Science Requirements and Implementation - South Pole Station Computing and Communications

A Report to the National Science Foundation
by
The South Pole Science Users' Ad Hoc Committee on Computing and Communications

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The Amundsen-Scott South Pole Station is rapidly becoming a major scientific facility. However, unlike many facilities that support a single scientific discipline, the station resources must accomodate a variety of disciplines from seismology to astrophysics. This report attempts to address the growing scientific demands on the computing and communications infrastructure. Almost all science experiments will benefit from a more effective (easier to use) link to CONUS, increased bandwidth, and support for familiar software environments. The report consists of two sections:

- A general set of guidelines for upgrading the South Pole computing and networking environment
  - Support for 4 major computing environments (SUN, VAX, Macintosh, PC)
  - Non-centralized computing model
  - Local Area Networks
- A specific proposal for
  - Increasing the total bandwidth from South Pole to CONUS
  - Implementing an Internet link to the station for the 1992-93 Austral

summer season

Part I. Computing

The computing systems at South Pole must address a variety of requirements from heterogeneous science groups having great diversity in home institutions, scientific needs, and university computing environments. In addition, the South Pole systems must provide access to computing capabilities which are current enough to be useful and mature enough to be operable within the constraints of long lead procurement and shipping times, limited access by factory personnel, and limited repair facilities and spares.

There are two basic categories of science users - those at Amundsen-Scott for a few weeks, and those present for a year. The short-term users have limited time and resources with which to adapt to differences between facilities available at South Pole and those at their home institution. The long term users have sufficient time to more fully utilize specialized resources at South Pole. The largest numbers of users, by far, are the short- term summer scientists. In addition, both of these categories can have both expert and novice users, having rather different support requirements.

The near-term (5 year) requirements must be tempered with both prediction of the evolution in computing and recognition that functional research systems require some stability in the environment. The assumptions which are implicit in the requirements which follow include:

- Portability of computers and computer storage is improving dramatically.

- Rapid access to the local South Pole network will be required for imported portable computers.

- Most users prefer and need to work in the compute environment with which they are familiar.

- Support for large items such as monitors, printers, and some media (i.e., 1/2 inch tape drives) will continue to be required.

- The traffic on the local science network will be modest with respect to "ethernet" throughput (10 Mbps, 50 Kbps untuned transfer rate).

- Bit mapped displays are becoming increasingly important (and affordable).

The following describes the several levels of science requirements including intent, operability, hardware support, software support, and user support. In addition, some consequences of these requirements on implementation are discussed to provide assistance in timely upgrading the South Pole computing capability.

Requirements - Intent:

The South Pole computing system should provide the scientific community:

- Access to data (file transfer)
- Access to colleagues (mail)

- Access to instruments (interactive login from US)
- Access to analysis

These requirements are in approximate order of ease of implementation. The priorities are so close, particularly for the first three, that they should be considered equal.

Access to data is a fundamental requirement. Many experiments planned for winter operations at the South Pole will require almost instant access to data. Prior to the availability of satellite transfer, data had to be returned by mail during the brief summer season. This often resulted in a two year response time between detection of an experiment anomaly and providing a fix (data recorded in Austral winter, data return in Austral summer, discovery by analysis in Austral winter, fix in Austral summer). The ability to transmit a limited amount of data permits at least experiment monitoring. The desire, of course, is to return a substantial number of the measurements close to the time of acquisition.

Access to colleagues with the advent of electronic mail at South Pole has vastly improved the ability to include CONUS staff in diagnosis and repair of problems, as well has permitting investigators to continue some of their other research functions while sequestered at South Pole. The current implementation, which involves a non-standard, labor- and time- intensive file transfer step, is frustrating to the majority of researchers, who have come to rely on the ready access and rapid response of mail over the national networks.

The remote interactive logon has been an unfulfilled requirement for several years for currently active experiments. This involves remotely varying experimental parameters from the US. There is a strong requirement for very short stimulus-response times, to realize the full utility of interactive experiment capability. It now appears technically feasible. It provides, in addition, the possibility for remote support of system management.

Over the years, some level of analysis capability has been used. This includes first order look at continuing data sets, unplanned analysis of anomalies, and, occasionally, full up analysis. It is anticipated that MOST of this analysis will occur on the experimenters' own computers imported seasonally, or on facilities dedicated to each experiment since analysis capability is very sensitive to the configuration of the computing environment. However, a modest basic level of analysis capability is required to support a) small, one- time experiments, b) failure of facilities associated with experiments, c) analysis while waiting for departure from pole or while waiting for arrival of equipment, and d) media conversion where appropriate.

All of the above requirements may be satisfied, in part, by the implementation of an Internet link to the South Pole. While the bandwidths and access times may not satisfy future requirements, the plan discussed in part II (Communications) of this recommendation paper takes advantage of existing satellites and technology to start the process. Longer range plans must be developed for true remote control of South Pole experiments.

Requirements on Computing Environment:

A sampling of groups currently using the station facilities for research yields the following information:

- Most will bring own computer (disk, CPU)
- Monitor, printer support will continue to be needed
- Access to network will be required
- Many experiments will utilize logon from US, most require it

Below is a table listing surveyed groups and their current hardware and needs:

Group/PI	Computer type ACQ	RED	AUX	Network	Media owner/ device	Need logon from USA
Gonzalo	PC			Ether	?	Required
Carrol	PC			None	own floppy	
Rosenberg	PC			?	own (3 1/2 opt)	
IRIS	OS9	SUN		Ether	own (DC600a)	Yes
IRIS U	PC	VAX		Ether	station/8mm	Yes
GMCC	PC			Ether	own (tape)	
MET	PC			Ether	station	
MET	VAX			Serial		
CMBR P	SUN			Ether	own (5 1/4 opt,DAT)	Yes
CMBR D	SUN			Ether	own (DAT)	Yes
CMBR P,D	PC			serial?		
CMBR Berk	Mac	Sun				
GASP	Mac	VAX	SUN	Ether	station/8mm/opt	Yes
SPASE	Mac	VAX	SUN	Ether	station/8mm/opt	Yes
AMANDA	Mac	VAX	SUN	Ether	station/8mm/opt	Yes
Astro	PC/UNIX			Ether	own	Yes
Spirex	tbd			Ether	own	Required

The heterogeneous background of investigators at South Pole results in a wide diversity of computing preferences. This extends much further than choice of hardware - the system configuration for each machine (particularly in the small workstation class) and the choice of software for the machine can make identical hardware appear significantly different to the user. Researchers will increasingly import their own environment to South Pole because:

- the time available for learning a new computing environment at pole is short relative to the time required to fully understand a new computing environment

- productivity is critically dependent on understanding the compute environment

- the computing environments can be so diverse

- computing trends change faster than the time scales required to negotiate resources for the station

It must therefore be a requirement that the station support connectivity for diverse systems while maintaining its own relatively predictable computing facilities.

This diversity requires careful attention to staffing. It will be hard to find a single person to maintain this heterogenous system. The person(s) will have to have more expertise than those hired in the past. However, with better communications to the station, experts do not necessarily have to be at the site in order to help. Using remote logins, staff at McMurdo or on CONUS may be available to remotely assist with software support or other problems.

There are four categories of hardware (and operating system) which make up about 95% of the various university computing environments - those are a) SUN, 2) VAX, 3) PC (AT style), and 4) Macintosh. These systems in turn have some commonality which should be supported at South Pole:

Common across all elements:

- Ethernet
- FTP/TELNET
- Serial ports
- Postscript (some differences)
- SCSI (least supported on PCs, but a good, and available, option)
- Xwindows, motif (supported best in SUN, VAX)

Note that the systems share the attribute of bit mapped displays, but each is rather unique. It is possible to stock monitors which work for given systems, but it is rare that the monitors will work across manufacturers. Disks and tape drives may be shared. Printers may be shared, but the queuing mechanisms are so diverse that it is currently most reliable to provide separate printers for each machine. In addition, the best print services are provided when the printer matches that FULLY supported by the manufacturer.

We recommend that the station purchase and support the following:

Supported machines:	Macintosh, PC, SUN, VAX
Form:	Color bit mapped workstations
Number:	No less that 2 of each (for backup)
Number of public access terminals (including workstations)	10% of summer population
Software support:	Common set (see below) + as requested by investigators
Hardware spares:	SCSI: magnetic disks, 3.5" optical, Bernoulli or other removable media(?), PC SCSI interface boards ethernet: ports, adapters, thin-net connectors
Printers:	2 postscript printers (one QNS Color, one Apple Laserwriter - both in Science bldg)

Common within each element (some of the software is debatable)

class	Macintosh	PC	SUN	VAX
editor	WORD WORDPERFECT	WORDPERFECT Norton	VI EMACS SEDT(vms sim.)	EDT EVE VI (unix sim)
compiler	C,C++ Fortran	C Fortran Basic	C,C++ Fortran	C Fortran
	Versaterm NCSA Telnet	PROCOMM KEA VT240	?	set host
	FTP	FTP blast	FTP	FTP

terminal emul.	kermit xmodem native	kermit xmodem	kermit	blast kermit
file transfer			cp, rcp	copy

Network Requirements:

- Science speed requirements within 5 years modest
- Separate LANS for science and support
- Ethernet adequate 10 Mbps 50Kbps nominal throughput 800 bytes/ second tuned throughput
- Any fiber pulls should be FDDI compatible
- Ok to implement backbone with FDDI if cost (including spares) ok
- Fiber should be backed up with wire (reparability issue)

- Fiber can be a maintenance problem (splicing more difficult than for wire) and a single-point failure.
- Thin net must be supported
- Serial connections must be supported within most work centers
- Appletalk support desirable, especially in the Science Bldg
- Remote work areas with a substantial number of experiments should be divided into independent local networks (address, physical) to improve operability, independence from external failures, and portable address configuration. Recommended areas are Clean Air (and surrounding experiments), CARA, CMBR (while different), Remote experiments (Skylab, IRIS), and Station.

Operability:

- Connect own machine to station within 1 hour of arrival
- Account on station machines within one hour of arrival
- Access methods tcp/ip, Appletalk, serial, [decnet]
- Access to network when satellite visible
- Access to network should not require addition of software to import machines - address configuration ok
- Open access as feasible
- Support for access to printers, i/o etc.
- Common spares - SCSI disks, printers, monitors, keyboards
- Printer support - Postscript, HP
- Some printers should be supported on network, some by direct connection

- Single point failures have work-around
- Centralized storage - buffering requirements only
- Researchers prefer to use software service with which they are familiar (editor, mail)
- Home environment preferred for analysis (which implies import of disks and/or CPUs

Terminal Requirements:

- Message preparation

- A substantial amount of keyboard time is spent in message preparation & reading.

- Number of public terminals for this should = 10% of the summer station population.

- Standard character terminals are adequate for this purpose, should be able to connect to most station machines (via terminal servers). Cost per connection = $500.

Analysis:

- Minimal software support for data analysis required.

- Analysis requires graphics, and, increasingly, bit mapped capabilities.

- University environment tends toward workstation (SUN, VAX) and personal computers (Mac, PC's). With assumption that folks bring primary analysis software and machine, x-windows access to those machines is still needed.

- Recommend 3 Suns, 3 Macs (Quadras), 2 Vaxstations, 3 PC/486 as suitable mix. Color is not required in all SUNS and Macs, but at least one of each should have large (19") color monitors). Recommended cost range about 8-10K each for workstation, 5-6k for each Mac, and 2-3k for each PC. (Question arises... where will these machines go? Space available is tight)

- Should be no fewer than two of anything for spares consideration. Should be configured with as many common parts as possible (disks, etc.). Additional workstations should be planned for remote work areas (Clean Air, CARA).

Special topic - PC servers and science:

- Central system source of single point failure
- Additional logon procedure awkward
- Not useful for data acquisition (unacceptable down times)
- Added complexity to negotiate resource sharing not consistent

with short times at station

- Added complexity for software management unwieldy and not consistent with short times at station

- Account management can result in delays which are large relative to time at station

- Little analysis carried out on PC's

Conclusion - minimal requirement for PC network from science sector.

Part II. Communications

The South Pole science community strongly recommends that Internet be brought to Amundsen-Scott Station for the 1993-94 summer season. The plan outlined below provides for:

1. The implementation of an Internet link on LES-9 and GOES-2 for 1993-94 Austral summer season

2. Higher available bandwidths for data transmission

3. The investigation into higher data rate links for the future

These implementations include using an intelligent router at each end of the link that can automatically make appropriate use of each link when the link is available. The

DECrouter 2000 is a moderate cost ($14,000) unit that would probably be adequate, but some research should be done to determine the best routers for this application.

The modems used should be the Fairchild SM-2800. It is important to verify that the routers chosen will interface properly with these modems. It might also be useful to install a pair of MICOM (or equivalent) multiplexers to allow a couple of voice channels to be multiplexed into the data stream on demand.

The receive system should be based on Icom R-9000 receivers. These receivers would be common to both systems, and would probably accommodate any future link with down- converters. It should be noted that there are many considerations to selecting receivers for this application in addition to simple frequency and bandwidth specifications.

There would need to be an up-converter designed and several copies built - this is to accommodate the 70 MHz input requirement from the modem with the IF output of the receiver at 10.7 MHz. The transmit chain is somewhat more complicated, as it is unlikely that any commercial equipment exists, except for the power amplifier for GOES-2. These transmit systems would need to be designed and built.

The 100 watt amplifier for LES-9 operates at UHF frequencies (300 MHz) and the components are cheap and readily available since there are many commercial 2-way radio services around those frequencies. The GOES-2 amplifier needs to operate at L-Band frequencies (above 1 GHz) and therefore requires the more expensive traveling wave tube (TWT) technology for which there are no equivalent commercial uses.

The specific recommendations for each system are as follows:

1) LES-9	cost $
	100
	5000

1. Existing receive antenna with RF 4000
splitter. 2. Icom R-9000 Receiver with up- ????
converter on IF 3. Fairchild Model SM- 2000
2800 Modem 500
4. Custom Built Up-converter for
Transmit 5. Custom Built Power
Amplifier (100 Watt) 6. Transmit antenna
near the Dome

LES-9 bitrate is expected to be 16-32Kbps. There are likely to be some periods of degraded performance due to various mechanisms which result in signal fading. Assuming 16Kbps, 6 hours daily availability yields 34.5 MBytes/day throughput.

2) GOES-2 cost
$

1400
1000
500
1. TVRO type Dish Antenna (approx. 3 5000
meter) 2. Commercial Duplexer 4000
3. Commercial Preamplifier ????
4. Icom R-9000 Receiver with up-converter 18000
on IF 5. Fairchild Model SM-2800 Modem
6. Custom Built Up-converter for Transmit
7. Commercial 100 Watt Power Amplifier

GOES-2 bitrate is expected to be 56Kbps. It is visible at South Pole for approximately 3 hours, increasing in elevation about 0.6 degrees per year. This yields 60.4 MBytes/day throughput.

Installation Notes:

The Dish Antenna should be located near the Dome and elevated on a platform at least 2 meters. We will start with a fixed antenna for now; perhaps go to elevation-only steering as a future enhancement to increase bitrate and/or improve reliability.

The Preamplifier should be located at the dish, and should be one that will operate at the expected ambient temperature (-100F).

The transmit up-converter and power amplifier will need to be located near the dish, and installed in a reasonably temperature controlled environment.

It would probably be best to use a vault beneath the surface, with AC power available for the equipment and heating system. There should also be a temperature interlock system to prevent inadvertent use at temperatures which are too hot or too cold.

It will be necessary to make provisions for remotely monitoring the health of the equipment at the Communications building.

Standard RG-8 cable or equivalent can be used to bring the receive signal into the building and the 70 MHz transmit signal out to the vault.

3) Both Systems

The Modems, Receivers, and 10.7 to 70 MHz Up-converters are common to both systems, and spares can be used accordingly. Spares for other components must be provided.

The selected Ethernet Router must handle both systems automatically, and spares for this critical item must be provided. It will also be necessary to use the same type of router at the CONUS connection(s).

Future:

The total throughput will likely be less than 100 Mbytes/day, insufficient for the 400 Mbytes/day estimate given by CARA as necessary within 3 years. The GOES-2/LES-9 plan may be supplemented by the Marisat F1 satellite, if it becomes available for use at Pole. Future large bandwidth requirements may be satisfied by a possible TDRS link to Pole.

However, the Internet connection will benefit all experiments and users, providing easier access to CONUS and significantly more bandwidth than is offered now. This plan will provide a working model to explore alternate methods of increasing data bandwidth and internet connection time.