Introduction to AMS Operations

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Contents

• **Main Components of AMS** (Alpha Magnetic Spectrometer)
  • Subdetectors
  • Electronics

• **Communications Between Space and Ground**
  • ISS (International Space Station) Avionics
  • TDRSS (Tracking & Data Relay Satellite System)

• **Shift Positions in POCC** (Payload Operations Control Center)
  • Data / Lead / PM / TEE / SOC / Thermal
AMS (Alpha Magnetic Spectrometer)

Transition Radiation Detector

Silicon Tracker

Electromagnetic Calorimeter

Ring-Imaging Cherenkov Detector

Time of Flight

Magnet
List 1: AMS Subdetectors

• ACC: Anti-Coincidence Counter
• AMS: Alpha Magnetic Spectrometer
• ECAL: Electromagnetic Calorimeter
• RICH: Ring-Imaging Cherenkov Detector
• ToF: Time of Flight
• TRD: Transition Radiation Detector
• TRK: Silicon Tracker
List 2: AMS Electronics

- **AMSW:** AMSWire (Communication Protocol)
- **DAQ:** Data Acquisition
- **JINF-x:** Low Level DAQ Computer (See [x])
- **JINJ:** High Level DAQ Computer
- **JLV1:** Level 1 Trigger
- **JMDC:** Main Data Computer
- **x:** 
  
  - E=ECAL
  - R=RICH
  - S=ToF/ACC
  - T=TRK
  - U=TRD
- **xDR:** x Data Reduction (See [x])
List 2: AMS Electronics (Cont.)

- **CAN:** Controller Area Network *(Communication Protocol)*
- **GTSN:** Global Temperature Sensor Network
- **PDS:** Power Distribution System
- **TTCE:** Tracker Thermal Control Electronics
- **USCM:** Universal Slow Control Module
  - -J: JMDC Power
  - -M: Monitoring
  - -UG: TRD Gas
ISS Avionics

Acronyms:
- ACBSP = Assembly Complete Baseband Signal Processor
- ACRFG = Assembly Complete Radio Frequency Group
- APS = Automated Payload Switch
- C&CMOD = Control & Command MOD
- C&T = Communications & Tracking
- HCOR = High rate Communication Outage Recorder
- HRFM = High Rate Frame Multiplexer
- HRHG = Payload Ethernet Hub Gateway
- PLMMD = Payload Multiplexer-Demultiplexer (MEM)
- RTPC = Rack Interface Controller
- RPCM = Remote Power Control Module
- UIP = Utility Interface Panel

Notes:
1. All connection In/Out of APS are HBDL
2. APID naming:
   - 876 = HKLR/HKLC: ISS Housekeeping Data Low Rate (see 3.)
   - 976 = SCI : AMS Science Data
   - 977 = HKHR : AMS Housekeeping Data High Rate
   - 978 = SCTBPP : SCI buffered by AMS Laptop Playback
   - 979 = HKRPB : HKHR recorded by AMS Laptop Playback
   - 980 = P2PQ : Payload to Payload Request
   - 981 = P2PRP : Payload to Payload Reply
   - 982 = SCTBPP : SCI buffered in JBOX Playback (was APID=975)
   - 983 = HKRPB : HKHR buffered in JBOX Playback
   - 1355 = HKRPB : HKRPB recorded by AMS Laptop
   - 1354 = SCTBPP : SCIBPP recorded by AMS Laptop
3. 876 includes AMS and AMS Laptop Housekeeping Data Low Rate

A. Lebedev 13/07/05 (A. Basili mod. 22/01/12)
List 3: ISS Avionics

- ISS: International Space Station
- HRDL: High Rate Data Link
- LRDL: Low Rate Data Link
- Ku-band: Channel for AMS data downlink
- Ku-Fwd: Ku-Forward, access AMS Laptop (up/down)
- S-band: Channel for AMS command/data uplink
List 3: ISS Avionics (Cont.)

- **1553**: A data bus communication protocol
- **APS**: Automated Payload Switch
- **ER6**: Express Rack 6
- **PLMDM**: Payload Multiplexer-Demultiplexer
- **RIC**: Rack Interface Controller
TDRS: Tracking and Data Relay Satellite
GMT: Greenwich Mean Time
TDRS: Tracking and Data Relay Satellite
AOS: Acquisition of Signal
LOS: Loss of Signal
Ku-band (for AMS data downlink)
S-band (for AMS command & data uplink)
AOS/LOS

S -- T041 - 1:33

LOS ---- 3m

S+K T171 43m
List 4: ISS Communications

• **AOS:** Acquisition of Signal
• **LOS:** Loss of Signal
• **CDP:** Custom Data Packet
• **NASA:** National Aeronautics and Space Administration
• **OPTIMIS:** Operation Planning Timeline Integration System
• **PDSS:** Payload Data Service System
• **TDRS:** Tracking and Data Relay Satellite
• **TDRSS:** Tracking and Data Relay Satellite System
List 4: ISS Communications (Cont.)

• GSC: Ground Support Computers
• JSC: Johnson Space Center
• MCC: Mission Control Center
• MSFC: Marshall Space Flight Center
• NISN: NASA Integrated Services Network
• POIC: Payload Operations Integration Center
• SDIL: Software Development and Integration Laboratory
• WSGT: White Sands Ground Terminal
Shift Positions in POCC

- Data
- Lead
- PM (RICH, ToF, ECAL)
- TEE (TRD, TRK, TTCS, ACC)
- SOC
- Thermal
Shift Positions in POCC

• Data
• Lead
• PM (RICH, ToF, ECAL)
• TEE (TRD, TRK, TTCS, ACC)
• SOC
• Thermal
Data: AMS Data Streams

**JMDC**

**BLOCKs to FRAMEs**
- 4KB
- 4KB

**JBUX**
112GB
~ 1 Day

**AMS Laptop**
750 GB
~ 1 Week

**HRDL: High Rate Data Link**

**Connections**
- SCI
- HK
- HKLR
- HKHR
- HKBPB
- HKRBPB
- SCIBPB
- SCIRBPB
Data: AMS Data Streams

- Real-time
- Loss of Data
- Delay
- Complete Data if Ku available as scheduled
Data: AMS Data Streams

Expected Ku

Actual Ku

HKLR, HKHR

HKBPB, SCIBPB

HKRBPB, SCIRBPB

Unexpected Ku Outage

Missing Data
Data: AMS Data Streams

Expected Ku

Actual Ku

HKLR, HKHR

HKBPB, SCIBPB

HKRBPB, SCIRBPB

Playback Data from AMS Laptop
List 5: AMS Data Streams

- **HKLR:** Housekeeping Data Low Rate
- **HKHR:** Housekeeping Data High Rate
- **HKBPB:** HK Data Buffered (JBUX) Playback
- **HKRBPB:** HK Data Recorded (Laptop) BPB
- **SCIBPB:** Science Data Buffered (JBUX) Playback
- **SCIRBPB:** Science Data Recorded (Laptop) BPB
- **PB:** Playback
Data: AMS Laptop

• Missing Data Finding:
  HKBPB, SCIBPB

• Missing Data Playback:
  HKRBPB, SCIRBPB

• Monitor & Maintenance:
  • Laptop CHD (Critical Health & Status Data)
  • File Downlink
AMS Data Flow

Boxes:
- NASA Controlled
- AMS Controlled

Acronyms:
- APID = APlication ID
- APS = Automated Payload Switch
- CDP = Custom Data Packet
- CHD = Critical Health Data
- ER6 = Express Rack 6
- HOSC = Huntsville Operations Support Center
- HPOC = HOSC Power Off Configuration
- MCC = Mission Control Center
- PDSS = Payload Data Service System
- PIMDM = Payload Multiplexer-Demultiplexer
- POCC = Payload Operations Control Center
- RIC = Rack Interface Controller
- TDRSS = Tracking and Data Relay Satellite System
- WSGT = White Sands Ground Terminal

APIDs:
- 876 = HKLR/HKALC
- 981 = P2PRP
- 976 = SCI
- 982 = SCIBPB
- 977 = HKHR
- 983 = HKBPB
- 978 = SCIRPB
- 981 = HKRBP
- 876 contains both AMS and Laptop Housekeeping Low Rate data in the form of CDP.

CHD is in HK[LH]R, and is also available via S-Band Dump on contingency

(mod 18/01/12)
M.Krafczyk 10/01/12
AMS: BLOCKs to FRAMEs

**Boxes:**
- NASA Controlled =
- AMS Controlled =

**Acronyms:**
- APID = APllication ID
- APS = Automated Payload Switch
- CDP = Critical Data Packet
- CHD = Critical Health Data
- ER6 = Express Rack 6
- HOSC = Huntsville Operations Support Center
- HPOC = HOSC Power Off Configuration
- MCC = Mission Control Center
- PDSS = Payload Data Service System
- PIMEM = Payload Multiplexer-Demultiplexer
- POCC = Payload Operations Control Center
- RIC = Rack Interface Controller
- TDRS = Tracking and Data Relay Satellite System
- WSGT = White Sands Ground Terminal

**APIDs:**
- 876 = HKLR/HKLAC
- 981 = P2PRP
- 976 = SCI
- 982 = SCIRBP
- 977 = HKHR
- 983 = HKBPP
- 978 = SCIRPB
- 1354 = SCIRBPB
- 979 = HKRPP
- 1355 = HKRPPB
- 980 = P2PRQ

876 contains both AMS and Laptop Housekeeping Low Rate data in the form of CDP.

CHD is in HK[LH]R, and is also available via S-Band Dump on contingency.

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Data: Sequence Error

• Sequence Number:
  • Frame 1, Frame 2, Frame 3, Frame 4, Frame 5, ...

• Sequence Error:
  • Frame 1, Frame 2, Frame 3, Frame 5, Frame 6, ...
AMS Data Flow

Boxes:
NASA Controlled =
AMS Controlled =

Acronyms:
APID = Application ID
APS = Automated Payload Switch
CDP = Custom Data Packet
CHD = Critical Health Data
ER6 = Express Rack 6
HOSC = Huntsville Operations Support Center
HPOC = HOSC Power Off Configuration
MCC = Mission Control Center
PDSS = Payload Data Service System
PLMDM = Payload Multiplexer-Demultiplexer
POCC = Payload Operations Control Center
RIC = Rack Interface Controller
TDRSS = Tracking and Data Relay Satellite System
WSGT = White Sands Ground Terminal

APIDs:
876 = HKLR/HKALC
981 = P2PRP
976 = SCI
982 = SCIBPP
977 = HHR
983 = HKBBP
978 = SCIRPB
1354 = SCIRBBP
979 = HKBBP
1355 = HKBBPP
980 = P2PRQ
876 contains both AMS and Laptop Housekeeping Low Rate data in the form of CDP.

CHD is in HK[LH]R, and is also available via S-Band Dump on contingency

(mod 18/01/12)
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List 6: Connections to NASA

- HOSC: Huntsville Operations Support Center
- FEP: Front-End Processor
- RIC: Rack Interface Controller
- HOSCfep: Commands to AMS
- HOSCfepRIC: Commands to AMS Laptop
- ERIS: EHS Remote Interface Servers
  (EHS = Enhanced HOSC System)
AMS Data Flow

Boxes:
NASA Controlled =
AMS Controlled =

Acronyms:
APID = Application ID
APS = Automated Payload Switch
CDP = Custom Data Packet
CHD = Critical Health Data
ER6 = Express Rack 6
HOSC = Huntsville Operations Support Center
HPSC = HOSC Power Off Configuration
MCC = Mission Control Center
PDSS = Payload Data Service System
PLMDM = Payload Multiplexer-Demultiplexer
POCC = Payload Operations Control Center
RSIC = Rack Interface Controller
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APIDs:
876 = HKLR/HKALC
981 = P2PRP
976 = SCI
982 = SCIBPB
977 = HKHR
983 = HKBPB
978 = SCIRPB
1354 = SCIRBPB
979 = HKPBP
1355 = HKRPB
980 = P2PRQ
876 contains both AMS and Laptop Housekeeping Low Rate data in the form of CDP.

CHD is in HK[LR]R, and is also available via S-Band Dump on contingency

(mod 18/01/12)
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List 7: Servers and Consoles

- \texttt{pcgsc[50,51,52,53]} \textbf{Servers @ GSC}
- \texttt{pcposp[0,1]} \textbf{Servers @ POCC}
- \texttt{pcposc[0,1]} \textbf{Servers @ Backup POCC}
- \texttt{pcposj[0,1]} \textbf{Servers @ JSC}
- \texttt{pcpost[0,1,...]} \textbf{Servers @ Taiwan}
- \texttt{pcpocNN} \textbf{Consoles}
- \texttt{epvtNNX} \textbf{External Private Servers}
Shift Positions in POCC

• Data
• **Lead**
• PM (RICH, ToF, ECAL)
• TEE (TRD, TRK, TTCS, ACC)
• SOC
• Thermal
Lead: IVoDS (Internet Voice Distribution System)

POD (Payload Operations Director)
PRO (Payload Rack Officer)
DMC (Download Management Control)
OC (Operations Controller)
M-DATA (Marshall Data)

AMS LEAD
AMS DATA

ASIA PM
ASIA TEE

Geneva
Taiwan
Marshall
List 8: IVoDS

• DMC: Download Management Control
• **IVoDS:** Internet Voice Distribution System
• M-DATA: Marshall Data
• OC: Operations Controller
• POD: Payload Operations Director
• PRO: Payload Rack Officer
Lead: Orbital Operations

• 1 Orbit ≈ 93 min
• ½ Orbit ≈ 46 min
  • Calibration
  • DSP Test
  • DSP Auto-fix
• ¼ Orbit ≈ 23 min:
  • New DAQ Run
  • DSP Test
Lead: DAQ

Calibration
New Run

New Run
Lead: DAQ

SAA: South Atlantic Anomaly
Lead: DSP Test

- Test: CRC check for the program memories.
  - CRC = cyclic redundancy check
- If failed: reboot, load files from the flash memory
  - Automatic fix: when crossing the equator
  - Manual fix: occasionally (e.g., failed to auto-fix)
Lead: DSP Test

DSP Test

DSP Test

DSP Auto-fix
Lead: TQ-list = Time-Based Q-list

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<tr>
<th>Time</th>
<th>Description</th>
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</thead>
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<tr>
<td>00 062.16:11:34 01:32:35 Rq</td>
<td>WA=W14=JMC-itself DT=1F058B Execute Command File DC=14 2020...</td>
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<td>WA=W10=JMC-HRDL DT=1F05A5 JBOX Tasks Control DC=2 0300</td>
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</table>
## Lead: TQ-list = Time-Based Q-list

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<tr>
<th>Item Number</th>
<th>Number (+/- for Enabled/Disabled)</th>
<th>GMT Time</th>
<th>Repeat Time</th>
<th>Read/Write Request</th>
<th>Who does What</th>
<th>Data Count &amp; Data</th>
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<td>DAQ</td>
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<tr>
<td>Item 1</td>
<td>062.16:34:42 01:32:35</td>
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<td>NA=014=MDC-itself DT=1F058B Execute Command File DC=14 2020...</td>
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<tr>
<td>Item 2</td>
<td>062.16:57:50 01:32:35</td>
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<td>Item 11</td>
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<td>Item 12</td>
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</tr>
<tr>
<td>Item 13</td>
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<td>Item 14</td>
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Lead: CQ-list = Counter-Based Q-list

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**Lead: CQ-list = Counter-Based Q-list**

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<th>Item Number</th>
<th>Repeat Counter</th>
<th>Read/Write Request</th>
<th>Who does What</th>
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Lead: Daily & Monthly Operations

• Every Day:
  • TAS (Tracker Alignment System) Run
  • Synchronize JMDC with GPS (Global Positioning System)

• Every Month:
  • Reload JAP (JMDC Applications)
Lead: CHD = Critical Health Data

Pages:
05: JMDC status
06/07: LRDL/HRDL settings
09: DAQ status
10: JBUX status
11: Level-3 Trigger status
12: PDS status
13: GTSN status
15: TTCS status
16/17: 8 Important Temperature Sensors
21: HRDL Rate

Status:
AL: Master Alert
PS: Power Step
HA: HRDL Active
HO: HRDL Owner
MA: Monitoring Active
MO: Monitoring Owner
LA: LRDL Active
LO: LRDL Owner
DA: DAQ Active
DO: DAQ Owner

Soft  HB  FC  ID  AL  PS  HA  HO  MA  MO  LA  LO  DA  DO  TMD

[02-21(052) 20:07:39] JAP : 163 102 3 0 5 1 3 1 3 1 3 1 3 [3]: stat: wdt time stdout=0 pwr=doze, days=24 qlist=21 tlist=20
[02-21(052) 20:07:40] JAP : 164 102 3 0 5 1 3 1 3 1 3 1 3 [3]: trol: isl: rl=21 bus=a tx=164 err=3
[02-21(052) 20:07:41] JAP : 165 102 3 0 5 1 3 1 3 1 3 1 3 [3]: hrdl: out/hrdl rx=203 tx=184 err=0, sci->jbxh nkh->both, signal: hrdl sync
[02-21(052) 20:07:42] JAP : 166 102 3 0 5 1 3 1 3 1 3 1 3 [3]: cmsd: hrdl=0 iss=25 std=0 nasa=0
[02-21(052) 20:07:43] JAP : 167 102 3 0 5 1 3 1 3 1 3 1 3 [3]: daq: evt=0 size=2.0KB, step=7, good for calib, elist=0
[02-21(052) 20:07:44] JAP : 168 102 3 0 5 1 3 1 3 1 3 1 3 [3]: jbxh: remain=04 jbxh=14 hrdl=104 ready, ins out era, playback=0
[02-21(052) 20:07:45] JAP : 169 102 3 0 5 1 3 1 3 1 3 1 3 [3]: \lv3: err=2 time=114us comp=20%
[02-21(052) 20:07:46] JAP : 170 102 3 0 5 1 3 1 3 1 3 1 3 [3]: pds: bus A & B, watts=1399, Thigh=44C @ B-83, USCM=A
[02-21(052) 20:07:47] JAP : 171 102 3 0 5 1 3 1 3 1 3 1 3 [3]: gtsn: over: a=0 w=0, under: a=0 w=6, highest=36, lowest=-11
[02-21(052) 20:07:48] JAP : 172 102 3 0 5 1 3 1 3 1 3 1 3 [3]: wug: ok
[02-21(052) 20:07:49] JAP : 173 102 3 0 5 1 3 1 3 1 3 1 3 [3]: ttcv: min=3, max=19, Pump: PB
[02-21(052) 20:07:50] JAP : 174 102 3 0 5 1 3 1 3 1 3 1 3 [3]: gmon: t0=1 t1=12 t2=15 t3=27
[02-21(052) 20:07:51] JAP : 175 102 3 0 5 1 3 1 3 1 3 1 3 [3]: gmon: t4=0 t5=15 t6=-9 t7=-11
[02-21(052) 20:07:51] JAP : 176 102 3 0 5 1 3 1 3 1 3 1 3 [3]: rate: HRDL rate: set=17.00mbps output=16.68mbps

02-21(052) 20:07:39 02-21(052) 20:07:40 02-21(052) 20:07:41 02-21(052) 20:07:42 02-21(052) 20:07:43 02-21(052) 20:07:44 02-21(052) 20:07:45 02-21(052) 20:07:46 02-21(052) 20:07:47 02-21(052) 20:07:48 02-21(052) 20:07:49 02-21(052) 20:07:50 02-21(052) 20:07:51
List 9: AMS Operations

• CAL: Calibration
• CHD: Critical Health & Status Data
• CQ-list: Counter-Based Q-list
• DSP: Digital Signal Processor
• GPS: Global Positioning System
• JAP: JMDC Applications
• SAA: South Atlantic Anomaly
• TAS: Tracker Alignment System
• TQ-list: Time-Based Q-list
Shift Positions in POCC

• Data
• Lead
• PM (RICH, ToF, ECAL)
• TEE (TRD, TRK, TTCS, ACC)
• SOC
• Thermal
PM & TEE: Most Reported

- **ECAL:** High Occupancy
- **RICH:** High Occupancy / Bad Hit / Bad Status
- **TRD:** High Voltage Intercalibration / Gas Refill
- **TRK:** Bit Upset
- **TTCS:** Pump Spike
  (TTCS = Tracker Thermal Control System)
High Occupancy

- PMT: Photomultiplier Tube (sensitive light detector)
TRD: High Voltage & Gas

• Every Day: HV (High Voltage) intercalibration
• Every Month: Gas refill

Filled with Gas (Xe & CO₂)
TTCS: Pump Spike – Death of Pump PA
TTCS: Pump Spike – Less Readouts (old)
TTCS: Pump Spike – More Readouts (new)
TTCS: Pump Spike – Protection
Shift Positions in POCC

- Data
- Lead
- PM (RICH, ToF, ECAL)
- TEE (TRD, TRK, TTCS, ACC)
- **SOC**
- Thermal
SOC = Science Operations Center

- Frames
  - Preproduction
  - RAW
    - ROOT(DST)
      - Validator
      - Uploader

- CASTOR
- CASTOR Facilities

- DATABASE ORACLE(PDBR)
- Web Server
- Production Server
  - AMS Cluster (PBS)
  - CERN lxbatch (LSF)

- Operators
- Remote Computing Facilities
  - Remote Centers
    - Data
    - Meta-data / Control

- ROOT(DST)
- (Producer)
SOC: Event Display
SOC: SCIRBPB Data from Laptop

1.  [Data]  Missing data finding

2.  [Data]  Missing data playback (from Laptop)

3.  [SOC]  Missing data merging
Shift Positions in POCC

- Data
- Lead
- PM (RICH, ToF, ECAL)
- TEE (TRD, TRK, TTCS, ACC)
- SOC
- Thermal
Thermal: Temperature Sensors

• 1180 Temperature Sensors
  • TRD Gas Box-C Canister
  • Tracker Plane 1
  • TTCB
  • Lower ToF PMT305p2
  • PDS-D
  • ...
Thermal: ISS Attitudes – β Angle
Thermal: ISS Attitudes – β Angle
Thermal: ISS Attitudes – Directions
Thermal: ISS Attitudes – Directions
Thermal: ISS Attitudes – Rotary Joints
Thermal: ISS Attitudes – Programs
List 10: ISS Attitudes

• $\beta$ angle
• Starboard / Port
• Ram / Wake
• $[X,Y,Z]$VV $[X,Y,Z]$-axis in the Velocity Vector
• $[S,P]$SARJ: $[\text{Starboard,Port}]$ Solar Array Rotary Joint
• $[S,P]$TRRJ: $[\text{Starboard,Port}]$ Thermal Radiator Rotary Joint