

## **AMS Ground Support Computers For ISS mission.**

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### **Abstract**

The AMS02 detector is scheduled to begin to take data on board of the ISS in the fall of year 2005 for three consecutive years. Requirements to the AMS Ground Support Computers (GSC) at Marshall Space Flight Center (MSFC), event storage and data transmission are discussed, possible solution and system architecture are presented.

# 1 Introduction

The AMS02 detector is scheduled to begin to take data in the fall of year 2005 and continue to operate thru the year 2009. Facing increased complexity of the detector and the outstanding long run as well as changing the NASA concept of data access from the Payload Operation and Control Centers (POCC) [1, 2, 4] it requires a new philosophy of AMS Ground Support Computers and Equipment (abbreviated GSC and GSE in this document).

GSC will be located in the Huntsville Operations Science Center (HOSC) at MSFC and will be controlled and maintained by the AMS collaboration (see section Maintenance and responsibilities). These computers will have the following specific duties:

- Receive high rate, low rate and ancillary AMS data from POIC facilities (fig.1), remove various NASA headers and store data on local disks at sustained rate is 2 MB/s is foreseen and disk space for 2 weeks (approx. 0.5 TByte including data mirroring) is planned. These disks are to act as a local buffer, not long term storage.
- Retransmit all data to remote centers (AMS POCC and AMS Science Operation Center), and data will be stored permanently in SOC. The retransmission is not synchronised to the incoming data, allowing for varying transmission rates between MSFC and the remote center. Retransmission will be over the Internet using Internet conventional protocols such as FTP.

The AMS commanding and “real-time” monitoring will be based on TReK SW and done directly from AMS POCC [5, 6].

Other science and monitoring sites will receive their data from AMS Science Operation Center; the POIC computer is a front-line machine whose primary function is as an interface, not a server. As the POIC computer must operate autonomously (an AMS collaborator on continuous duty at MSFC is not foreseen), there will be a warm backup computer in the HOSC.

## 2 AMS02 GSC Data Volume

AMS02 will have 2 MBit/sec (orbit average) bandwidth from ISS to the ground. Table 1 shows the AMS02 related data transmitted to POCC and SOC.

Stream	Bandwidth	Volume (GB/day)	Volume (GB/month)	Volume (TB/year)
Science Data	2 Mbit/s	22	660	8
Slow Control				
NASA ancillary				

Table 1: AMS02 Data Volumes

The data is transferred typically twice, i.e. to both POCC and SOC. Keeping in mind the possible network and computer failures, line unavailability we are adding 100% contingency. This means the line between MSFC and AMS centers must operate with the speed at least 6 MBit/sec.

## 3 Possible Solution

The AMS-02 High-Rate Data Link Ground Support Equipment will be based on commercial off-the-shelf (COTS) PC computers running Linux.

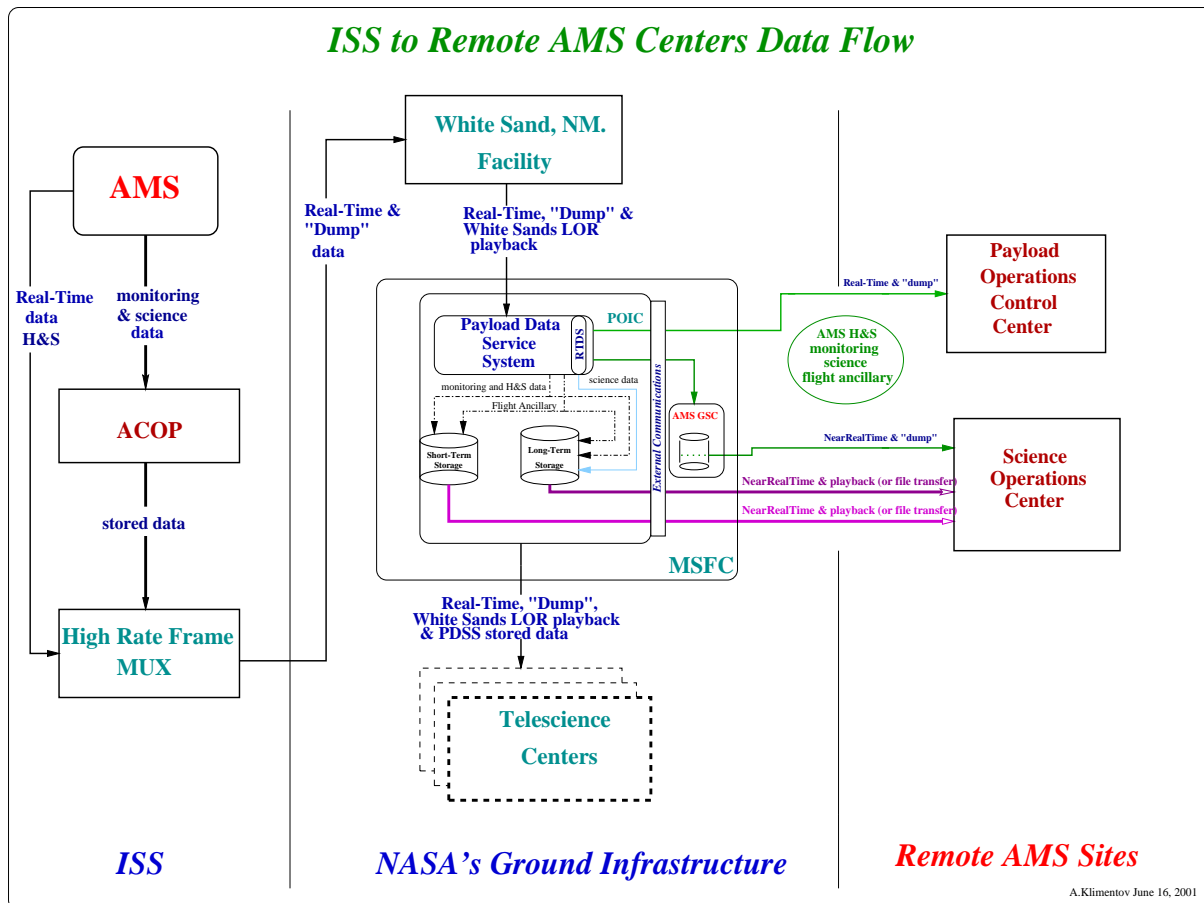


Figure 1: AMS02 Data Flow

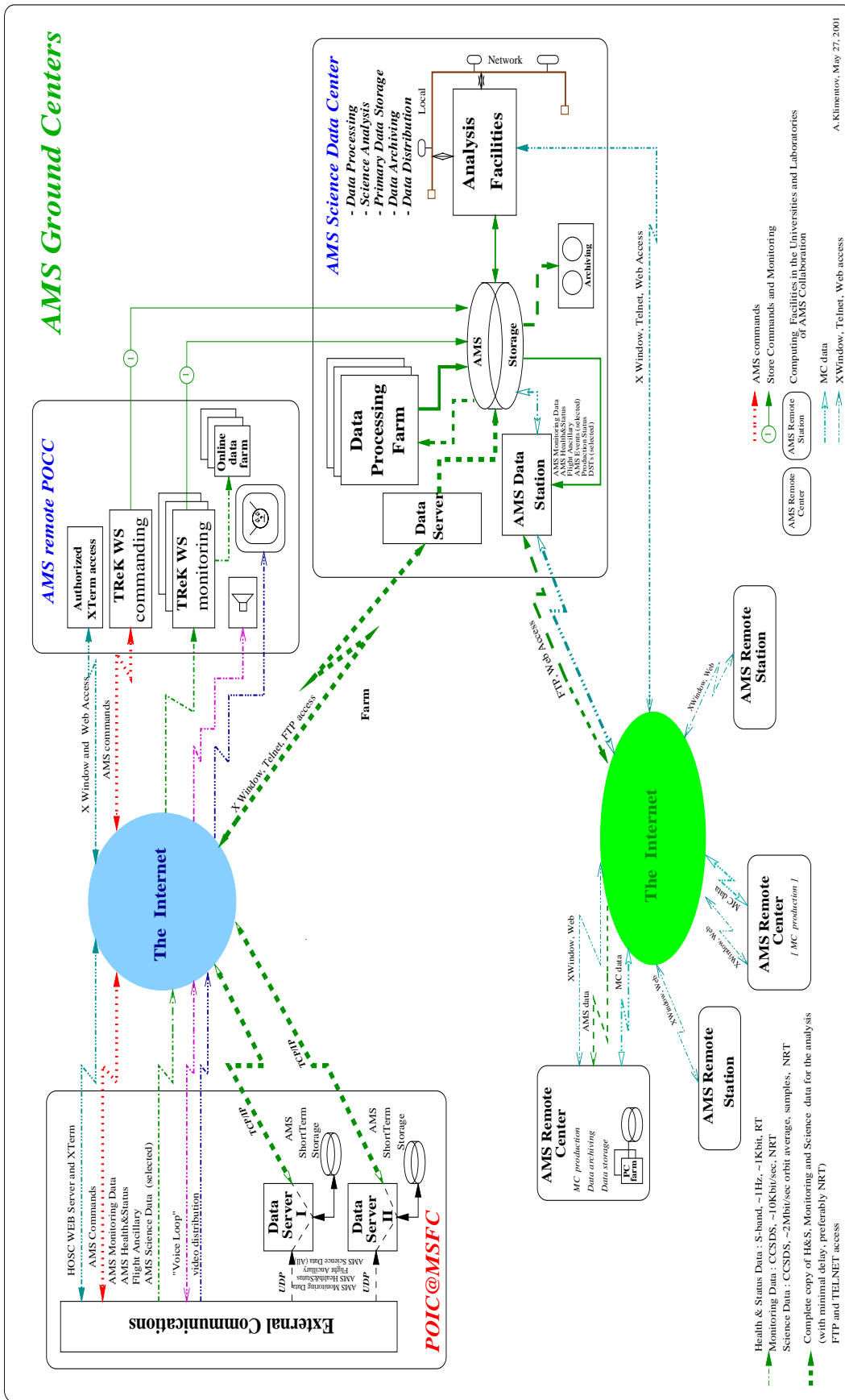


Figure 2: AMS02 Data Flow

## GSE Architecture

Physically, the COTS PCs will be no larger than 220x484x650mm (8.7x19x26in) and weight no more than 27kg (60lbs) each. The units can be either free-standing or 19" rack-mountable (rack not provided by AMS).

The power requirements will be less than 500 W each of 100–240 VAC at 60/50 Hz with UL listed and CE and VDE approved power supplies. A single standard PC display monitor (15"–19", CRT or LCD) plus a keyboard/mouse can optionally be attached (either directly or with a display/keyboard switching unit) but the GSE can be operated without any of these.

No special AC power supply requirements are set by GSE, i.e. they are tolerant of power failures and start automatically upon power restoration. If deemed necessary, each PC may be supplemented (by HUT) by a small UPS power device not exceeding 100x200x300mm (4x8x12in) and 13kg (30lbs). (The devices use maintenance-free sealed lead-acid batteries with leak-proof suspended electrolyte.)

Redundancy is provided in the form of 3 identical GSE PC units, of which two are up and running concurrently. The same data stream is made available to both of the running GSE computers which both make an identical disk recording on their hard disks. Should one GSE PC fail, the second on-line unit continues to operate while the failed GSE PC is being replaced. (See section maintenance details.)

The GSE PCs have AMD Athlon 2 GHz-class processors, 512 MB (or more) of main memory, and up to four internal IDE hard disks each. (This disks may be enclosed in removable cartridges, but not necessarily.) A minimum of approximately 300 GB of disk space is provided by each GSE PC, translating to approximately 330 hours of AMS-02 data buffer time, i.e. about 14 days. This time should prove sufficient to resolve Internet-related problems and GSE hardware failures.

For connecting to the Internet, the GSE PCs provide a standard bidirectional 10/100Mbit/s Ethernet connection (100Base-TX, RJ45) running the standard Linux kernel (2.2.x/2.4.x or later) TCP/IP protocol stack with standard TCP services. Only those services agreed upon by MSFC and AMS collaboration will be enabled by default. Managing Internet service software security and updates is described in section Maintenance.

MSFC internal data distribution network is protected by providing an unidirectional interface from RTDS→GSE. This interface is TBD (see section 4 about POIC→GSE interface) but unidirectionality is a probable "designed-in" property of the interface.

The volume of Internet traffic generated by the connection of AMS GSE Linux computers to MSFC Internet gateway will be limited to a small multiple of 2 Mbits/s (24h/7d). This constraint is imposed by the limited average/sustained bit rate of 2 Mbits/s guaranteed to the AMS-02 experiment. This flow of data is necessarily transferred at least once (but probably twice, on the average) from MSFC POIC to both AMS Science Operation Center and AMS Payload Operation Control Center. The current plan to have two AMS centers combined with up to 100% of retransmissions result in an estimated upper limit of 6 Mbits/s sustained Internet bandwidth requirement by AMS-02.

## 4 AMS→MSFC POIC interfaces

Our current understanding of the MSFC POIC PDSS RTDS real-time telemetry interface is based on the following documents:

1. SSP 50304 Rev A, POIC Capabilities, section 5.4, Real-time Telemetry Interface, and section 5.5, Real-time Extracted Telemetry Services.
2. SSP 50305 Rev B, POIC to Generic User IDD, section 8.0, Telemetry Protocols.
3. SSSP 52000-PDS Rev C, Payload Data Sets Blank Book, section 5.3.2, Real-time Requirements.

More specifically, we have interpreted items 1 and 2 above to mean that AMS science and health and status data arrives as PDSS CCSDS packets encapsulated with EHS protocol into UDP packets. We are assuming that the EHS formats are described in section 8.1 of item 2 and PDSS CCSDS packets in section 8.2.

The role of the “extracted” telemetry interfaces (section 5.5 in item 1) is not clear to us. Currently we are interpreting that telemetry items which should be accessible using TReK must be defined in PDL (item 3) and that these can then additionally be assembled into GSE packets which are in format described in item 2 section 8.6, “Ground Support Equipment Packet Protocol”.

Thus we are assuming that we can receive AMS science telemetry data using UDP packets in formats specified in PGUIDD (item 2 above). Alternatively we are prepared to receive any frame-formatted serial bit stream data at rates up to 50 Mbits/s.

## 5 Maintenance and responsibilities<sup>1)</sup>

The AMS HRDL GSE maintenance responsibilities can be divided as follows for the duration of AMS-02 ISS mission.

- MSFC:
  - Switch on and/or off the on-line AMS HRDL GSE PC 1 and/or GSE PC 2 based on (an email? call?) request from AMS POCC shift leader and who can coordinate requests from the AMS collaboration.
  - Disconnect GSE PC(s) from MSFC POIC RTDS data supply interface if MSFC deems it necessary.
  - Disconnect GSE PC(s) from MSFC Internet gateway if MSFC deems it necessary. (Suspected malfunction, security problem, etc.)
- MIT:
  - Disconnect/reconnect GSE PC(s) from/to MSFC interfaces.
  - Verify nominal operation of GSE PCs using available indicators such as a reference display monitor output or similar.
  - Swap an offline GSE PC into a online PC.

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<sup>1)</sup>Data Handling during AMS integration, pre-flight tests and shuttle part of AMS02 mission are described elsewhere

- Ship failed PCs to HUT for repairs; unpack and install replacements.
- SW development for data transmission to AMS remote sites.
- installation of GSC test-bed PC at MSFC
- HUT:
  - System architecture design, including dedicated data acquisition hardware if needed.
  - Pre-flight tests.
  - SW development to retrieve data from POIC.
  - Repair failed PCs at HUT and ship them back to MSFC for MIT unpacking.
  - Remotely apply Internet networking security updates to on-line GSE PCs.
  - If the steps above are not adequate to correct a GSE problem, arrange MSFC on-site assistance.
- LMES:
  - Coordinate updating of PDL database

## 6 Implementation plan and milestones

Year	Action
March 2002	current note release
April 2002	Feedback from MSFC personnel
May 2002	AMS/NASA meeting at MSFC and test-bed GS computer (provided by MIT) installation at MSFC
	MSFC→MIT, MSFC→CERN data transmission tests
	Approval GSC@MSFC concept by the AMS Collaboration
beg 2003	put AMS information into POIC database
	POIC → AMS GSC tests
end 2003	POIC → AMS GSC → MIT/CERN tests
2004	AMS ready for ACOP→ POIC → AMS GSC → MIT/CERN tests
L-9 months	Final version of AMS GSC and SW installation at MSFC

Table 2: Milestones for AMS GSC tests

## 7 Conclusion, action items and questions

AMS GSC at MSFC architecture and functions are defined, the implementation plan and milestones are proposed.

- Access to '<https://red-dwarf.msfc.nasa.gov>' (urgent need to get up-to-date copies of POIC Capabilities Document(SSP 50304) and POIC to Generic User IDD (PGUIDD) (SSP 50305))

- MSFC response on AMS way of data handling and RTDS/POIC data access is needed, especially if our interpretation of the available interfaces is correct.
- MSFC specification of telemetry data stream format.

## References

- [1] POIC Capabilities Document. International Space Station Program. SSP 50304 Revision A, October 1999.
- [2] POIC to Generic User Interface Definition Document. International Space Station Program. revision B. SSP 50305, December 2000.
- [3] Payload Data Sets Blank Book. International Space Station Program. revision C. SSP 52000-PDS, August 2001.
- [4] C.Lapenta, talk given at MSFC May, 2001. AMS TIM;
- [5] M. Schneider, et al. "TReK User Guide (Beta Release C)", TREK-USER-001, Dec. 15, 1999.
- [6] P. Fisher and A. Klimentov "Ground Data Handling For AMS02 ISS mission.", AMS note 2002\_05\_02;