Health and Status.
9. Functional interfaces to ISS avionics C&DH systems.
2. Functional interfaces to the ISS HRDL interfaces.
3. Data recording.
4. Data playback.
5. Detailed data management.
6. Detailed management of data contents with regard to external systems.
7. External command processing for applications commands.

3.6 THERMAL SYSTEM

The "EXPRESS Rack locker" provides ACOP with the cooling air through ducted ports at the back plate of ACOP. The current baseline does not foresee to insert additional fans inside the ACOP locker to reinforce the airflow. The width and height of the two square ports of the inlet and the outlet for the ducted cooling air are 110 mm and 110 mm respectively at the back plate of ACOP here for the thermal and fluidic modelling. The ports are fitted with screens, with an open area ratio of 60.02%, in order to filter the cooling air. A typical flow rate, 15+/-3 cubic feet per minute (cfm), of the cooling air with a normal operation pressure of 10.2 lb/in^2 (psia) is compressed into the inlet of ACOP. See Figure 3-24.

Two ducts are designed to connect the ports of the inlet and the outlet with the fin channels as heat sinks extruded from the chassis of ACOP electronic modules in order to reduce the pressure loss, resulting into an abrupt expansion and contraction of the air flow while no duct is designed-in.

At both sides of the ACOP chassis, 56 fins are extruded respectively to be the heat sinks in order to increase both of the heat transfer area and the heat transfer coefficient of the cooling air. The thickness of the alloy aluminium fins is 1.5 mm with height and length of 60 mm and 162 mm respectively. The gap between two adjacent fins is 2.5 mm. See Table 3-11.

Table 1. Geometry of the fin channels of ACOP and the applied heat transfer coefficient h			
Number of fins at one side	**Thickness**	**Height**	**Length**
56	**1.5 mm**	**60 mm**	**162 mm**
Distance between two adjacent fins	**Value of h by a semi-empirical correlation**	**Value of h by the laminar flow model**	**Material**
2.5 mm	**40.3 $W/m^2°C$**	**42.1 $W/m^2°C$**	**7075-T7351**

Table 3-11: Geometry of the fin channels of ACOP and the applied heat transfer coefficient h

The effective hydraulic diameter of the fin channels is calculated to be 4.8 mm. Under this value of the effective channel diameter, the thickness of the thermal boundary layer of the fin wall can be reduced to be a small value such that for a constant Nusselt number of a laminar channel flow, the heat transfer coefficient h, inverse to the effective diameter, can be enlarged to a desired value around 40 $W/m^2°C$. In addition to the increased heat transfer coefficient, the area for heat convection to the cooling air is also augmented significantly to decrease the systematically thermal resistance, leading to an apparent decrease of both of the boards and the parts working temperature.

The power dissipation is produced by every active part of each board in the ACOP electronic modules, including the four hard disk drivers. The power consumption in the form of heat conducts to the mounting board via the solder leads and the part case. The heat spreads to the board edge mainly via the copper layers implemented as the power and ground planes. Then, through the card-locker and the spacer fastening the boards to the inner side of the chassis, the heat conducts to the chassis. The fin channels extruded from the chassis absorb the heat to the surfaces. Finally the cooling air conveys away the heat via the forced convection.

The cooling air comes into the inlet, and passes through the filtering screen, and then is confined in and flows through the duct, and enters into the fin channels to take away the power dissipation, and comes out to the front chamber to cool the LCD panel, and then goes through the fin channels of the opposite side, and enters into the opposite duct and finally goes out to the Rack locker via the outlet port.

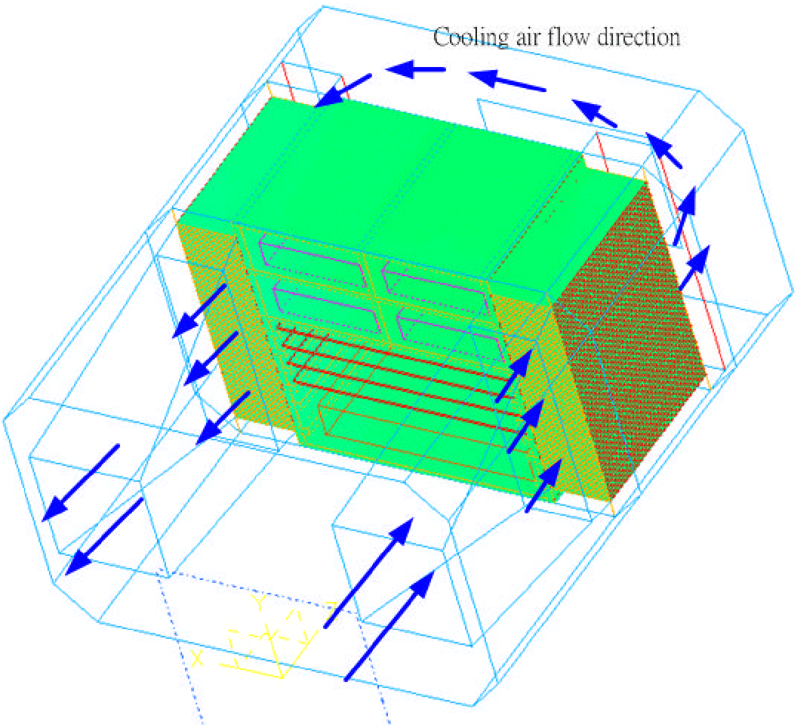

Figure 3-24: Flow direction of the supplied cooling air

3.6.1 THERMAL ANALYSIS RESULTS SUMMARY

For the complicated domain with a coupling of heat transfer and flow dynamics, the computation tool should be dedicated to a flexible and efficiency analyzed code in order to obtain the prediction results in a short time. Here "I-DEAS+TMG+ESC" code is applied to solve the computation task. According to the code, the solid and the fluid domain must be meshed before the calculation by employing a finite difference method.
The analyzed domain is meshed into 224716 elements by the mapped method. For the solid and the fluid, 67,045 hexahedral elements and 157,671 trihedral elements are meshed respectively.

In the thermal analysis five different cases has been carried out with differently allocated thermal load due to different locations of the two working hard drives. The worst case if case 1 where the two working HDD's are put on the top of ACOP. Results are shown in the figures Figure 3-25 and Figure 3-26.

The maximum temperature occurs at the central chassis for mounting the HDD's to be around 44.1 ? , as shown in Figure 3-25. The predicted temperature distribution of the fin channel of the hot side is very uniform, resulting from resulting from the high thermal conductivity of the channels.
Although the flow rate of the cooling air is not large to cool an electronic subsystem, via the appropriately thermal management design of the fin channels, both the area for the thermal load to transfer and the heat transfer coefficient are large enough to overcome the shortage of the low air flow rate, leading to a temperature increase of around 14 ? on the ACOP chassis.

At the central chassis of top ACOP, the cooling is not introduced into to cool down the working temperature. However, the thermal conductivity of chassis is high enough to conduct the power dissipation of HDD's effectively to the rest regions of the chassis, leading to a significant reduction of the working temperature.

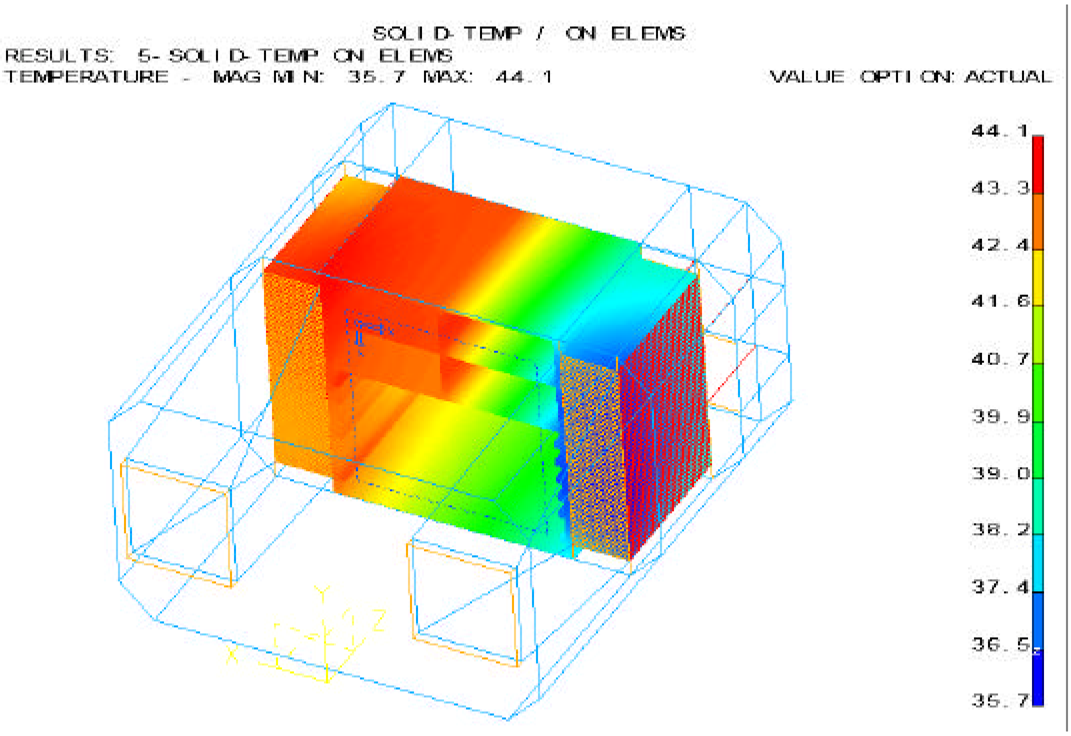

Figure 3-25: Predicted temperature profile of the fin channels and chassis for case 1

Figure 3-26 shows the predicted temperature profile of the front panel for case 1. Although the power dissipation of the LCD monitor is provided by 6.3 W, the heat can conduct to the rest regions of the ACOP enclosure effectively, resulting into a maximum temperature of around 41.4 ? at the centre of the LCD monitor.

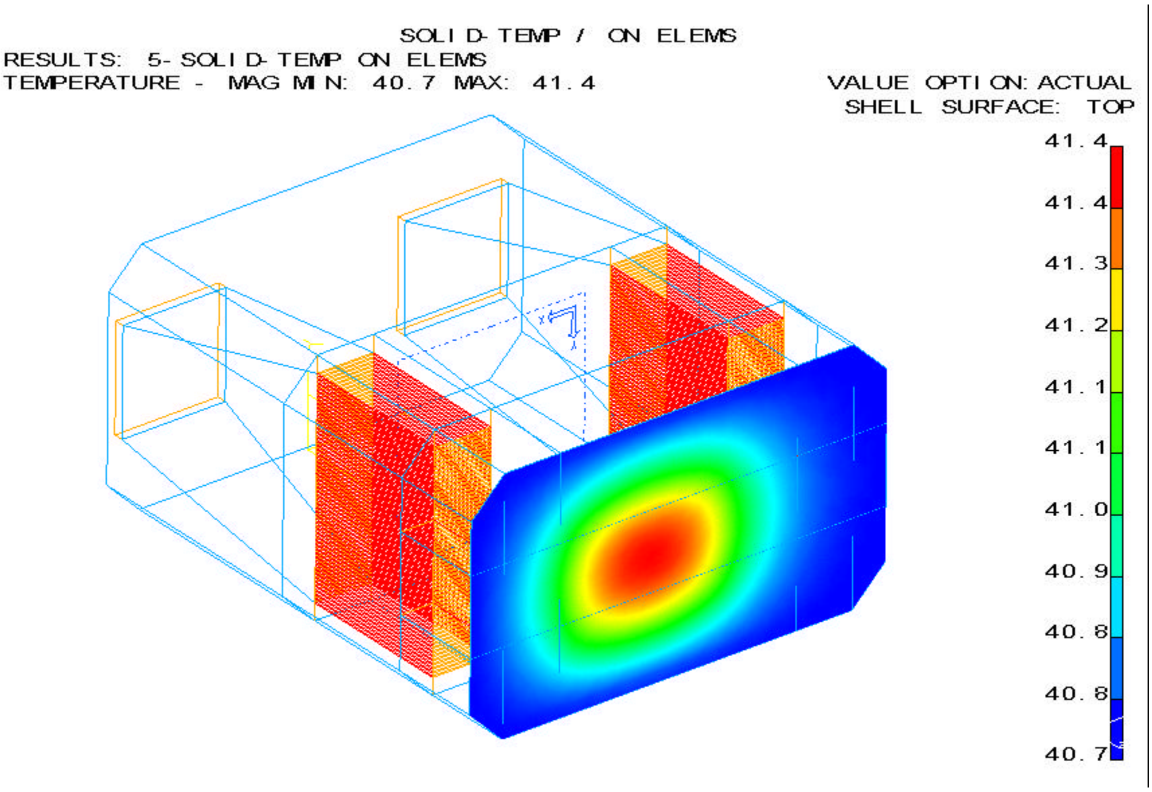

Figure 3-26: Predicted temperature profile of the front panel for case 1

In the both cases the temperatures are below the safety limit of 49°C.

4. ACOP INTERFACES

4.1 MECHANICAL INTERFACES

4.1.1 STRUCTURE MOUNTED INTERFACE

ACOP is mounted to the back plate of the Rack by 4 Captive Sleeve Bolt (SPS NS202163-4-1)

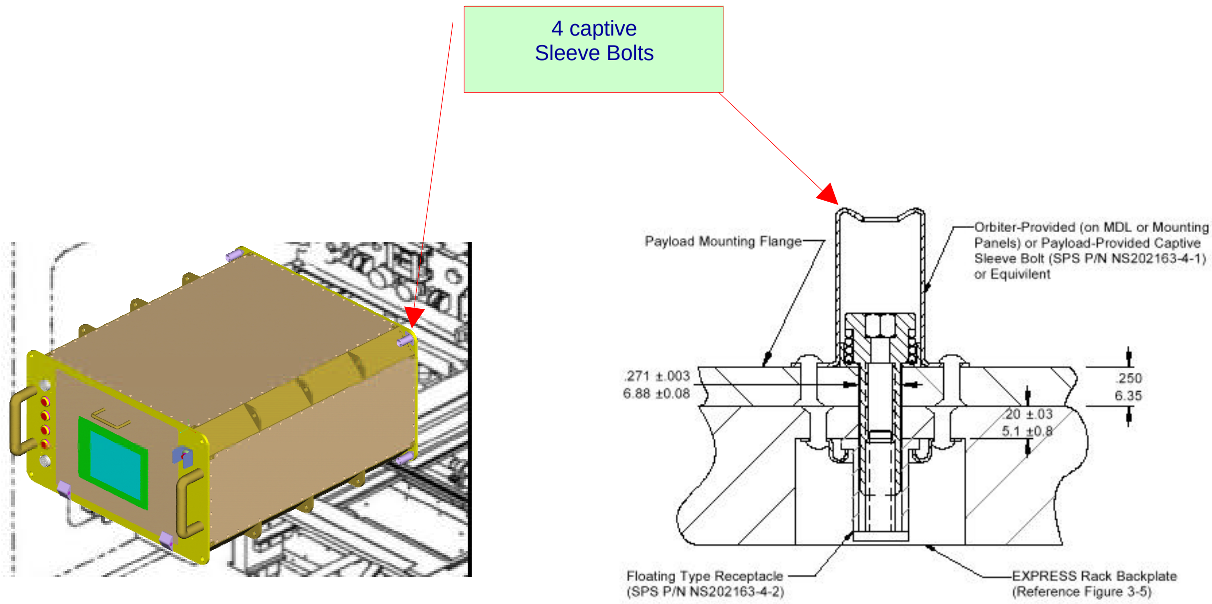

Figure 4-1 Structure Interface

4.1.2 AIRFLOW INTERFACE

Cooling airflow via Avionics Air Assembly (AAA) will blow in and out through the holes on back plate of the Rack.

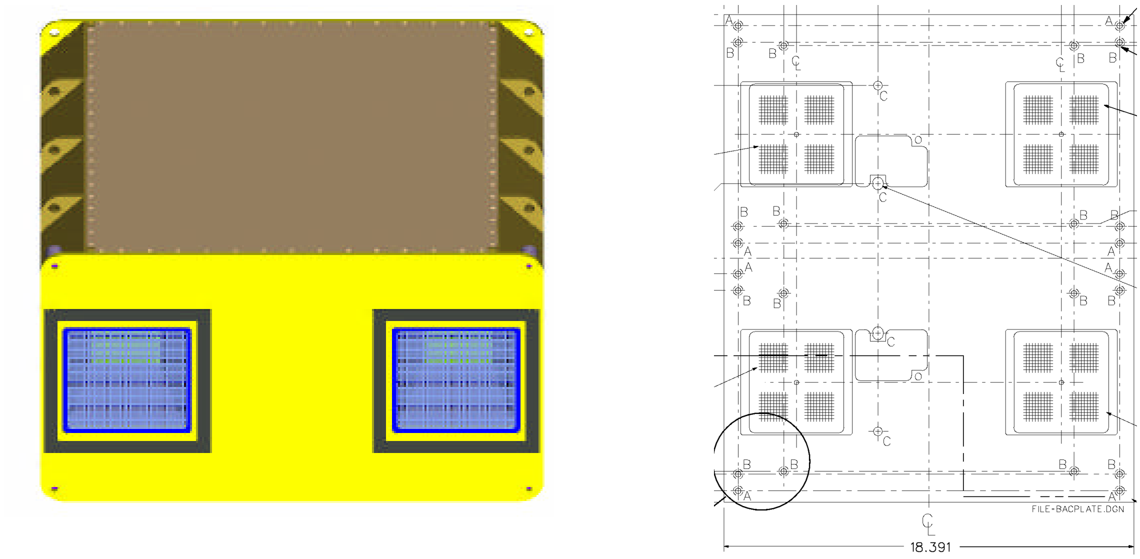

Figure 4-2 Airflow holes on ACOP and EXPRESS Rack

The ACOP airflow holes are protected by screens and optionally will provide mountings for suitable filters.

4.2 ELECTRICAL INTERFACES

4.2.1 POWER INTERFACES

- The Power requirement will be compliant to the SSP52000-IDD-ERP document section 6
- ACOP will not be powered during STS transportation.
- On ISS ACOP will be powered from the ER upper or lower connector panel. A cable, with connectors meeting SSP-52000-IDD-ERP section 6.6, will be provided to link ACOP's front panel power connector to the ER connector panel.
- ACOP power request is <=200Watt (TBC).
- ACOP input power line will be isolated from the structure by at least 1 Mega Ohm with a parallel capacitance of <= 10MicroF measured at ACOP interface connector contact
- 24 VDC to 32 VDC (nominal 28VDC) input from a power cable
- Double-pole circuit breaker with on/off switch and reset

4.2.2 DATA AND COMMANDS INTERFACES

- The following Data Interface requirements will meet the SSP52000-IDD-ERP document section 9.

    - Ethernet Interface. It will provide ER protocol to communicate to the RIC.

- The HRDL Interface will meet the SSP52050 and SSP50183 documents.

    - HRDL connections are a special resource required for ACOP that usually are not available for a standard Express Rack payload.
    - Full time – (1) TX and (1) RX fiber are used for a AMS-02 to ACOP private payload network to support the complex data management required.
    - Intermittent – (1) TX fiber is used to downlink AMS-02 telemetry data.

- OZ3 engineering study identified (2) TX and (1) RX HRDL fibers on the UIP as available during the AMS-02 mission. (TX and RX under TESS (complete mission) and TX under MELFI(as initiation location, may have to move)).
- To connect the HRDL channels, optical fiber cables will be installed inside the laboratory from ACOP to these J7 connectors, following a defined path agreed between EPIM and AMS-02 Program.

4.3 CREW INTERFACES

The crew is provided two interfaces to ACOP. A simple automatic teller machine (ATM) style of soft labeled buttons is provided via the front panel LCD (TBC). Support is provided for key monitoring and operations functions for both ACOP and AMS-02 via this interface. This interface includes ACOP front panel controls for the LCD for backlighting and contrast.

A second, more robust, interface is provided via the EXPRESS Rack Laptop (ERL) computer. It is anticipated that several graphical interfaces for both ACOP and AMS-02 will be developed for ERL.

5. OPERATIONAL SCENARIO

The Flight operation are here below listed:

5.1 LAUNCH PHASE

Nominally ACOP will be launched installed in a transportation rack within the MPLM (other transportation modes are foreseen including aft flight deck and ATV). ACOP is not powered and no hard drives are installed during assent. Hard drives, and other spare parts, are carried in a soft side stowage bag.

5.2 FLIGHT PHASE

Installation of ACOP inside An US-LAB ISPR

The ACOP will be installed into a US-LAB ISPR by the crew by securing the four captive bolts in the rear of ACOP to the EXPRES rack back plate. The launch locks on the front panel will be released and four hard drives installed.

External Cable Installation

The crew has to install the external cables that connect ACOP to the ISS: Power cable (to be connected to Jx of ACOP front panel see RD4) , HRDL cable (to be connected to Jy of ACOP front panel see RD4) and Data cable (to be connected to Jz of ACOP front panel see RD4)

ACOP POWER ON

Other then brief (less then 8 hours periods) of ISS low power modes and during hard drive exchange ACOP will be powered on. The Power On phase consists of putting ACOP's front panel circuit breaker in the "on" and verifying on the display that the booting phase of ACOP has finished successfully and ACOP is in the cold start mode (see below). ACOP's operational mode can then be selected by interaction with the command interfaces (either by the crew or ground.)

ACOP Power Off

Nominally ACOP is informed that it is being powered down. When so instructed it enters the Active Idle mode. Once this condition has been verified ACOP can be switched off.

HARD Drive Disks installation and Exchange

The ISS crew will be in charge of installation and exchange of hard drives. The operation will be made with ACOP powered down.

The crew has to:

1. Retrieve the appropriate ACOP storage bag.
2. Power down ACOP.
3. Open the LCD front panel by pulling the LCD front panel handle. The LCD font panel will remain in the open position thanks to a friction hinge.
4. HDDs already installed are removed and returned to the stowage bag.
5. Fresh HDDs will be inserted in the four slots present inside the ACOP and fixed with the card retainer: lever arm type card retainers will be used so no dedicated tools are required for this activity..
6. The crew will log the disk serial numbers of disks removed and installed.
7. Restore power and resume operation.
8. Re-stow the ACOP stowage bag.

5.2.1 OPERATIVE MODES

ACOP is primarily a ground operated system but can be crew commanded.

ACOP will have the following principal operating modes:

- Powered off
- Cold start
- Software upgrade (a special function of cold start)
- Warm start
- Active idle
- Active recording
- Active playback
- Active recording and playback

During any of the active modes ACOP can serve as a crew interface directing commands to AMS-02.

During any of the states other then powered off ACOP will accept ground commands.

6. SAFETY ANALYSIS

This section summarizes the system safety analysis by which the hazard reports were developed (see section § 7). The safety assessment effort reflects the current baseline for ACOP.

The ACOP design including interfaces, operation, materials and parts has been evaluated and analyzed for compliance with safety requirements defined in NSTS 1700.7B. All hardware of ACOP is new and none is of the type of re-flown or series hardware.

Generic and unique hazards identified in the conceptual phase are evaluated in this safety assessment.

Generic "safety subsystems" involved in this analysis for ACOP are:

- Structures
- Electrical
- Materials
- Human factors

which are in relationship with the following hazard categories:

- Collision
- Rupture
- Electrical shock
- Offgassing / toxicity
- Fire
- Injury / illness
- Temperature extremes
- Radiation

These potential hazards are discussed in this data package.

6.1 STRUCTURES

6.1.1 STRUCTURAL FAILURE/COLLISION

The potential hazard associated to ACOP structure is the possibility that hardware may deform or break away and collide with the ISS and orbiter during launch or landing due to launch/landing loads or in-orbit loads during on-orbit operations.

The loads carrying structure of the ACOP has been analyzed and the structural items have been identified. These items are able to sustain the induced loads over the complete life cycle (ground, lift-off, orbit, landing) without failure. The structure (metallic) is verified by analysis using factors of 1.25 for yield and 2.0 for ultimate conditions.

The safety assessments consider the worst possible design failure of the worst induced environment.

Results of the structural analysis show that the MoS are positive for all applied loads and compliant with the structural requirement except for the insert analysis.
The ACOP interface is made using the configuration A defined in AD1 (section 3.4.3.6.2.1). In this configuration the attachment point is as the Figure 3-11 shown. After calculating like bolt analysis, MoS (-0.183) for insert is negative.
To avoid this problem the following solutions are under investigation:

- Modification of the joint type: from A to B. In this case the hole pattern in the I/F panel are different. Either
    - modify the mechanics to comply also with B hole pattern (with particular attention to integration of chassis, cabling and manufacturing) or
    - evaluate the possibility of using an adapter (TBC after PDR).
- Reduce mass with current joints or/and
- Move the chassis toward the back of the locker to increase the margin of safety.

Materials compatibility will be considered. The materials will be selected from MSFC-HDBK-527/JSC-09604/MAPTIS database to meet requirements of MFSC-SPEC-522B for stress corrosion.

Design will be based on fracture control plan procedures in accordance with the requirements of NASA-STD-5003. The potential hazard is tracked on unique hazard report ACP-HR-002.

The area/volume ratio of ACOP is high enough to avoid any pressure difference. See Standardized Hazard Control Report STD-HR-001.

6.2 ELECTRICAL SUBSYSTEM

Electrical systems are considered hazardous in terms of electrical shock and short circuit.
Circuit protection and wires sizes will be selected in accordance with TM102179 "Selection of wires and circuit protection devices for NSTS Orbiter Vehicle Payload Electrical circuits" as interpreted by NSTS 18789B Letter TA-92-038 (see section 3.4.2). Power distribution schematic is provided in the Figure 3-14. Preliminary list of the internal harness of ACOP is provided in the Table 3-9.

The electrical connection will be made per procedures with the power to ACOP turned off. ACOP design meets the requirements of NSTS 18789B Letter MA2-99-170 for low power connections.

High voltage DC-AC inverter typically TBD Vdc (> 32V) that is installed inside ACOP to provide power for backlight tubes lighting of LCD display creates a potential electrical shock hazard. Crew could never get in contact with these power source during ACOP operations when the front panel is opened to replace the hard drives. The potential hazard is controlled with following provisions:

- ACOP is power switched off when the front panel is opened
- High voltage inverter is not accessible because it is inside a metallic box
- Proper electrical bonding and grounding provisions, as per section 7.5-7.7 of AD1, and appropriate bonding provisions for installation of hardware during in-orbit operations, in accordance with NASA letter MA2-99-142, are foreseen (redundant bonding path, adequate bonding surfaces).

System bonding and grounding diagram is provided in the Figure 3-23.

The potential hazard is tracked on standard hazard report STD-ACP-HR-001 and ACP-HR-003.

6.2.1 ELECTROMAGNETIC COMPATIBILITY

Full compliance to applicable requirements will be envisaged and EMC testing will be performed.
The ACOP mechanical boxes will operate as a shield against the internally generated emissions and the externally generated emissions.
Additional internal metallic shield e/o shield at cable level will be used to increase the EMI shielding.

The potential hazard is tracked on standard hazard report STD-ACP-HR-001.

6.3 MATERIALS

6.3.1 FLAMMABILITY

Materials having A-rating of flammability will be used at maximum extent. The materials will be selected from MSFC-HDBK-527/JSC-09604/MAPTIS database.

6.3.2 OFFGASSING

It will be of major importance to use non-off-gassing materials for the ACOP box outer housing being exposed to the cabin environment.
Materials are selected from MAPTIS with acceptable offgassing characteristics, as possible.

The potential hazard is tracked on standard hazard report STD-ACP-HR-001.

6.3.3 SHATTERABLE MATERIALS

LCD (TBC) display is not stressed component and the potential shatterable hazard is controlled with covering by protection plastic (LEXAN). The potential hazard is tracked on standard hazard report STD-ACP-HR-001.

6.4 HUMAN FACTORS

The two areas of concern for human factors are sharp edges/protrusion and touch temperature that could each cause damage to the crew during IVA.

Control provisions shall be mainly based on accurate design to prevent possible injury to crew caused by burrs, corners, edges, protrusions, pinching and cutting points during on-ground operations. Design will be compliant to NASA-STD-3000 / SSP 50005 requirements.

The potential hazard is tracked on standard hazard report STD-ACP-HR-001.

6.4.1 TEMPERATURE EXTREMES

ACOP meets touch temperatures requirements of NSTS 18798B Letter MA2-95-048. Payload is lower power consumption equipment and during nominal operation the item hottest are not accessible to the crew. Preliminary thermal analysis assures the touch temperature limits of –18°C to 49°C that are not exceeded; the maximum touch temperatures are :

- 44.1 ? value, at the central chassis for mounting the hard drives as shown in Figure 3-25
- 41.4 ? at the centre of the LCD monitor as shown in the Figure 3-26

In case of loss of air cooling service the rack switches-off power to all payloads. The only internal failures that can cause overtemperature condition are identified in the internal short circuits, ACOP design meets safety requirements of NSTS 18798 Interpretation Letter TA-92-038 (see section 3.4.2.1).

The potential hazard is tracked on standard hazard report STD-ACP-HR-001.

6.5 ROTATING EQUIPMENT

The ACOP contains 4 hard drives to provide an estimated 20 days of recording. At PDR phase the hard drives are under investigation so the final choice is TBD. In any case requirements of NASA-STD-5003 are applicable to design. Hard drives are contained in the metallic box of ACOP.
The potential hazard is tracked on standard hazard report STD-ACP-HR-001.

6.6 FIRE PROTECTION

Fire prevention is handled in the design process. The ACOP is made with approved materials and with proper wire sizing and circuit protection according to requirements specified by Sections 6.2.2 and 6.2.3 of SSP-52000-IDD-ERP, Issue D requirements [AD1]. Elimination of fire sources through conformal coating and electronic parts derating was implemented in the design. Proper grounding is also implemented. Since ACOP is interfaced with the rack AAA and smoke sensor (TBC), neither specific means of fire detection nor a dedicated PFE port are necessary.

6.7 RAPID SAFING

ACOP Payload consists of hardware within a rack space and will not impede emergency IVA egrees.

6.8 OPERATIONS/MAINTENANCE

All the necessary information and instructions regarding operations and maintenance of ACOP system are described in the section 5 .
Design provision required for on-orbit maintenance meets the requirements of Letter MA2-00-038.

7. HAZARD REPORTS

This section provided the required Hazard Control Reports for ACOP.

The Hazard Control Reports are subdivided into:

- Flight Payload Standardized Hazard Control Report, prepared in accordance with NASA Letter NC4-98-048 (JSC Form 1230)
- Unique Hazard Control Reports, prepared in accordance with NSTS/ISS 13830C (JSC Form 542B)

7.1 FLIGHT PAYLOAD STANDARDIZED HAZARD CONTROL REPORT

In the following pages the Standardized Hazard Control Report are reported, as per JSC Form 1230. The list of the Standardized Hazard Reports is hereafter reported:

Standardized Hazard	Status	Remarks
1. Structural Failure		Included in hazard report ACP-HR-002
2. Structural failure of sealed containers		Not applicable
3. Structural failure of vented containers		Not applicable
4. Sharp edges	Open	
5. Shatterable materials	Open	
6. Flammable materials	Open	
7. Material offgassing	Open	
8. Non ionizing radiation 8.1 Non-Transmitters	Open	
8.2 Lasers		Not applicable
9. Battery failure		Not applicable
10. Touch Temperature	Open	
11. Electrical power distribution	Open	
12. Ignition of flammable atmosphere in cargo bay		Not applicable
13. Rotating equipment	Open	
14. Mating/demating power connectors	Open	
15. Contingency return and rapid safing		Not applicable
16. Release of mercury from bulbs into crew habitable environment		Not applicable

FLIGHT PAYLOAD STANDARDIZED HAZARD CONTROL REPORT		A. NUMBER	B. PHASE	C. DATE
		STD- ACP-HR-001	**Phase 0/I**	11/01/05
D. PAYLOAD, DTO, DSO or RME *(Include Part Number(s), if applicable)*		**HAZARD TITLE**	**E. VEHICLE**	
ACOP		STANDARD HAZARDS	Shuttle/Station	

F. DESCRIPTION OF HAZARD:	**G. HAZARD CONTROLS:** *(complies with)*	**H. APP.**	**I. VERIFICATION METHOD, REFERENCE AND STATUS:**
1. Structural Failure *(payloads must comply with the listed requirements for all phases of flight)* *Note: Locker and Soft Stowage items only.*	a) Designed to meet the standard modular locker stowage requirements of NSTS 21000-IDD-MDK or equivalent IDD ______ , or b) Stowed in SPACEHAB per MDC91W5023.	☐ ☐	See Structural Failure Unique Hazard Report -ACP-HR-002 Open
2. Structural Failure of Sealed Containers Note: The 1230 form is not applicable for "sealed container"(s) employed in levels of containment control of hazardous fluid	Sealed containers must meet the criteria of NASA-STD-5003, Para. 4.2.2.4.2.3a, contain a substance which is not a hazard if released, be made of conventional metals (e.g. Al, inconel, monel, steel or titanium), contain less than 14,240 foot-pounds (19,130 Joules) of stored energy due to pressure, and have a maximum delta pressure of 1.5 atm.	☐	N.A.

FLIGHT PAYLOAD STANDARDIZED HAZARD CONTROL REPORT		A. NUMBER	B. PHASE	C. DATE
		STD- ACP-HR-001	**Phase 0/I**	11/01/05
D. PAYLOAD, DTO, DSO or RME *(Include Part Number(s), if applicable)*		**HAZARD TITLE**	**E. VEHICLE**	
ACOP		STANDARD HAZARDS	Shuttle/Station	

F. DESCRIPTION OF HAZARD:	**G. HAZARD CONTROLS:** *(complies with)*	**H. APP.**	**I. VERIFICATION METHOD, REFERENCE AND STATUS:**
3. Structural Failure of Vented Containers	For intentionally vented containers, vents are sized to maintain a 1.4 factor of safety for Shuttle or a 1.5 factor of safety for Station with respect to pressure loads. Meets all of the applicable pressure rates defined for one or more of the following.		N.A. Note: Area/volume ratio is high enough to avoid any pressure difference
	a) Shuttle payload bay – ICD 2-19001, Para. 10.6.1	☐	
	b) Station environment – SSP 52005, paragraph 4.1.12 or equivalent payload specific ICD ______.	☐	
	c) Station PFE discharge – SSP 57000, Para. 3.1.1.4K, or equivalent payload specific ICD ______.	☐	
	d) Shuttle Middeck – NSTS 21000-IDD-MDK, Section 6.1.	☐	

FLIGHT PAYLOAD STANDARDIZED HAZARD CONTROL REPORT		A. NUMBER		B. PHASE	C. DATE
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D. PAYLOAD, DTO, DSO or RME *(Include Part Number(s), if applicable)*		**HAZARD TITLE**		**E. VEHICLE**	
ACOP		STANDARD HAZARDS		Shuttle/Station	
F. DESCRIPTION OF HAZARD:	**G. HAZARD CONTROLS:** *(complies with)*	**H. APP.**	**I. VERIFICATION METHOD, REFERENCE AND STATUS:**		
4. Sharp Edges, Corners, and/or Protrusions.	Meets the **intent** of one or more of the following: a) NASA-STD-3000 / SSP 50005 b) SLP 2104 c) NSTS 07700 Vol. XIV App. 7 (EVA hardware) d) NSTS 07700 Vol. XIV App. 9 (IVA hardware) / SSP 57000 e) SSP 41163, Para. 3.3.6.12.3 (IVA), Para. 3.3.6.12.4 (EVA).	 ☐ ☐ ☐ ☒ ☐	4.e.1 Review and approval of ACOP Hardware design. Open 4.e.2 QA inspection and certification of the as-built hardware is in accordance with approved drawings. Open		
5. Shatterable Material Release	a) All materials are contained. b) Optical glass (i.e. lenses, filters, etc.) components of crew cabin experiment hardware that are non-stressed (no delta pressure) and have passed both a vibration test at flight levels and a post-test visual inspection. c) Payload bay hardware shatterable material components that weigh less than 0.25 lb and are non-stressed (no delta pressure) or non-structural.	☒ ☐ ☐	5.a.1 Review and approval of LCD (TBC) protection plastic covering (LEXAN). Open 5.a.2 QA inspection and certification that the LCD (TBC) is protected by a plastic covering . OPEN		

FLIGHT PAYLOAD STANDARDIZED HAZARD CONTROL REPORT		A. NUMBER	B. PHASE	C. DATE
		STD- ACP-HR-001	**Phase 0/I**	11/01/05
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ACOP		STANDARD HAZARDS	Shuttle/Station	

F. DESCRIPTION OF HAZARD:	G. HAZARD CONTROLS: *(complies with)*	H. APP.	I. VERIFICATION METHOD, REFERENCE AND STATUS:
6. Flammable Materials	a) A-rated materials selected from MAPTIS, or b) Flammability assessment per NSTS 22648	☒ ☐	6.a/b.1 Review and approval of material list and MUA (if any) to be approved by ASI/NASA. - Open
7. Materials Offgassing	a) Offgassing tests of assembled article per NHB 8060.1 and/or NASA-STD-6001	☒	7.a.1 Review and approval of material list and MUA (if any) to be approved by ASI/NASA - Open Note: Materials are selected from MAPTIS with acceptable offgassing characteristics, as possible.
8. Nonionizing Radiation 8.1 Non-transmitters	Meets all that apply: a) Pass ICD-2-19001, 10.7.3.2.2 / SSP 30238 EMI compatibility testing, or b) NSTS/USA approved analysis ICD Section 20, or c) ISS/EMEP approved TIA d) Meets SSP 41163, Para. 3.3.6.6 **and** SSP 50094, Para. 3.4.	☒ ☐ ☐ ☐	8.1.a.1 Review and approval of EMI Compatibility test report - Open
8.2 Lasers	a) Beams are totally contained at the maximum possible power and there is no crew access, or b) Meet ANSI Z136.1-2000 for class 1, 2, or 3a Lasers (as measured at the source).	☐ ☐	N.A.

FLIGHT PAYLOAD STANDARDIZED HAZARD CONTROL REPORT		A. NUMBER	B. PHASE	C. DATE
		STD- ACP-HR-001	**Phase 0/I**	11/01/05
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ACOP		STANDARD HAZARDS	Shuttle/Station	

F. DESCRIPTION OF HAZARD:	**G. HAZARD CONTROLS:** *(complies with)*	**H. APP.**	**I. VERIFICATION METHOD, REFERENCE AND STATUS:**
9. Battery Failure *(use of this form is limited to small commercial batteries as listed below)* 9.1 Alkaline-MnO_2, Carbon- Zn, or Zn-Air in sizes D or smaller having 6 or fewer cells either all in parallel or all in series (series/parallel combinations require a unique hazard report), no potential charging source, and cells are **not** in gas-tight compartment. 9.2 a. Ni-Cd, Ni-MH, or Ag-Zn which have a capacity of 300 mAh or less, and no more than 3 cells per common circuit , and cells are **not** in gas-tight compartment. b. Li-CFx, Li-Iodine, Li-MnO_2, which have a capacity of 300 mAh or less, and no more than 3 cells per common circuit.	Pass acceptance tests which include open circuit & loaded voltage measurements, visual examination, and leakage check under vacuum (e.g. 6 hours at 0.1 psia). *Note: Above acceptance testing for button cells in Section 9.2 which are soldered to a circuit board in commercial equipment (not applicable to those button cells in a spring-loaded clip) is limited to a functional check of the equipment utilizing the subject battery.*	☐	N.A. *Note: Application and schematic reviewed and approved by JSC/EP5.*

FLIGHT PAYLOAD STANDARDIZED HAZARD CONTROL REPORT		A. NUMBER	B. PHASE	C. DATE
		STD- ACP-HR-001	**Phase 0/I**	11/01/05
D. PAYLOAD, DTO, DSO or RME *(Include Part Number(s), if applicable)*		**HAZARD TITLE**	**E. VEHICLE**	
ACOP		STANDARD HAZARDS	Shuttle/Station	

F. DESCRIPTION OF HAZARD:	G. HAZARD CONTROLS: *(complies with)*	H. APP.	I. VERIFICATION METHOD, REFERENCE AND STATUS:
10. Touch Temperature	a) Within IVA touch temperature range of –18 Degrees C. (0 Degrees F.) and 49 Degrees C. (120 Degrees F.) and satisfies the intentional contact constraints of letter MA2-95-048 (if applicable). b) Meets EVA touch temperature criteria of NSTS 07700 Vol. XIV App. 7.	☒ ☐	10.a.1 Review and approval of thermal analysis report. Open
11. Electrical Power Distribution	a) Shuttle-powered payloads – Meets all circuit protection requirements of Letter TA-92-038. b) Station-powered payloads – Meets station interface circuit protection requirements of SSP 57000 and payload circuit protection requirements of Letter TA-92-038.	☐ ☒	11.b.1 Review and approval of Electrical Analysis and Design - Open 11.b.2 QA inspection and certification of the as-built electrical circuitry is in accordance with approved drawings and part lists. Open See Attachment #1to HR for power distribution schematic and wire sizing
12. Ignition of Flammable Atmospheres in Payload Bay	All ignition sources in the Payload bay, for launch and landing, are controlled as required in Letter NS2/81-MO82, and MLI grounded per ICD 2-19001.	☐	N.A. - Unit is not powered in Cargo Bay
13. Rotating Equipment	Rotating equipment meets criteria of NASA-STD-5003 for obvious containment.	☒	Rotating Equipment are hard drives that are contained in the housing box of ACOP. Rotating Energy: TBD. 13.1 Review and approval of design.

FLIGHT PAYLOAD STANDARDIZED HAZARD CONTROL REPORT	A. NUMBER	B. PHASE	C. DATE
	STD- ACP-HR-001	**Phase 0/I**	11/01/05

D. PAYLOAD, DTO, DSO or RME *(Include Part Number(s), if applicable)*	HAZARD TITLE	E. VEHICLE
ACOP	STANDARD HAZARDS	Shuttle/Station

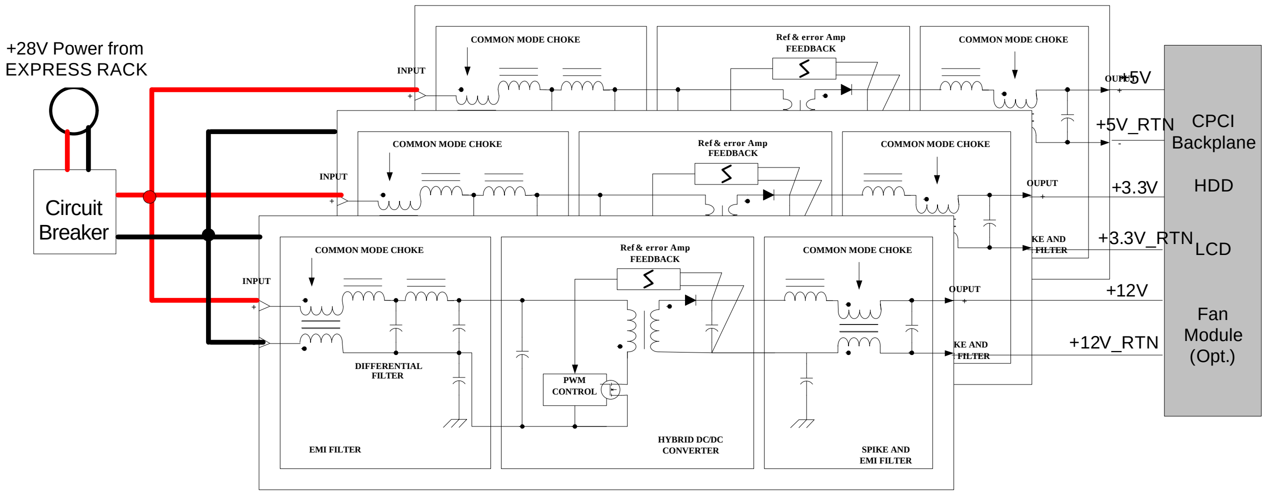
F. DESCRIPTION OF HAZARD:	G. HAZARD CONTROLS: *(complies with)*	H. APP.	I. VERIFICATION METHOD, REFERENCE AND STATUS:
14. Mating/demating powered connectors	a) Meets the low power criteria of letter MA2-99-170 or, b) Meets the paragraph 1 criteria of letter MA2-99-170 (e.g., IVA and open circuit voltage no greater than 32 volts).	☒ ☐	14.b.1 Review and approval of electrical design - Open 14.b.2 QA inspection and certification of the as-built electrical circuitry is in accordance with approved drawings and part lists. Open
15. Contingency Return and Rapid Safing	Shuttle Environment: a) If middeck payload – can be stowed within 50 min. (see paragraph 3 of letter MA2-96-190). b) If SPACEHAB transfer item – can establish a safe for return configuration within 3 min. (see paragraph 5 of letter MA2-96-190). Station Environment: c) Payload design does not impede emergency IVA egress to the remaining adjacent pressurized volumes.	☐ ☐ ☒	ACOP Payload consists of hardware within a rack space and will not impede emergency IVA egrees. Closed
16. Release of Mercury from bulbs into crew habitable environment.	a) Mercury vapor bulbs contain less than 30 mg of Mercury per bulb, and b) No more than one bulb could break due to a single failure.	☐	N.A.

APPROVAL	PAYLOAD ORGANIZATION	SSP/ISS

FLIGHT PAYLOAD STANDARDIZED HAZARD CONTROL REPORT			A. NUMBER		B. PHASE	C. DATE
			STD- ACP-HR-001		**Phase 0/I**	11/01/05
D. PAYLOAD, DTO, DSO or RME *(Include Part Number(s), if applicable)*			**HAZARD TITLE**		**E. VEHICLE**	
ACOP			STANDARD HAZARDS		Shuttle/Station	
F. DESCRIPTION OF HAZARD:	**G. HAZARD CONTROLS:** *(complies with)*		**H. APP.**	**I. VERIFICATION METHOD, REFERENCE AND STATUS:**		
PHASE I						
PHASE II						
PHASE III						

ATTACHMENT# 1

ACOP POWER DISTRIBUTION SCHEMATIC



7.2 UNIQUE HAZARD CONTROL REPORTS

In the following pages the Unique Hazard Reports are reported, as per JSC Form 542B.
The list of Unique Hazard Reports with their proper status is hereafter provided:

Hazard Report No.	Hazard Report Title	Status
ACP-HR-002	Structure Failure	Open
ACP-HR-003	IVA Electrical Shock	Open

PAYLOAD HAZARD REPORT

a. NO: ACP-HR-002

b. PAYLOAD: ACOP

c. PHASE: 0/I

d. SUBSYSTEM: STRUCTURES

e. HAZARD GROUP: COLLISION

f. DATE: 10/01/05

g. HAZARD TITLE:

STRUCTURE FAILURE

i. HAZARD CATEGORY

☒ CATASTROPHIC

☐ CRITICAL

h. APPLICABLE SAFETY REQUIREMENTS:

NSTS 1700.7B and ISS Addendum: par. 200.1b, 208.1, 208.2, 208.3

j. DESCRIPTION OF HAZARD:

Structural failure of elements, due to flight environment or use, causes to deform or to break away and results in loose object which could impact the ISS or cabin crew

k. HAZARD CAUSES:

1 Structural elements of payload equipment lack structural strength to withstand loads
2 Use of structural materials which are susceptible to stress corrosion cracking or other environmental degradation

l. HAZARD CONTROLS:

1.1 ACOP has to show positive Margin of Safety applying the Safety Factor of 1.25 yield and 2.00 ultimate for metallic structure
2.1 The materials will be selected from MSFC-HDBK-527/JSC-09604/MAPTIS database to meet requirements of MFSC-SPEC-522B. .Materials not listed by this document shall be managed with MUA to be approved by ASI/NASA

m. SAFETY VERIFICATION METHODS:

1.1.1 Structural design stress analysis will be performed to verify positive margins (in accordance with requirements of NSTS 14046 and SSP 52005).
1.1.2 Approval of Structural Verification Program (TBC) by ASI and NASA Structures Working Group. Ref.: Verification Plan
1.1.3 Random Vibration test and modal survey analysis
2.1.1 Review and approval of material lists and MUA by ASI/NASA

n. STATUS OF VERIFICATION:

1.1.1	Open
1.1.2	Open
1.1.3	Open
2.1.1	Open

o. APPROVAL	PAYLOAD ORGANIZATION	SSP/ISS
PHASE I		
PHASE II		
PHASE III		

PAYLOAD HAZARD REPORT CONTINUATION SHEET

a. NO: ACP-HR-002

b. PAYLOAD: ACOP

c. PHASE: 0/I

k. HAZARD CAUSES:

3 Metal fatigue or propagation of inherent or induced cracks/internal flaws
4 Use of counterfeit or substandard fasteners
5 Loosening of structural fasteners
6 Improper manufacture and/or assembly
7 ISS/MPLM (TBC) depressurization / re-pressurization induced loads

l. HAZARD CONTROLS:

3.1 Design will be based on fracture control plan procedures in accordance with the requirements of NASA-STD-5003.

4.1 Procurement from qualified sources

4.2 Structural fasteners will comply with Structural Verification Program. Ref.: Verification Plan

5.1 Structural fasteners incorporate positive locking features

6.1. The structural elements will be built in accordance with approved design manufacturing and drawings and assembly procedures

7.1 Structural Analysis to take into account these induced loads in worst case

m. SAFETY VERIFICATION METHODS:

3.1.1 Review and Approval of Fracture Control Plan by ASI/NASA

3.1.2 Review and approval of ACOP Fracture Control Report Summary by ASI/NASA

4.1.1 Review and approval of materials, mechanical parts and process lists by ASI/NASA

4.2.1 Review and approval of Structural Verification Program. Ref.: Verification Plan

5.1.1 Review of design drawings for inclusion of positive locking features on all structural fasteners

5.1.2 Inspection verifying as-built hardware is in accordance with approved design drawings

6.1.1 Review and approval of drawings and procedures

6.1.2 QA certification that as-built hardware ensure compliance with approved drawings, parts lists and assembly procedures

7.1.1 Review and approval of Structural Analysis

n. STATUS OF VERIFICATION:

3.1.1	Open
3.1.2	Open
4.1.1	Open
4.2.1	Open
5.1.1	Open
5.1.2	Open
6.1.1	Open
6.1.2	Open
7.1.1	Open

PAYLOAD HAZARD REPORT

a. NO: ACP-HR-003

b. PAYLOAD:

ACOP

c. PHASE: 0/I

d. SUBSYSTEM:

ELECTRICAL

e. HAZARD GROUP:

ELECTRICAL SHOCK

f. DATE:

21/07/04

g. HAZARD TITLE:

IVA Electrical shock

i. HAZARD CATEGORY

☒ CATASTROPHIC

☐ CRITICAL

h. APPLICABLE SAFETY REQUIREMENTS:

NSTS 1700.7B and ISS Addendum: § 102.1, 200.1b plus letter MA2-99-142

j. DESCRIPTION OF HAZARD:

Incidental contact with inverter high voltage source (TBD > 32V) inside ACOP to LCD (TBC) backlighting can cause severe damages to crew.

k. HAZARD CAUSES:

1. Improper bonding/grounding provisions

l. HAZARD CONTROLS:

1.1 Bonding and grounding as per SSP 52000-IDD-ERP and Interpretation letter MA2-99-142. See Attachment #1 to HR.

m. SAFETY VERIFICATION METHODS:

1.1.1 Design review
1.1.2 On-orbit grounding verification after ACOP installation
1.1.3 Bonding/grounding test

n. STATUS OF VERIFICATION:

1.1.1	Open
1.1.2	Open
1.1.3	Open

o. APPROVAL	PAYLOAD ORGANIZATION	SSP/ISS
PHASE I		
PHASE II		
PHASE III		

PAYLOAD HAZARD REPORT CONTINUATION SHEET	a. NO: ACP-HR-004
b. PAYLOAD: ACOP	c. PHASE: 0/I

k. HAZARD CAUSES:

2 High voltage sources accessible to personnel during operations
3 Defective components, wires, insulation, design and/or workmanship

l. HAZARD CONTROLS:

2.1 High voltage source is not accessible to the crew. It is enclosed in ACOP housing metallic box and all wires are insulated
3.1 Adequate selection of proper material/components/wires. Design meets circuit protection requirements of letter TA-92-038

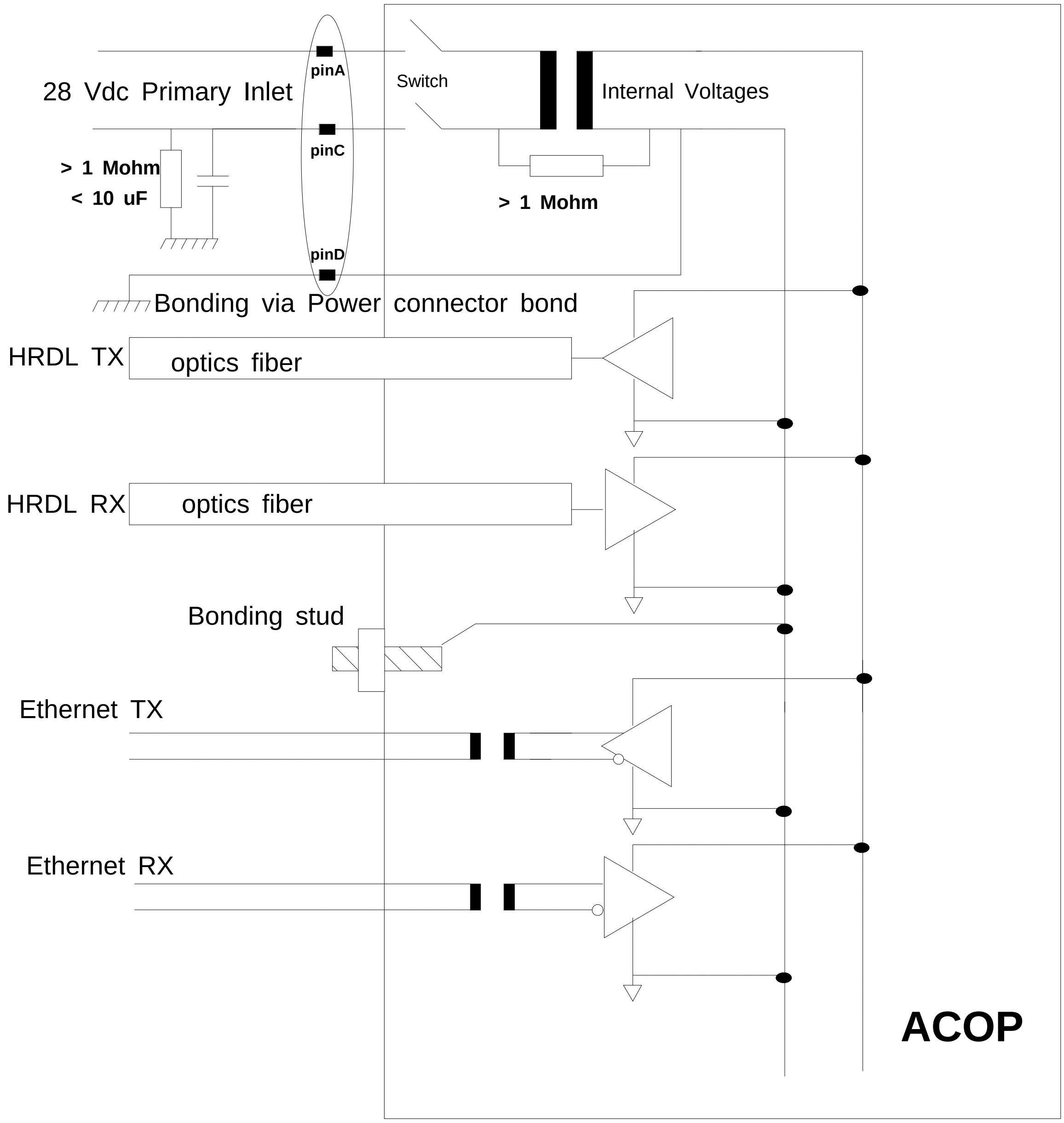
m. SAFETY VERIFICATION METHODS:

2.1.1 Review of design
2.1.2 QA inspection/certification of as built hardware to approved drawings
3.1.1 Review and approval of electrical design and analysis component list
3.1.2 QA inspection/certification of as built hardware to approved drawings

n. STATUS OF VERIFICATION:

2.1.1	Open
2.1.2	Open
3.1.1	Open
3.1.2	Open

ATTACHMENT#1
ACOP Bonding & Grounding Schematic



ANNEX1- FRACTURE CONTROL PLAN

In this annex is reported ACP-PL-CGS-005 Issue 1 “Fracture Control Plan” .
The document will be delivered apart.

ANNEX 2 – VERIFICATION PLAN

In this annex is reported ACP-PL-CGS-005 "Verification Plan" as reference to structural verification requirements. The document will be delivered apart.