ACOP Overview and Operations

Presenter: Peter Dennett

Credits: MG
Post PDR Freeze Changes

Since the completion of the PDR data analysis and data pack creation there have been two significant design changes.

1. **Fans have been added.**

2. **The base plate mounting style has been changed (A to B).**

Our PDR presentations present the data consistent with the data pack but discuss these changes at the end of some of technical presentations.
Presentation Contents

• Operations Scenario
• Mechanical and Cooling
• Avionics
• Power
• Crew Interfaces
• Software
• Budgets
ACOP Services

ACOP is a special purpose computer to be launched to the International Space Station (ISS) to assist the operations of AMS-02 experiment. ACOP provides these services:

- On-orbit recording mechanism for large volumes of data at high rates
- Play back for downlink of the recorded data at high rates
- Crew interface for complex experiments
- General computing facilities
- Alternate bi-directional commanding path via HRDL interface
Operations Concepts (1)

- 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.
- ACOP provides the mechanism for the crew to monitor and control AMS-02.
- As KU access is available, ACOP will be commanded to use its additional HRDL TX connection to down link data. ACOP will have the ability to burst this transmission (~20Mbits/sec).
- All data transmitted by AMS-02 are recorded onto ACOP’s hard drives as a master copy of the AMS-02 science data.
Operations Concepts (2)

- 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 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).
- Hard drives and spare parts stored in a soft side transportation bag.
- 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.
Mechanical Design

- Mid-Deck Locker (MDL) envelope.
- Installed in EXPRESS Rack MDL location.
- Mechanical parts of FM and QM will be made in aluminum alloy.
- Zero-G retention feature to prevent equipment from floating.
- Opening front panel with friction hinges for internal access to the hard drives for periodic replacement (about every 20 days).
- Opening front panel locked for launch/landing by four 1/4 captive fasteners.
- Magnetic latch for on orbit operations.
Mechanical Format

- ACOP envelope meets the Mid-Deck Locker (MDL) envelope
EXPRESS Mounting
Side View Open

March 2005

ACOP PDR
Front Panel View
Cut Away View
Mechanical Parts

- CADDY
- CHASSIS
- BP FRAME
- AIR FILTER
- FRONT PANEL
- LOCKER
- DUCT
- SIDE PLATE
Card Locks

- All CompactPCI Boards, Hard Drives and the Power Supply Board are fixed and extracted by hand operated card locks.
- No special tools are required.
Hard Drive Mounting

- Hard Drives mounted on caddies for easy and reliable replacement
- Connector put on the rear side and plugged into the corresponding connector on the Backplane.
- The force to plug in or out the connector is 5 kg for a 26 pin D-Sub type connector.
Cooling - AAA

- ACOP interfaces to the EXPRESS Rack Avionics Air Assembly (AAA) for cooling.
- No water cooling utilized.
Cooling Heat Sinks

- Heat generated internally to ACOP will be transferred to the fins present on the chassis sides by conduction.
- The cooling airflow will blow through the fins removing the heat by forced convection.
Cooling Flow

Airflow passes through front space.

Air Duct

Air Outlet

Air Inlet from AAA
Mounting

- ACOP will be fixed to the EXPRESS Rack back plate by means of 4 Captive Sleeve Bolts
Back Plate Mounting

- The use of payload attachment points A (four)
Avionics Interfaces (1)

- **Power Supply**
  - +28Vdc standard power feed provided by the EXPRESS Rack
  - On/Off switching capability; over-current protected
  - Compliant with SSP 52000-IDD-ERP Section 6 (Electrical Power Interfaces)
  - **Continuous power required**

- **Ethernet**
  - Standard EXPRESS Rack interface
  - Used for communications with RIC and EXPRESS Rack Laptop Computer (via PEHB)
  - Compliant with SSP 52000-IDD-ERP Section 7.7 (Signal Isolation and Grounding Requirements) and Section 9.2 (Ethernet Communications).
  - Two IEEE802.3 10/100BaseT Ethernet ports available
• **High Rate Data Link**
  - Used for all the communications (Commands, House Keeping and Health & Status Data, Science Data) between ACOP and AMS-02.
  - 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.
  - **HRDL connections are a special resource required for ACOP that usually are not available for a standard EXPRESS Rack payload.**
  - Compliant with SSP 50184 Section 3 and SSP 52050 Section 3.4
  - A dedicated connector on the ACOP Front Panel will be used
  - To connect the HRDL channels, optical fiber cables will be installed inside the US Lab following a defined path agreed between EPIM and AMS-02 Program
Avionics Interfaces (3)

• **RS-422**
  - Available on the ACOP-SBC Card Front Panel for ground tests and debugging
  - Not used in nominal conditions for communications between ACOP and ER Laptop Computer on-orbit
  - Connector not available on the ACOP Front Panel, but accessible only when the movable part of the ACOP Front Panel is open (TBC).
  - Compliant with the RS-422 standard.

• **Universal Serial Bus**
  - Two USB 1.1 interfaces (TBC) present on the ACOP-T102 Card Front Panel for allowing quick ACOP software upgrade without using the standard ISS resources
  - Not used in nominal conditions
  - Connectors not available on the ACOP Front Panel, but accessible only when the movable part of the ACOP Front Panel is open (TBC).
  - Compliant with the USB Specification Revision 1.1 (1.5Mb/s)
Functional Connections

**ACOP System**

- ACOP Core
- HRDL
- Automated Payload Switching
- AMS-02

**EXPRESS Rack System**

- ER Laptop Software
- ER Laptop Computer
- Ethernet
- Payload Ethernet Hub Bridge
- Rack Interface Controller

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Electrical Block Diagram

CPCI 6U

ACOP-SBC

PPC750  AP Flash 32MB  BootFlash 4MB  SDRAM 256MB

Local Bus

Bus Bridge

ACOP-BP

32bits/33MHz CompactPCI Bus

cPCI 6U Spare Slot

ACOP-101

HRDL

USB

Video

DIO

Back Light

HRDL

Tx(2) Rx(1)

Front Panel

LCD (TBC)

Back Light

28V 5A

6U PS

ACOP-PS

In: 28V - 5A
Out: 3.3, 5 and 12V

Push Buttons

NET (2)

SIO

NET

SATA

HRDL

Tx(2) Rx(1)

HRDL

Tx(2) Rx(1)
Internal Harness Routing
## Internal Harness

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

• Input voltage range: 24 to 32Vdc
• Three internal voltages (3.3Vdc, 5Vdc and 12Vdc) generated by power DC/DC converters implemented with hybrid integrated circuits
• Independent DC/DC converters output regulation.
• Outputs meet the electrical requirements of PICMG specification for CompactPCI systems.
• Efficiency: > 75% @ full load (TBC)
• Built-in EMI filters
• Circuit breaker with a switch mounted on the ACOP front panel to provide the On/Off switching capability
• Input over-current protection provided by the circuit breaker
• Protections (TBC): over-voltage, over-current, over-temperature
Grounding & Bonding (1)

- All the parts of the ACOP box made in aluminum and electrically connected together to operate as an EMC shield
- ACOP bonding class: R (Radio Frequency Bond-RF).
- Metallic shells of all the ACOP external electrical connectors 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.
- ACOP shall be bonded via the bond path present in the EXPRESS Rack-to-payload power connector (pin D).
- A bonding stud will be implemented on the ACOP Front Panel to:
  - allow the single point connection of the internal secondary power references (internal side of the ACOP Front Panel)
  - if necessary, to connect an external bonding strap between ACOP and the EXPRESS Rack (external side of the front panel).
Grounding and Bonding (2)

- Fixed and movable parts of ACOP Front Panel connected by a bonding strap (the bonding between them will not rely only on the friction hinges)
- Primary electrical power isolated from ACOP chassis by a minimum of 1 Mohm in parallel with a capacitance < 10uF.
- Galvanic isolation between primary power bus and all the secondary internal or distributed powers (greater than 1 Mohm)
- All the secondary power references connected together and to the ACOP structure in a single point represented by the internal bonding stud.
- Ethernet connection with the EXPRESS Rack RIC as per SSP 52000-IDD-ERP Section 7.7 for isolation and grounding.
- The HRDL interfaces will use optic fiber cables as physical layer, (no electrical connections).
- RS 422 Interface only for ground test (TBC).
- USB 1.1 (TBC) ports present to be used by crew in non-nominal scenarios (SW patches) to connect portable devices (USB keys)
Crew Interfaces (1)

- ACOP front panel:
  - Power and data connectors
  - Power on/off switch
  - Push buttons
  - LCD

- The front panel can be opened to have access to:
  - The hard drives for periodic replacement.
  - The RS-422 and USB connectors.
  - Circuit boards for replacement (off nominal).

- The EXPRESS Rack Laptop ACOP Interface.
- Air filters in rear.
Liquid Crystal Display

- Allows the ISS crew to be informed about the main ACOP parameters, without need of using the MMI available via the ER Laptop Computer.

- The continuous monitoring provided by this interface includes, according to the AMS-02 program needs:
  - ACOP House Keeping and Health & Status data (i.e. power supply status, internal temperatures, available space on the memory units).
  - AMS-02 House Keeping and Health & Status data

- Data to be actually displayed at a given time are selected by means of the Push Buttons

- Compliant with SSP 52000-IDD-ERP Section 12.6 (Controls and Displays).
Crew Interfaces (3)

- Main LCD characteristics:
  - Screen size 6.4”
  - Display format 640x480 RGB
  - Display colors: 262,144
  - Vertical frequency: ~ 60Hz
  - Active area/Outline area = 62.3%
  - Backlight brightness adjustable

- Push Buttons
  - Allows the ISS crew to control the main ACOP functions by issuing predefined commands without external equipment and without using the ER Laptop Computer.
  - Compliant with SSP 52000-IDD-ERP Section 12.6 (Controls and Displays).

- Fan Filters
Software Interfaces

The ACOP Software Interfaces manage:

• All the information flow between ACOP and EXPRESS Rack via PEHB and RIC:
  - ACOP House Keeping and Health & Status data
  - AMS-02 House Keeping and Health & Status data
  - AMS Science Data packets
  - Tele-commands for ACOP
  - Tele-commands to be routed to AMS-02

• All the information flow between ACOP and AMS-02:
  - Commands
  - House Keeping and Health & Status Data
  - Science Data packets
Software

- Flight Software:
  - System Manager
  - ISS Interfaces Manager
  - Man-Machine Interface

- Ground Software:
  - EGSE Software for testing
  - Training Software
Flight Software

- ACOP-SYS-SW: System Software, operating system and support libraries
- ACOP-APP-SW: Application Software, providing the mission explicit application software functions on the ACOP hardware
- ACOP-ERL-SW: EXPRESS Rack Laptop Software, payload developed software running on the EXPRESS Laptop Computer
Basic Software

• ACOP System Software (Basic Software)
  ➢ Boot strapping operations.
  ➢ Initialization of the ACOP Hardware.
  ➢ Operations of the ACOP Hardware Interfaces via device drivers.
  ➢ Exception handling.
  ➢ Diagnostic and system self-tests.
  ➢ Monitoring of resources and environment relevant to ACOP Health and Status.
  ➢ Management of data storage devices and file systems.
  ➢ Functional interfaces to ISS Avionics C&DH Systems.
  ➢ Crew interface via ERLS.
  ➢ External command processing for system commands.
  ➢ Execution and control of ACOP-APP-SW.
Application and ERL Software

- **ACOP Application Software**
  - Functional interfaces to the ISS HRDL Interfaces.
  - Data recording.
  - Data playback.
  - Detailed data management.
  - Detailed management of data contents with regard to external systems.
  - External command processing for applications commands.

- **ACOP EXPRESS Rack Laptop Software**
  - ACOP and AMS-02 commanding capability.
  - Housekeeping and Science Data reception.
  - ACOP and AMS-02 monitoring and control capability.
  - Composed by Basic Software (providing transport layer) and Application Software (providing application layer).
Ground Software

• **EGSE Software**
  Basic Software for testing the ACOP Basic Software and Application Software for testing the ACOP Application Software supporting:
  - ACOP and AMS-02 commands generation and delivery
  - ACOP and AMS-02 house-keeping and health & status data acquisition
  - AMS-02 science data packets acquisition
  - AMS-02 format telemetry data packets simulation

• **Training Software**
  - Installed on Training Model
  - Developed as needed for training the ISS Crew and the ground personnel
# ACOP Mass Budget

<table>
<thead>
<tr>
<th>Item</th>
<th>Mass [Kg]</th>
<th>Contingency [%]</th>
<th>Mass with Contingency [Kg]</th>
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<tr>
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<td>FRONT PANEL</td>
<td>0.857</td>
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<td>0.943</td>
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<td>HANDLE</td>
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<td>0.359</td>
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<td>CHASSIS</td>
<td>8.91</td>
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<td>9.8</td>
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<td>SIDE PLATE</td>
<td>0.46</td>
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<td>BP FRAME</td>
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<td>HDD BACKPLANE</td>
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<td>10</td>
<td>0.22</td>
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<td>CONNECTORS, CABLES</td>
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# Storage Bag Mass Budget

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<th>Item</th>
<th>Mass [Kg]</th>
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<td>Padding</td>
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<td>2.2</td>
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<td>HRDL cable</td>
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<td>3.3</td>
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<td>Power cable</td>
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<td>0.66</td>
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<tr>
<td>Data cable</td>
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<td>ACOP-SBC</td>
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<tr>
<td>(20) Hard drives @ 1kg</td>
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<td><strong>Total</strong></td>
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## Power Budget Data

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<tr>
<td></td>
<td></td>
<td>Stand-by</td>
<td>Operative (average)</td>
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<tr>
<td>ACOP-SBC</td>
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<td>1.65</td>
</tr>
<tr>
<td>ACOP-T102</td>
<td></td>
<td>-</td>
<td>1.65</td>
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<tr>
<td>ACOP-T103</td>
<td></td>
<td>-</td>
<td>5.00</td>
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<td>ACOP-PS</td>
<td></td>
<td>-</td>
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<tr>
<td>ACOP-LCD (TBC)</td>
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<tr>
<td>HDD1</td>
<td>0.72</td>
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<td>12.54</td>
</tr>
<tr>
<td>HDD2</td>
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<td>-</td>
<td>12.54</td>
</tr>
<tr>
<td>HDD3</td>
<td>0.72</td>
<td>-</td>
<td>12.54</td>
</tr>
<tr>
<td>HDD4</td>
<td>0.72</td>
<td>-</td>
<td>12.54</td>
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## Power Budget Single HD

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<td>ACOP-SBC</td>
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<tr>
<td>ACOP-T101</td>
<td>1.65</td>
</tr>
<tr>
<td>ACOP-T102</td>
<td>1.65</td>
</tr>
<tr>
<td>ACOP-T103</td>
<td>5.00</td>
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<tr>
<td>Spare Slot</td>
<td>0.00</td>
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<tr>
<td>ACOP-PS</td>
<td>11.35</td>
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<tr>
<td>ACOP-LCD (TBC)</td>
<td>6.30</td>
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<tr>
<td>HDD1</td>
<td>8.20 (Estimated Duty Cycle)</td>
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</tr>
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<td>ACOP-T103</td>
<td>5.00</td>
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<tr>
<td>Spare Slot</td>
<td>0.00</td>
</tr>
<tr>
<td>ACOP-PS</td>
<td>11.35</td>
</tr>
<tr>
<td>ACOP-LCD (TBC)</td>
<td>6.30</td>
</tr>
<tr>
<td>HDD1</td>
<td>8.20 (Estimated Duty Cycle)</td>
</tr>
<tr>
<td>HDD2</td>
<td>8.20 (Estimated Duty Cycle)</td>
</tr>
<tr>
<td>HDD3</td>
<td>0.72</td>
</tr>
<tr>
<td>HDD4</td>
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<td><strong>Total</strong></td>
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