Mr. Ron Koger xxxxx

Dear Mr. Koger,

Enclosed please find the report Science Requirements for South Pole Station Computing and Communications. This report was prepared by the Communications and Computing Subcommittee (CCS) under charge by the South Pole Users' Committee (SPUC).

The Users' Committee accepts this report and wishes to emphasize certain recommendations made therein that were amplified at ASA's April 27 Communications and Computing meeting at NSF.

¥ Communications - more bandwidth, connection time, and accessibility

¥ Communications Development Strategy - take quick action when new satellite opportunities present themselves; the scientific community is more than willing to accept the risks inherent with this strategy.

¥ Networking - many users are providing their own computers but need a transparent connection to a high speed, efficient network, both local and global; priority should be given to communication and networking over the purchase of computers.

We hope the submission of this document is the beginning of a continuing dialog in the process of implementing these recommendations.

The South Pole Users' Committee would like to thank ASA for its generous support of this committee.

Robert M. Morse, for the Committee

Science Requirements for South Pole Station Computing and Communications

A Report to the South Pole Users' Committee
by
The South Pole Working Group on Computing and Communications
R. F. Loewenstein, William Smythe, and Brent Jones
May
1995

The Amundsen-Scott South Pole Station is rapidly increasing its role as a major scientific facility. However, unlike many facilities that support a single scientific discipline, the station resources must accommodate a variety of disciplines from astrophysics to seismology. This report attempts to address specific growing scientific demands on the computing and communications infrastructure, discussing justifications and recommendations.

The three main topics of this report - Communications, Networks, and Computers - all integrate together to form a necessary tool for the science effort. We may have to draw boundaries to help determine how to spend valuable resources on them, but these boundaries increasingly blur and disappear as the dependence of scientific research upon long distance networking grows.

Since the previous report from this working group two years ago both improvements and losses in capability have occurred. Many of the recommendations from the previous report (see attachment) have neither been implemented nor discussed.

A summary scorecard for computing and communications is as follows:

Improvements in capability:

- Satellite bandwidth
(Bandwidth has improved, though availability remains about constant) - Direct connection to the Internet
- Direct mail service (instead of a tedious hand transfer)
- Direct file transfer under user control

Losses in capability:

- Workspace (and terminal space) in dome for researchers has decreased - Access convenience to VAX has been reduced by replacing terminals with PCs
Some users like 'dumb' terminals as opposed to PC's

Important recommendations of previous report that were not implemented:

- Segmentation and subnetting of LAN
Affects reliability, maintainability, performance, and management
Remove IPX from main LAN
- Support for direct connect of portable computers to the LAN is minimal - Support for some of the operating systems, hardware, and communication systems is
still ad hoc
- Bit-mapped access (x-terminal, graphics, and image display) capability is effectively
absent

Important recommendations from this report:

- Implement prior recommendations

- Semiannual(?) meetings for review and feedback between ASA and representatives of
the Users' Committee

- For communications:

- Improve availability and bandwidth
near term: 12 h/day and 1 GByte/day minimum
long term: 24 h/day and 2 GByte/day goal
- Pursue TDRSS connection
- Utilize prototype capabilities during winter
- Improve uniformity of performance for operational systems
- Improve documentation and sparing for operational and prototype systems - Improve domain name services
- Add
- remote phone calling (or patching)
- multiplexed phone link on GOES-3
- (limited) FAX capability
- network prototyping support

- For local area network:

- Add finger services (name@SPOLE.GOV)
- Improve connection availability (and workspace) for portable computers
- Support Appletalk network routed to ethernet LAN
- Improve performance of network with subnetting and network segmentation
- Use TCP/IP as primary access protocol
- Remove IPX (Novell) to its own LAN

- Use distributed managers for local subnets

- For computing:

-Support science access in dome with bit-mapped workstations (general screen capability should be 1000x1000x8 pixels)

Recommended quantities:
4(Mac) Power PCs with Versaterm and Mac-X or equivalent
2(DEC) Alpha workstations (terminal and X included)
2(Sun) Sparc 2 workstations (terminal and X included)
2(PC)Pentium or 486 with KEA and Exceed or equivalent
3Generic terminals to central computer if it still exists

- Improve print access and print support for all workstations
- Increase user workspace, make some room for lying out paperwork (elevate terminals, add drawers, etc.)
- Improve configuration support for all four operating systems - Add remote support for systems management

I. Communications

Almost all science experiments will benefit from more periods of Internet connectivity, increased bandwidth, and familiar software environments. Better communications will also benefit staffing, because experts will not necessarily have to be at the station to help maintain and configure the systems.

The wide area network access provides a vital suite of services for the science community including experiment monitoring, anomaly diagnosis, consulting, data transfer for concurrent analysis, time critical data entry into databases such as weather (WMO) and seismic monitoring (AFTAC), and remote experiment control. There are two access requirements, throughput and availability - the present desire for throughput is about 1 GByte/day, and the desire for availability is 24 hour coverage.

The cost-effectiveness of WAN access cannot be overemphasized. Prior to availability of the WAN, winter experiments at Amundsen-Scott station would commonly spend one season collecting data, a second season analyzing that data and designing fixes for anomalies in the data, and a third season testing the fixes. With WAN access, experimenters can examine the data in near real-time, diagnose anomalies and (often) implement fixes during the same season, providing a factor of two or more reduction in the cost of fielding successful experiments. Fast mail access, and the availability of teleconferencing, when required, facilitates correct diagnosis and repair of failures in complex equipment. The ability to interact directly with experiments from the US provides another dimension to improving the overall throughput of experiments. It makes it possible to vary the experimental paradigms on short time scales, to adapt the experiment to short-lived physical phenomena, and to include a much greater depth of scientific expertise than is possible with the small winter- over population. The participation of a wider community can also improve the acceptance and demand for the Antarctic program.

The ability to provide data to time-critical databases is also important for the stature of the Antarctic station. Data must be entered into the World Meteorological Organization system within about four hours to be included in predictive weather models. For seismic monitoring, the data must be on-line, with delays no greater than 30 minutes and having few accessibility gaps, to be relevant for AFTAC monitoring. The data from Amundsen-Scott station have important, unique characteristics for these databases, and would be in great demand if they could be provided in a timely fashion.

The complex science experiments that CARA and AMANDA are now attempting to conduct at the pole have been predicated on increasingly better communications to the Pole. Indeed, communication has moved from a minor support tool to being integral to the experiments themselves. Communication is so critical to these major astrophysical projects, that they run a reasonable risk of failure, if adequate communications are not provided in the form of (1) phone service to CONUS from the work areas, (2) reasonable Internet connections several times a day, and (3) large data throughput capabilities. Failure to improve existing communications as soon as possible will threaten not only the effectiveness of the South Pole science operations, but also the external perceptions of the feasibility of conducting complex research programs at the South Pole.

The effect on seismology, for example, of failing to provide suitable data throughput includes a loss South Pole contributions for highly visible analyses of major earthquakes, and a potential loss of a season's data if an instrument malfunction goes undetected. The effect of failing to achieve sufficient coverage in a 24 hour period is that of losing the possibility of joint participations and contributions from the Air Force.

Next winter season's data throughput is estimated to be ~1 GByte/day, assuming all planned projects become operational. This number is based on the sum of individual science program's estimates. This year, the existing data channels will become saturated. Table 1 summarizes the current situation as well as next year's projected capability.

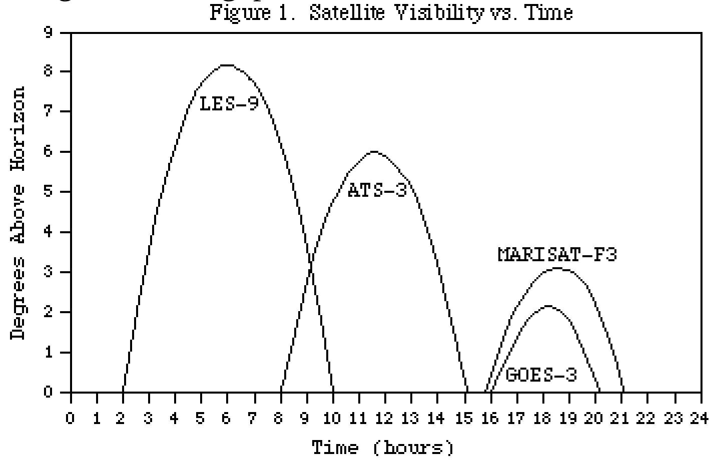
Table 1. Communication Summary

Satellite	1994			1995-96 (?) and beyond		
	bandwidth (Kbps)	~availability (hrs/day)	Throughput (MB/day)	bandwidth (Kbps)	~availability (hrs/day)	Throughput (MB/day)
ATS-3	voice	5	-	voice	5	-
LES-9	32 (128?)	6	69 (276?)	32 (128?)	5	69 (276)
GOES-3	-	-	-	256-512 (T1?) voice	3	276-552 (1500)
MARISAT-F3 ($15-29K/month)	10 [56] voice	1 [5]	3.6 [100]	10 [56] voice	1 [5]	3.6 [100]
Effective Mbytes/day			72			348 - 624 (1876)

() - indicates possible maximum, depending on test results - your mileage may vary.
[] - indicates maximum, depending on lease fees

Note that in order to fulfill this year's goals, it is extremely urgent that Marisat-F3 be brought on-line for the remaining of the winter season. While the gain in throughput is small, F-3's

Figure 1. Satellite Visibility vs. Time



phasing with respect to LES-9 and ATS-3 is essential to maintain necessary contact with winter-overs and experiments. Next year the combination of LES-9 and GOES-3 will satisfy a reasonably phased connection to the Internet. They may also satisfy data throughput demands.

As Figure 1 indicates, F-3 and GOES-3 are visible simultaneously. So while F-3 may not be necessary after November 1994, it should still be considered as an emergency backup.

Below is a list of requirements, deficiencies, and concerns we have been able to identify in our discussions with many research groups at South Pole:

1. Continue to identify and acquire existing usable satellites for

    a. Higher throughput and
b. Internet connectivity several times during the day

Assuming that launching our own satellites is out of the question, the most reasonable approach to increase the communications capability at the Pole is to continue to identify and acquire existing usable satellites, either free (LES-9, ATS-3, GOES-3) or leased (MARISAT F series). Current rates for Marisat F3 are $15K/month for 1 hour/day at 9.6Kbps or $29K/month for 1 hour/day at 56Kbps. These costs translate to $145/MByte and $48/MByte, respectively.

Table 1 shows that GOES-3 will take most of the throughput load, as well as being above the horizon about 12 hours from LES-9. It is a single point failure and we cannot depend on its services forever. Even if it operates trouble free, it is not clear what will happen after the agreement with NOAA expires. While we may expect a rate between 256-512 Kbps, it is questionable whether we can achieve T1 rates. Tests by Paul Eden (no earlier than August 95) will help determine maximum rates. If it is possible to achieve T1 rates, purchases for modems and (perhaps) dishes may be required.

It is also likely that, in a few years, TDRSS will be available for ultra high data bandwidths out of the Pole. We should pursue this possibility.

2. Better connection dependability

LES-9 can one day be very good, and another day be absolutely terrible. This is apparently caused by fading and ionospheric conditions. While it is unlikely that we can improve the performance, there are cases in which poor performance can be improved (bringing LES 9 from 24 Kbps up to 38.4 Kbps by changing modulation techniques is an example). A plan for ensuring satellite reliability should be developed and thoroughly reviewed.

In addition, the sparing and documentation for these critical satellite systems appear to be minimal at best. Time should be spent documenting what now exists.

3. Phone service to CONUS from the work areas

Currently, the ATS-3 phone link requires the winter-over to make the phone call from the Comms building. Not only is this inconvenient, but impractical. It is very important to make things as convenient and productive as possible. We recommend developing procedures to allow calls to be made at any phone on station. This should become the standard, continuing when GOES-3 and Marisat are available.

If GOES-3 achieves 384 Kbps this summer, and fractional T1 equipment is on site, 2 phone lines of 8 Kbit each could be allocated, subtracting a mere 16 Kbps of bandwidth, leaving 368 Kbps available for data. This is a sacrifice of only about 4% of the total bandwidth (a small fraction of a dB) to support two lines that could be utilized the entire time the satellite is visible.

Note that if full T1 were available on GOES-3, the number of lines can double to 4 and impact the 384 Kbps link by only 2%.

4. Fax capability

There should be some means of easily transmitting the contents of a paper page to and from the station. We recognize the potential for bandwidth abuse with faxes. However, it is sometimes extremely important to be able to transmit diagrams and sketches.

5. Data allotment

The allocation of satellite bandwidth resources, and measurement of use is important to ensure that all experiments have adequate communications with home, to ensure that resource intensive activities (such as, perhaps, fax transmission) are recognized and placed in proper perspective, and to properly anticipate requirements for future growth. On the other side, strict allocations are likely to inhibit creative applications of the network capabilities, a creativity that is extremely important for finding cost-effective methods for carrying out research at South Pole. We recommend allocations of use be avoided unless they become absolutely necessary.

Priority of bandwidth use should be in the following order: email, data, direct access, voice (except in emergencies), and fax.

6. Role of Science Support in communications

One issue is the changing role of communications in scientific activities. In the past, communications was perceived as strictly an information pathway. That perception is no longer valid, as communications now provide the means of controlling and modifying remote experiments, as well as receiving real-time data from them. While an "Information Systems" approach to communications operation has served well in the past, it is now worthwhile to review what role Science Support should play in this arena. For instance, should Science Support money go toward subsidizing some of the communications, given that communications is such an integral part of the science?

7. Prototype development strategy

Planning and budgeting for future communication possibilities is difficult to do, given how quickly some opportunities present themselves. We recommend that a more flexible procedure be developed that allows quick action to take advantage of targets of opportunity for better communications.

8. Risks should be accepted for prototypes

It is very probable that the evolution of better communications to the Pole will continue in rapid bursts of testing, prototyping and phased implementation. Once proven, a prototype can be cleaned up for acceptance as standard equipment for station; if the prototype fails, it still may serve as a testbed for later success.

A good example of this rapid response and prototype evolution was the implementation (1993-94) of the GOES 2 link. However, after GOES was successfully run for the winter 1993-94 season, there was no follow-up replacement of prototype electronics with acceptance grade items. Even though GOES 2 became unavailable, it was known that GOES 3 would use its electronics. No documentation was made available to the next year's staff. The summer season should have been used to incorporate breadboard circuitry into a more reliable state.

9.

Spares

How much spare equipment should we require? How much risk should we accept?

II. Network

Good Communications is founded on good networking. Routers and network design should be considered as part of the communications infrastructure. Indeed, that infrastructure could even be considered to extend into the very desktop computers used by researchers.

One of the problems with the station network is, as we see it, the continued dominance of the network by ASA's managerial data traffic (MAPCON, etc.) on the backbone. We propose a plan to continue use of the Novell system for ASA Operations personnel, while creating a more research oriented design for the network. We also discuss a Distributed Management scenario.

Recommendations:

1. Network Plan

An example of a possible network architecture that is modular and responsive to changing technology is shown below:

MaterialsO&M
||
(Novell server any branch)
||
domain serverOPS_router
(sun or alpha)|
||
____|________________|___________________backbone (sci or comms or both)
||
Science router|
||
_______________________________|_______ Comms_router
||||||||
|||||(satellites)
Skylab Clean_air MOPF |Science bldg|
IRISrouter | (+appletalk to TCP/IP)(voice MUX)
|| (general printer)
||
||____CARA astronomy net
general
(Appletalk to TCP/IP)
(general printer)

During the 94-95 summer season, the station was still running one LAN. The current mode of LAN growth seems to be ad hoc (we have never seen a plan). We understand that subnets are being implemented in the Pomerantz Observatory this winter season. Subnets are necessary to cut down on the large data traffic that will begin to occur as AMANDA and CARA come on line and are beneficial in allowing a more manageable network. This traffic should be local only, except in the cases of downloading to CONUS or backing up to the central backup facility (presumably in the Science Bldg.).

While fiber should be FDDI capable, network protocols should remain normal ethernet, and not be replaced by FDDI or ATM. The current protocols are adequate for science needs for the near term. We see no need to spend resources on higher speed protocols at this time.

2. Network Management

The subnet design makes the job of a single network manager more difficult. In the case of many of the science groups, we recommend that a Distributed Manager Scenario be adopted where local 'managers' are responsible for their own subnet, such as CARA or AMANDA. ASA staff at the station would be responsible for maintaining the backbone and routers up to where the researchers' computers plug into the wall. The ASA staff should also be available for consulting and help, but the research staff should be responsible for their own machines, backups, software upgrades, etc. Local managers would also be responsible for configuring any domain name servers, as well as notifying the ASA system manager of changes relevant to the main network or name server. With proper communications to CONUS, non-resident managers may remotely login and continue in a limited management role.

Requests by groups for a subnet address allocation which they configure and maintain, and/or a physical subnet, separated by a router, should be honored. Conditions of agreement should include a requirement of registering all domain addresses with the system manager (for the name server, network diagnosis, and packet accounting), and keeping the network wiring configuration diagram current. This would greatly reduce the number of discussions and negotiations over network configurations, would allow large continuing research projects to configure their workstations in the manner most suitable for their research, and would off-load some of the responsibilities of the system manager.

3. Accounts

Install a finger server that is kept current.

Use the domain name for all accounts, so that rfl@spole.gov is sufficient to email to rfl. Likewise, fingering a name @spole.gov should return adequate information to facilitate contacting that person. At present, individual machine names have to be known to reach a person at Pole, and it is not always possible to determine how to email to them without fingering first. Example: how do you contact Dave Fischer at the pole by email (assuming he were still there at this moment).

There may be a problem of keeping the database current with the transient population at pole. Also local managers have to inform the system manager of changes. But even with these few inaccuracies, the system could be better than it is now.

4. Connectivity to Network

IP numbers and a standard connection (10BaseT?) should be available for those who request them. LANs should have a range of IP numbers assigned to them. When a new user initially connects, the system manager should be informed.

We recommend a supported Appletalk network with a router to the Ethernet LAN, and support for parallel port connector for PCs in the science building.

5. 10BaseT, thinnet?

It is important to retain a capability to support thinnet connections. Research groups should be able to setup their own subnets which, in many cases, is easiest using thinnet.

III. Computing

There are two basic categories of science users - those at the Pole for a few weeks, and those present for a year or more. The needs of both must be considered. 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 take advantage specialized resources at South Pole. In addition, each of these categories may have both expert and novice users, having rather different support requirements. The largest numbers of users, have been the short-term summer scientists. However, there has always been resident research groups such as (currently) CARA and AMANDA, NOAA, and (previously) NOAA, USGS, and Bartol.

Investigators will continue to bring their increasingly more powerful computers to the station. This permits the investigator to have much better control over the software and hardware configuration for that computer. In addition, little time is available for software development in the short summer season, making centralized computing at the station somewhat impractical.

Station computers do provide valuable services to the research environment. These include mail and name services, bulk data spooling and archiving, print services, remote access, access for personnel not having personal computers, and parts sparing.

Mail services have not evolved to the state where they are particularly convenient for portable computers. The route tables, addressing paradigms, and naming conventions are not sufficiently dynamic to deal conveniently with computers that change physical location frequently. Among the better alternatives is to telnet to the investigators' home computer and providing mail addresses on a station computer at south pole station. It is often difficult to remotely access mail on personal computer-based mail systems.

Recommendations:

1. Familiar computing environments and support

In the last paper generated by this working group, we listed as a guideline for upgrading the computing environment that there should be support for the four major computer platforms: SUN (UNIX), VAX (VMS), Macintosh, and PC. Some progress has been made and the situation is certainly better than it was several years ago. But there are still deficiencies. The predominant additions to the science building have been PCs, which have the least utility for the research community. The SUN access and operability are minimal, the VAX system is quite antiquated, has no full-screen access, and there are still too few Macs in the computer area relative to the demand. In addition, the two Macs that were present were not provided through standard Infosys support.

It is clear that the variety of operating systems and hardware places an exacting demand on the knowledge and experience of the support staff. It may be possible to ameliorate this problem by increasing remote support from CONUS or McMurdo using improved communications (see Staffing section).

2.
Email

Guest accounts should be established so that users can directly access Telnet from all terminals and workstations without requiring their own account. This permits researchers to monitor and check their email at their institutions - a very important capability for short term visitors.

3. Software support

There is little demand for support for common data analysis software. Most groups bring their own (on portables). Since some research groups may require specific analysis capability on the station computers, a modest amount of science support money should be budgeted to honor specific requests. It is anticipated that C, C++, and Fortran will continue to be supported on all SUNs and VAXes.

Limited, standard software sets should be resident on each machine, rather than on a networked server.

4. Graphic Package Support

The Station workstations should support standard terminal graphics rendering protocols such as X-Windows or Tektronics 4014.

5. Space

One of the basic needs of the short term researcher is the availability of work space. The space in the science building is overtaxed with emailers and non-research activity, with no desk space for the itinerant researcher. Is it possible to create more space in the science area? There is a storage room behind the SPASE area that could be cleaned out and used. There is no technical need to have all the terminals and computers in a single area. Perhaps some terminals can be placed in other areas of the Station.

We note that ASA has increased its own requirement for general workspace in the computer room with the use of MAPCON, CTS, and PTS inventory programs. This has had an impact on the science use of the space as well as the availability of terminals.

6. Common Networked Backup Device

Networked mass storage devices could benefit many projects and should be supported with necessary spares. Convenient backup methods should be available for all supported systems under user control.

7. Print Services

Print services should be available on the network for all workstations and remote sites. While PostScript is the most commonly used protocol and must be supported, we should also support HP, ANSII, and Tektronics protocols. The simplest solution for support of these protocols may be to purchase printers that support network connection and queuing from all machines.

Simple commands supporting indented and wide printing should be implemented.

8. Spares

It is desirable to maintain a stock of common spares, which includes monitors, SCSII devices, and power supplies.

IV. Staffing

Staffing is an issue that pervades all of the major categories in this report. In these areas skilled professionals should be sought after. This means that competitive salaries must be offered to attract qualified people. Many of the achievements in communications of the 93-94 season can be attributed to the ASA winter-over, Brent Jones, and Paul Eden at Malibar. Together they were able to improve the system after station closing. Such improvements have been historically sporadic and occur only when talented people are available for operations.

The challenge associated with supporting four hardware and operating system sets is recognized, but the productivity for research will be much higher if researchers are able to work within a familiar environment rather than spending valuable time at South Pole learning a new and unfamiliar system. We believe the investment in hardware, software, and staffing can be very modest relative to the cost of retraining researchers and of time lost from primary research objectives at South Pole.

A mixed computing environment is the norm for research groups, and system manager support is rarely given unless there are critical real-time requirements. It is not recommended that support staffing at South Pole be increased significantly to support the specified systems. Instead, new paradigms for support should be considered.

Recognizing that a single systems expert might be useful in McMurdo and even at ASA, South Pole might not have the expert on site for the entire summer season. With better communications to the station, experts do not necessarily have to be at the Station in order to help. Using remote logins, staff at McMurdo or CONUS may remotely assist with software support or other problems. We recommend the following division of labor between a systems Expert and a systems Manager to improve support at little added cost (in all cases below we refer to 'systems' as meaning ASA provided systems - researcher provided systems are the responsibility of that research group):

1. System Expert Duties

Experts should tune the computers, network devices, and communications gear near station opening and near station closing each year. It is believed that less than a week on site should be required for knowledgeable personnel to service these systems. The use of system experts will help ensure uniform performance. It is demonstrably true that, in the past, systems with which the system manager is familiar (and/or fond) have flourished while the remaining systems foundered.

The experts should be responsible for maintaining documentation, software upgrades, spares, and replacements as well as board level replacements and creating and documenting procedures for system backup, system recovery, and unit replacement. The experts should restore the systems to a standard configuration after the winter-over improvements, retaining those winter-over improvements that are judged to have enduring value.

Machines should be configured so that the experts can perform remote diagnosis, performance monitoring, security checks and software maintenance remotely.

The experts do not need to be on station during the summer, but should be available (by voice and network) for consultation with the system manager at other times during the year.

Specialized knowledge requirement - System Expert

Sub-unit replacement/repair (on station opening and closing)
Performance tests
Board additions
Software upgrades
System file maintenance
System reload files updates (to support unit replacement)
Parts inventory/ordering
System configuration maintenance and documentation

(2 site visits by 2 experts = 4 workweeks)

2. System Manager Duties

The system manager should be trained in backing up (and verifying) all systems, in unit replacement for failed systems, in performing security checks, and adding and deleting accounts and network addresses.

The system manager should be provided with simple and complete procedures for carrying out the above tasks. The backup/verify procedures should be automated to the extent possible. Each machine should have a standard reference system (provided by the expert) available on backup media so that the system manager can restore the functionality to a different machine should hardware failure, or a virus so require. To the greatest extent possible, the "transient" configuration information (such as user account information) should be kept separate from system software.

The system manager should be trained in restoring the system files for Macs and PCs, since those are files are most likely to suffer inadvertent modification by users. Users should be discouraged from modifying those files or adding software to the machines unilaterally.

The system manager should be trained in network configuration and network analysis, since an operable network is critical to correct functioning of the station.

Specific hardware support, such as installing network cards in PCs when requested by researchers, should be scheduled and provided separately from normal system manager support.

Basic knowledge requirement- System Operator

Backup and restore (all systems)
Complete unit swap
Network connections
Account additions/removals
PC/Mac config files

3. Research help

ASA should consider utilizing the skills and perhaps even training and letting small (1- 2K) contracts to knowledgeable individuals of research groups who would have been on site anyway as a part of their NORMAL research activities, to provide expert support while they are in residence at South Pole. This could improve the level of support of complex systems at very low cost, without impacting billets at the station.

V. General Items

The following costing and priority chart is approximate only. It is principally intended to provide a concrete example of the general requirements stated by the South Pole Users' committee. If rough costs differ by more than about 30% from these estimates (in either direction), or if a radically different set of options is envisioned by ASA engineering, then further design discussions should ensue between the Users' Committee and implementation engineers.

SCIENCE REQUIREMENTS IMPLEMENTATION PRIORITIES

-priorities = Very High (1), High (2), Medium (3)(lower priority items not on list) - 'priority yx' are given by year to facilitate spreading costs and scheduling

Object	rough cost	priority 95	96	97	Comments
Staffing	?	1	1	1	

improvements	?	1	1	1	
Workspace	15k	1	1	1	
Domain server	40K	1	1	1	Existing Sun, perhaps?
Segmenting subnet	0	2	1	1	3 Cisco, 2 Shiva
Novell off-load	30K 30K	1 2	1 1	1 1	Requires segmenting net
Computer replacement 4 MACs 2 ALPHA 2 SUN 2 PC	30K 15K	2 3	1 2	1 1	PPC ? if necessary for Science One Sun exists (Aspen)? Pentium

Object (continued)	rough cost	priority 95	96	97	Comments
PC Portables to LAN	3K	2	2	1	Xircon
MAC to LAN	4K	2	1	1	Shiva, Cayman, Asante
Review meetings	6K	1	1	1	at ASA?
TDRSS connection	?	3	2	1	
Remote phone	2K	1	1	1	capability currently exists
Fax	?	3	2	1	ops cost?
GOES-3	250K	1	1	1	replaced by GOES?
Marisat	360K/y	2	-	-	requires GOES
Multiplexed phone	?	1	1	1	large topic
Spares & docs (comms)	?	1	1	1	several solutions exist
Print services (for all machine types)	15K	1	1	1	backup and data transport
Archive storage hardware	15K	1	1	1	

In a broader view, we rate improvement in Communications as the highest scientific priority, followed by Networking, then Computing. If hard choices have to be made for immediate implementation, then the major request priorities are:

Throughput	1 Very
1GByte/day	High 3
2G/day Availability	Medium 1
2x6 hours/day	Very
24 hours/day Remote	High 3
Voice	Medium 1
Local Network	Very
modification	High 1
Computer replacement	Very
Fax	High 2
	High
	3 Medium

We strongly recommend periodic meetings among participants of the Science Users' Committee Working Groups and ASA personnel to discuss the actual implementation of requirements. In the past, recommendations from the users have, in many cases, gone unheeded or implemented in a manner not conducive for scientific research. Feedback from the science users in the planning process will help to ensure the best possible solution.