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AMS-02 POCC and SOC : Implementation Plan

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Abstract

This document provides a description and the implementation plan of the AMS Payload Operations and Control Centre (POCC) and the Science Operations Centre (SOC) within the framework of the AMS-02 data handling scheme.

The Payload Operations and Control Centre (POCC) performs the operation, control and monitoring of the AMS-02 detector on the space station. The Science Operations Centre (SOC) is the hub for processing and storing the AMS-02 detector data coming from the space station. POCC and SOC will be located at the basement of building 892 at CERN-Prevessin and will be in continuous operation throughout the mission (> 3 years).

1 Introduction

The design of the AMS-02 data handling scheme has to comply with the requirements of a long run of a complex detector on the space station. The design follows the guidelines provided by the NASA concept of data access from the Payload Operation and Control Centers (POCC) and incorporates the specific characteristics of the AMS project.

For AMS-02, the ground computing system [1] is conceptually divided into AMS Ground Centers:

- Ground Support Computers [2] (GSC at MSFC Huntsville AL): receive monitoring and science data from POIC[1]; buffer science, housekeeping and NASA ancillary data for transmission to Payload Operations and Control Center. Two redundant GSC units will be running at MSFC.
- Payload Operations and Control Center (POCC): where AMS operations take place, including commanding, storage and analysis of housekeeping data and partial science data analysis for rapid quality control and feedback.
- Science Operations Center (SOC): receives and stores all AMS science and housekeeping data, as well as ancillary data from NASA, ensures full science data reconstruction, calibration and alignment; archives all data and keeps data available for physics analysis.

[1] Payload Operations and Integration Center at NASA's MSCF.

- Regional Centers (RC) contain analysis facilities to support physicists from geographically close AMS universities and laboratories, RC also provide access to the AMS-02 data for visualization, detector verification studies and status of data processing. In addition, RC constitute the processing sites for the AMS-02 Monte Carlo production as well as AMS-02 Data reproductions.

The POCC and SOC are being set-up at the basement of building 892 (CERN-Prevessin), close to the AMS-02 detector integration facility. A backup POCC will be temporarily moved to KSC together with the detector itself for the pre-flight tests, then to JSC for the detector activation period. After successful installation on ISS and running-in of the experiment for 2-3 months, the backup POCC at JSC will be cold spared and CERN POCC will take over. The data transmission and operations issues during JSC phase of the AMS-02 ISS mission were discussed in [3]. In this note, we provide a complete description and the implementation plan of the POCC and SOC at CERN.

This note is organized as follows, we first provide a short description of the AMS data handling scheme, including AMS-02 data flow from ISS to ground centers, the data processing and storage strategy and the offline data production and analysis. We then describe of the POCC and SOC facilities at CERN, the power and network requirements and the implementation plan. The requirements and implications to CERN-IT are summarized in the last section.

2 AMS-02 Data Handling Scheme

The resources of the AMS Ground Centers (CPU power, storage capabilities, network connectivity...) are defined by the specificities of the AMS-02 experiment regarding

- Commanding and control
- Data flow from ISS to ground
- Online monitoring
- Offline production
- Data storage, archiving and distribution
- Science analysis
- MC production

In this section we provide the key parameters which define the resources to be allocated to the AMS POCC and SOC.

2.1 Commanding and Control

The AMS-02 detector commanding and control will be done from the POCC with the use of POCC consoles connected to a front-end processor (FEP). For ISS operations, one GSC at MSFC will operate as FEP.

2.2 AMS Data Flow

The AMS-02 data flow from ISS to ground centers is shown in Fig 1. The communication between MSFC and AMS computers at CERN is shown in Fig 2.

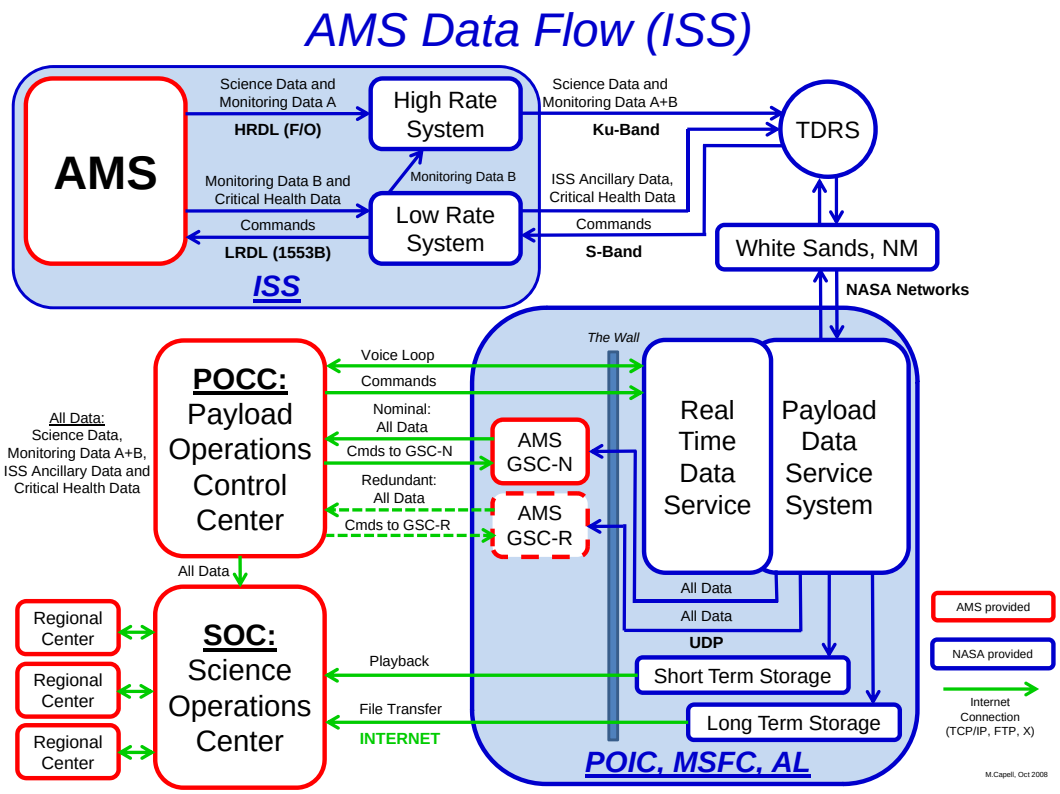

Figure 1: AMS-02 Data Flow.

2.3 Raw Data Volumes

The data volume transmitted from ISS to ground is assumed to be of 4 Mbit/s average. In addition to the science data, 1kbit/s of health and status data are received in real time. Data are buffered at POIC and transmitted in real time to POCC and SOC.

The total amount of raw data transmitted to POCC and SOC is estimated to be 15 TBytes/year.

2.4 Data Transfer and Networking

The POCC/SOC internet network must ensure the transmission of the AMS-02 raw data from POIC at MSCF, the distribution of the raw and processed data and the collection of the Monte Carlo production from the AMS-02 RC.

Keeping in mind a 50% contingency for the possible network and computer failures or line unavailability, the line between MSFC and AMS centers must operate at a speed above 6 Mbit/sec, which is within the reach using the current public Internet link between USA and Europe [4].

SOC connectivity with AMS-02 RC must ensure the collection of the MC files produced at the RCs (∼90 TBytes/year) and the distribution of raw and processed data files (∼80 TBytes/year). A Data Transfer (DT) system [5] has been implemented by INFN-Milano Bicocca to perform these tasks. The DT system is already in use to transfer MC data from several AMS-02 RCs. The throughput achieved between CERN and a single RC (∼50 Mbit/s) already fulfills requirements for the full MC production transfer. This result also guarantees that complete copies of the

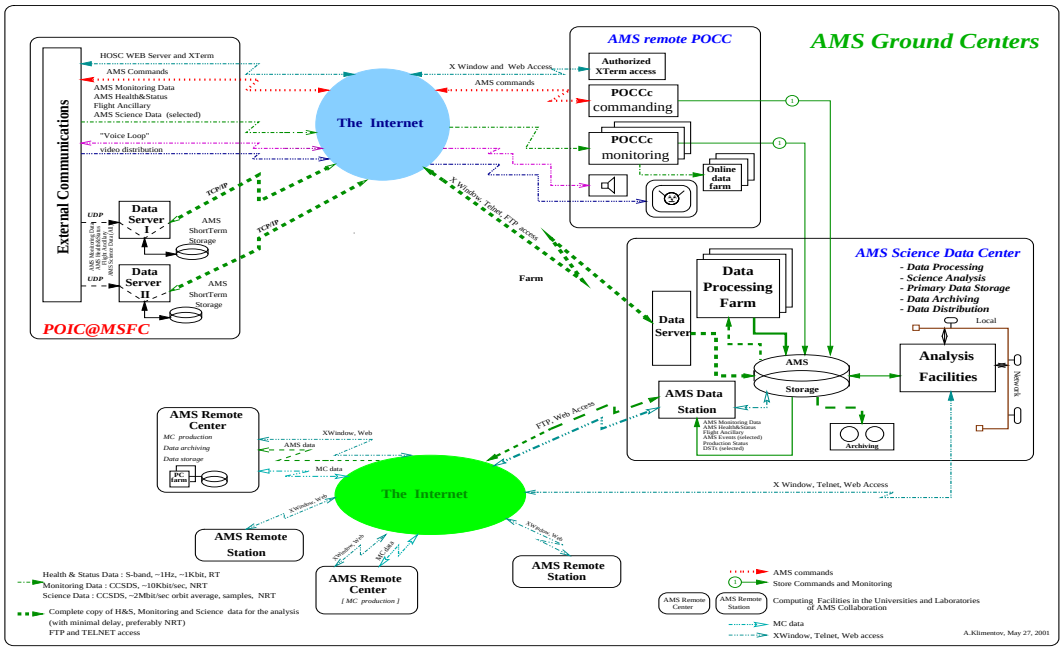

Figure 2: AMS-02 Ground Centers (adapted from [2]).

raw and processed data can be distributed to all RCs.

2.5 Online Monitoring

The online monitoring task will be performed at POCC. It will require the full reconstruction of approximately 10% of the AMS data typically within one hour after its arrival to POCC. The data production at POCC will consist in a small scale replica of the offline data production.

2.6 Offline Production

The full reconstruction of 100% of the events will be performed at SOC in near to real time, i.e., with a typical time delay of less than one day. In addition to this initial production, few data reproductions are foreseen.

The reconstruction event rate for AMS-02 is expected to be around 5 Hz on a 3GHz processor core [6]. For an expected average event rate of 250 Hz [7] ∼50 3GHz equivalent CPU cores are needed to cope with data production.

The solution adopted in AMS-02 is an homogeneous farm containing 8 production nodes, each one consisting in a Dell PowerEdge 1950 III server with two quad-core Intel Xeon 2.66GHz processors. More nodes may be purchased in case of necessity.

2.7 Data Storage, Archiving and Distribution

Access to all data will be granted to the AMS institutes. The design of the data storage and archiving architecture must fulfill this requirement in an efficient and reliable implementation.

In AMS, all the calibration information, raw data, Event Summary Data (ESD) and MC files will be on direct access disks at any time. This will require about 170 TBytes of disk space per year of operation.

The storage solution for AMS is provided by 4 RAID-6 redundant FC2SATA disk arrays with a total storage capability up to 500 TBytes. Each array may consist of a iStor 4920 24-Bay RAID server with 4 × 2200 16-Bay expansion subsystems and a storage capability of 126 TBytes. The arrays will use GFS shared filesystem which will allow the direct access to the data from any AMS cluster node equipped the FC2PCI HBA. To provide NFS access to any node of the AMS cluster, 4 dedicated file servers, each one consisting of a Dell PowerEdge 2950 III server with two quad-core Intel Xeon 3+GHz processors, will be used. The file servers will also provide the redundant cpu power to (re)reconstruct the AMS-02 data as well as will serve as batch machines for the AMS physics analysis. The scheme of the SOC interconnection layout using 2 Fiber Channel switches is shown in Fig. 3.

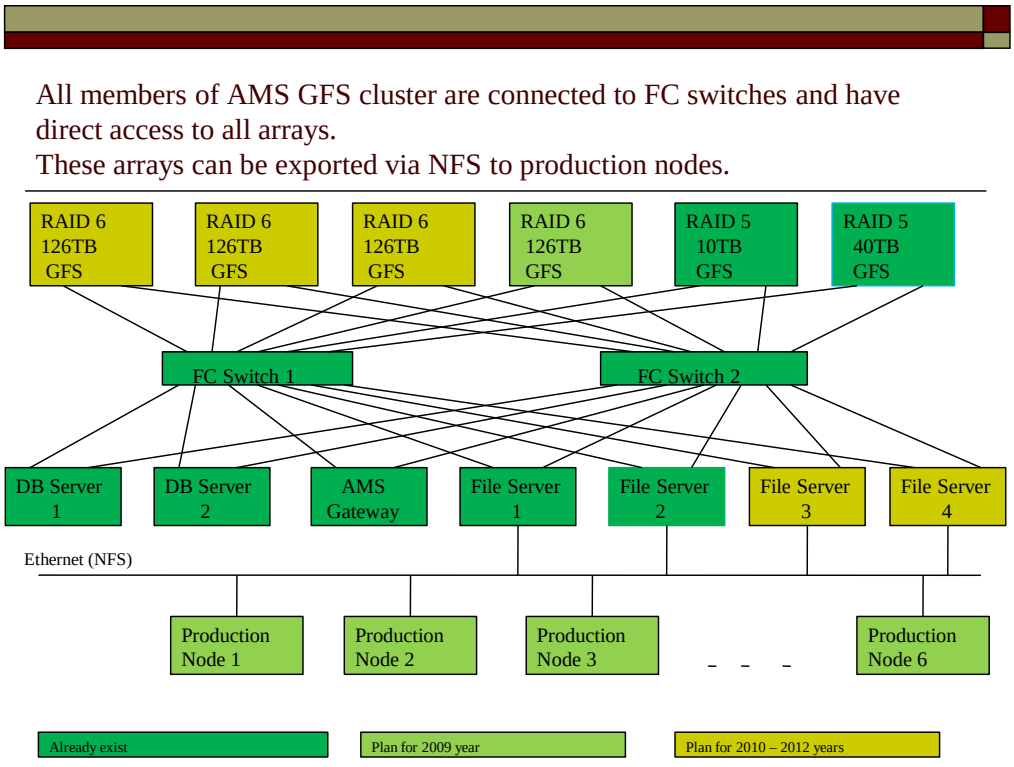

Figure 3: SOC interconnection layout and implementation sequence.

In addition, a Master Copy of all raw data, transfered by means of the INFN-Milano Bicocca DT system, will be kept at the AMS INFN Regional Center [8], and its Data Catalog will be replicated at INFN-Milano Bicocca. Additional copies of the AMS raw data and ESD will be distributed to the AMS Regional Centers.

An ORACLE database will store AMS-02 catalogues, event tags and production status. Access to the database is provided to the members of the collaboration via WWW interface. The database will be run by 2 Dell PowerEdge 2950 III servers.

2.8 Science Analysis and Monte Carlo Production

The AMS-02 Physics Analysis Facility (PAF) at SOC will allow fast batch and interactive access by the members of the AMS Collaboration to the bulk of the AMS-02 data. The PAF resources at SOC will be complemented with the additional computing power available at the AMS Regional Centers.

Based on the experience of AMS-01, allowing for a 100% increase in the number of actively working physicists and a 100% increase of the average event access time, a system equivalent to ∼7 3GHz CPU cores and few TBytes of disk space is required [1].

The AMS-02 PAF consists in a Dell PowerEdge 6800 server with 4 dual-core Intel Xeon 3.0GHz processors and 12 GB RAM together with the 4 file servers described above. LSF software is used as scheduler for batch jobs.

The AMS-02 Monte Carlo production is based on a distributed scheme which makes use of the computing power available at the AMS-02 RC. Data journaling and storage is centralized at the AMS SOC.

3 POCC

AMS computers at the POCC have to handle all activities related to the operation, control and monitoring of AMS-02 detector:

- send commands to AMS detector
- receive and store data from POIC (and if necessary from GSC at MSFC)
- monitor data and run quality control programs
- voice loop communication with NASA
- video display of ISS video distribution
- process about 10% of data in "real-time" mode to provide fast information to the shift taker.

3.1 Computing Resources

The POCC, in its final configuration, will consist of [9]:

- 1+1 POCC consoles for AMS-02 commanding, voice loop support and video display.
- 9+1 computers HP dc7800 with dual-core Intel Xeon 2.66 GHz processor and 4GB RAM to run AMS subsystems monitoring, event display and control programs.
- 1 storage server for data frames and blocks consiting in a Dell PowerVault DP600 with quad-core Intel Xeon 2.0GHz processor, 4GB RAM and 8 TBytes of disk space, 1 LTO-4 tape drive and a total of 100 0.8/1.6 TBytes data cartridges.
- 1 production node Dell PowerEdge 1950 III with two quad-core Intel Xeon 2.66GHz processors, 8GB RAM.

3.2 Auxiliary Equipment

In addition to the computers, POCC equipment includes the following hardware:

- 1 Gbit ethernet switch
- 1 network printer
- 22+1 21"-NEC LCD2179NX screens
- 10 headsets
- 2×1TByte spare disks

3.3 Power & Networking

POCC is located at the basement of building 892, SA-14 (CERN-Prevessin) for a total surface of 242 m^2.

The electrical power consumption of the equipment at POCC is 12 kW, including 2 kW needed for the cooling system (34 kBTU/hr).

24 network ports of Gbit ethernet connection are needed.

3.4 Implementation Plan

We will define the following steps in the POCC implementation:

1. FY2008: hardware already available or to be purchased in 2008
   - 2 POCC consoles
   - 6 dual monitor computers
   - 1 production node
   - 15 LCD screens
   - 1 Network Printer
   - 6 headsets
   - Gbit ethernet switch
   - Cooling system upgrade to 34 kBTU/hr
2. FY2009: to be purchased in 2009
   - 1 storage server and 10×1TByte disks
   - 4 dual monitor computers
   - 8 LCD screens
   - 4 headsets

4 SOC

The AMS Science Operations Center will provide all facilities required to receive and store all AMS-02 data, to reconstruct AMS-02 science data, calibrate and align the detector, store results of reconstruction as well as Monte Carlo simulations. In addition, SOC will distribute raw data and ESD files to the AMS RC. SOC will also provide the resources needed to perform science data analysis to the collaboration members.

4.1 Computing Resources

The SOC, in its final configuration, will consist of:

- Physics analysis and gateway server: Dell PowerEdge 6800 server with 4 dual-core Intel Xeon 3.0GHz processors and 12 GB RAM.
- 2 ORACLE data base servers Dell PowerEdge 2950 III.
- 2 data relay computers AMS-INFN RC/CERN.
- 4 disk arrays, e.g., iStor 4920 24-Bay RAID server with 4 $\times$ 2200 16-Bay expansion subsystems and a storage capability of 126 TBytes.
- 4 file servers Dell PowerEdge 2900 III with two quad-core Intel Xeon 3.0GHz processors, 24GB RAM and 6 TBytes of disk space.
- 8 production nodes Dell PowerEdge 1950 III with two quad-core Intel Xeon 2.66GHz processors, 8GB RAM.

4.2 Auxiliary Equipment

In addition to the computers, SOC equipment includes the following hardware:

- 2 Fiber Channel switches Qlogic SANBox 5600
- 8 Ethernet switches 16 ports 1Gb
- 4 Dell PE 2410 Rack (24U)
- 4 Dell APC Smart UPS 2200i
- Cooling System 60kBTU/hr

4.3 Power & Networking

SOC is located at the basement of building 892, SA-13 (CERN-Prevessin) for a total surface of 102 m^2.

The electrical power consumption of the equipment at SOC is 22 kW, including 5 kW needed for the cooling system (58 kBTU/hr).

10 network outlets of Gbit ethernet connection are needed.

4.4 Implementation Plan

We will define the following steps in the SOC implementation:

1. FY2008: hardware already available or to be purchased in 2008
   - Physics analysis and gateway node
   - 2 ORACLE data base servers
   - 2 file servers
   - 1 RAID disk server 48TBytes
   - 2 Fiber Channel switches
   - Cooling system upgrade to 60kBTU/hr
2. FY2009: to be purchased in 2009
   - 6 production nodes

- 1 RAID disk array 126TBytes
- 1 24U rack, 1 UPS, 2 Ethernet switches

3. FY2010-2012: to be purchased in the 3 year period 2010-2012
   - 2 file servers
   - 2 production nodes
   - 1 RAID disk array 126TBytes per year
   - 1 24U rack, 1 UPS, 2 Ethernet switches per year

5 POCC/SOC Personnel

Data taking activities at POCC and SOC will be carried out by physicists on the basis of regular shifts. In addition, the setting-up and operation of the POCC/SOC prior to and during the mission will require the participation of 1 senior system manager and 1 junior system manager in 2009 and 1 additional junior system manager in the 3 year period 2010-2012.

6 Cost Estimation and Spending Profile

Tables 1 and 2 show the cost estimates of POCC/SOC computing for FY2009 and FY2010-2012. Hardware, backup and maintenance and personnel expenses are grouped into separate items.

The total request for AMS computing at POCC/SOC for FY2009 is 305 kCHF. For the period FY2010-2012, a cost of 332 kCHF per year is foreseen.

7 CERN Support

As agreed in the Annex 4 of the Memorandum of Understanding between CERN and AMS, AMS will follow CERN's computing rules (OC5) as well as the related regulations. AMS commits to follow CERN's IT standards and requirements including those related to security and firewall access. Should exceptions be required, they need to be dicussed on a case by case basis and agreed up-front.

In particular it is agreed that

- AMS will continue to use its own computing facilities for data processing and analysis. As such, there are no requests to CERN-IT to support hardware or software, other than those explicitly listed below.
- IT will continue to tolerate the dedicated AMS AFS cell that was setup in 2003 by AMS after agreement with IT.
- AMS can profit from the latest contract negotiated between CERN and Platform allowing the usage of LSF anywhere on the CERN site. The software distribution and questions concerning support must pass via the IT Department. AMS plans to use IT-developed scripts for the installation and configuration of LSF. It is the responsibility of AMS to adapt, maintain and support these scripts.
- Advice on computing matters related to nonstandard solutions can only be given on a best effort basis.

- AMS and CERN-IT shall appoint each a contact person to establish a communication channel for computing matters.

References

[1] V. Choutko, A. Klimentov and M. Pohl "Computing Facilities for the AMS-02 ISS Mission", AMS note 2002_01_02.

[2] P. Fisher, A. Klimentov, A. Mujunen and J. Ritakari "AMS Ground Support Computers for ISS mission", AMS note 2002_03_01.

[3] V. Choutko, A. Klimentov, P. Nemeth, M. Pohl and B. Robichaux, "AMS-02 Ground Systems at NASA Johnson Space Center", AMS note 2004_XX.

[4] P. Fisher, A. Klimentov "Ground Data Handling for AMS02 ISS mission", AMS note 2001_05_01.

[5] M. Boschini, "AMS SOC to Regional Centers Data Transfer Status", Presentation at AMS TIM, CERN April 2005.

[6] V. Choutko, A. Eline "AMS-02 SOC/POC Implementation Plan", Presentation to CERN-IT Representatives, CERN, May 6, 2008.

[7] V. Choutko "Particle Rates for Year 2003", AMS note 2000_02_03.

[8] M. Boschini, "Italian Data Transfer", Presentation at AMS TIM, CERN July 2008, Software Splinter Meeting.

[9] X. Cai, "AMS-02 POCC Equipments", Presentation at AMS TIM, CERN April 2008.

POCC/SOC COMPUTING REQUEST FY2009

COMPUTERS:

POCC Hardware	**Qty**	**Cost (CHF)**
Storage Server		
Dell PV DP600 w/LTO-4 Drive	1	15 000
Shift Stations		
HP dc7800, 2x21"-LCD screen	4	5 000
SOC Hardware	**Qty**	**Cost (CHF)**
Production Nodes		
Dell PE 1950 III	6	24 000
RAID Disk Arrays		
e.g., iStor 4920+4xJBOD 2200	1	85 000
Auxiliary Hardware		4 000
Ethernet Switch 16 ports 1Gbit	2	
Dell PE 2410 Rack (24U)	1	
Dell APC Smart-UPS 2200i	1	
Total (Computers):		133 000

BACKUP AND MAINTENANCE:

Maintenance Cost	5 000
Castor	20 000
Total (Backup and Maintenance):	25 000

PERSONNEL:

1 senior system manager	93 000
1 junior system manager	54 000
Total (Personnel):	147 000

Total (FY2009):	305 000

Table 1: POCC/SOC cost estimate for FY2009.

POCC/SOC YEARLY COMPUTING REQUEST FY2010-2012

COMPUTERS:

POCC Hardware	**Qty**	**Cost (CHF)**
Storage Server		
LTO-4 0.8/1.6TByte Cartridge	30	3 000
SOC Hardware	**Qty**	**Cost (CHF)**
File Servers[1]		
Dell PE 2950 III	1	10 000
Production Nodes[1]		
Dell PE 1950 III	1	4 000
RAID Disk Arrays		
e.g., iStor 4920+4xJBOD 2200	1	85 000
Auxiliary Hardware		4 000
Ethernet Switch 16 ports 1Gbit	2	
Dell PE 2410 Rack (24U)	1	
Dell APC Smart-UPS 2200i	1	
Total (Computers):		106 000

BACKUP AND MAINTENANCE:

Maintenance Cost	5 000
Castor	20 000
Total (Backup and Maintenance):	25 000

PERSONNEL:

1 senior system manager	93 000
2 junior system manager	108 000
Total (Personnel):	201 000

Total (Yearly FY2010-2012):	332 000

Table 2: POCC/SOC yearly cost estimate for FY2010-2012.

[1] 2 file servers and 2 production nodes will be requested throughout the 3 year period FY2010-2012.