6.0 Findings

The Panel's review of existing policy regarding Antarctica and of ongoing activities in Antarctica has led to 22 findings which are presented in this section of the report.

6.1 Geopolitical Significance

The Panel examined the fundamental question of the value to the nation of the U. S. presence in Antarctica. In so doing, the Panel reviewed the historic basis of U. S. activity in the region, tracing in particular the evolution of U. S. involvement in Antarctica from the International Geophysical Year to the present.

The Antarctic Treaty, which entered into force in 1961, forms the basis of national policy for activity in the region. The Treaty reserves the region for peaceful purposes only; it neither recognizes nor disputes territorial claims and prohibits the assertion of new claims; and it protects the region's environment and ecology. These goals are in the national interest as stated in official documents and studies since the 1920s. The Treaty is the legal underpinning for governance of this non-sovereign territory.

Nevertheless, pre-existing claims of sovereignty still stand. But for the active presence of national research programs and commitment to the spirit of the Treaty, sovereignty claims could threaten peace on the continent and elsewhere. The leadership role of the U. S. in manifesting its presence in Antarctica in accord with the full spirit of the Treaty is instrumental in sustaining this instrument of responsible governance. The U. S. presence is powerfully expressed in the year-round operation of three research stations, and especially the station at the Earth's South Pole and the continent's geopolitical center. The U. S.'s scientific and environmental research in Antarctica give substance and relevance to the national presence.

6.2 Scientific Activity

The Panel concurs with the President's National Science and Technology Council's conclusions that the U. S. scientific effort in Antarctica is equivalent in quality to that conducted in the U. S. and elsewhere in the world, and that the science conducted in Antarctica either cannot be performed elsewhere or is best done in Antarctica. Much of this scientific research has potential significance for human health and welfare globally; e.g., studies evaluating the potential collapse of the West Antarctic Ice Sheet, an event which could result in an increased rate of sea-level rise; programs to monitor the ozone hole and its potential impact on organisms; and programs aimed at examining the impact of global warming on Antarctica's atmosphere, hydrosphere, cryosphere, and biosphere.

6.3 International Cooperation

The scope of international scientific research in Antarctica has expanded greatly since the field programs of the 1957-1958 International Geophysical Year which involved 12 nations. Twenty-eight nations now operate field programs in Antarctica. Seventeen of them in 1995 operated 37 year-round stations; these 17 and other nations also operated summer programs employing ships, aircraft, land facilities, and camps. The nongovernmental Scientific Committee on Antarctic Research of the International Council of Scientific Unions has grown to include 25 full-member nations and seven associate member nations. The Antarctic Treaty has grown from 12 signatories in 1959 to 43 in 1997 of which, in addition to the original 12 signatories, 14 have achieved consultative (voting) status because they pursue significant scientific activity in Antarctica.

Close scientific and logistics cooperation is maintained between the U. S., New Zealand and Italian programs, including shared space in New Zealand, shared transport to the Antarctic, and other cooperation, including that between McMurdo and neighboring New Zealand Scott Base.

A noteworthy example of international cooperation is an ice core project at Russia's Vostok Station in East Antarctica, where about 30 researchers from the U. S., France, and Russia are studying the ice record, expecting to trace back possibly 500,000 years. Studies of ice cores at Vostok already have shown a close link between climate and changing greenhouse gases in the atmosphere over the past 200,000 years. The drilling will penetrate to 12,000 ft. depth, just above Lake Vostok, a subglacial lake beneath Vostok Station. Lake Vostok and any life forms it may contain are hypothesized to have been sealed off from the atmosphere for hundreds of thousands of years. This program is a shared effort, both logistically and scientifically, among the three nations.

A very large international program underway at South Pole station is AMANDA, the Antarctic Muon and Neutrino Detector Array, which utilizes the Antarctic ice sheet as the detector for a neutrino telescope. AMANDA is a collaborative project involving scientists from the University of Wisconsin, Madison; the University of California, both the Berkeley and Irvine campuses; the University of Stockholm and the University of Uppsala, both in Sweden; the DESY (German Electron Synchrotron) Laboratory; individual scientists at NASA's Jet Propulsion Laboratory; and the U. S. Department of Energy's Lawrence Berkeley Laboratory.

It is evident that substantial effort has been devoted to integrating as closely as possible the operational planning and development of U. S. science programs with those of other nations. The trend is toward increased international collaboration in science.

While international cooperation at the individual and project level has existed for many years and is strongly supported by the Panel, international cooperation in logistics has only recently been regularized among the national programs. This latter form of cooperation is also strongly encouraged by the Panel. The mechanism for increased logistics cooperation is the Standing Committee on Antarctic Logistics and Operations, a sub-committee of the Council of Managers of National Antarctic Programs formed in 1990. Logistics managers from approximately 26 national programs come together annually to coordinate their operations and have increasingly begun to share resources where mutually beneficial. The Panel finds that this increasing cooperation, while perhaps not greatly reducing the cost of national programs, has nonetheless mutually increased the effectiveness of the programs, and should be encouraged.

International funding of basic infrastructure and facilities, however, appears to the Panel to go beyond the authority of the Council of Managers of National Antarctic Programs and into unknown and potentially hazardous legal terrain. The Panel found, considering the geopolitical history of Antarctica outside the reach of the Antarctic Treaty system, that joint funding and/or ownership of infrastructure and facilities may lead to substantial international legal issues while producing little or no fiscal benefit. The Panel is mindful of the experience of the space program in international cooperation, but draws a strong distinction between joint ownership of a space station — where there are no territorial issues in contention — and the joint ownership of a facility at, say, the South Pole.

6.4 Facilities

As has been noted, Antarctica represents a harsh environment. The U. S. presence on the continent and the science conducted there depend on the specialized infrastructure and logistics capabilities that enable the U. S. Antarctic Program. Indeed, many of the U. S. assets and programs in Antarctica are unparalleled in scope or capability. Key support facilities cannot, however, be viewed as having the same degree of merit, particularly when compared to the relative investments and modern character of facilities supported by other prominent Antarctic nations.

New Zealand's Scott Base, for example, has an infrastructure roughly equivalent to the U. S. South Pole Station. Its coastal location admittedly poses fewer logistical challenges than those confronted at the South Pole, and the scope of New Zealand's scientific research is less broad than that of the U. S. program. Nonetheless, Scott Base is a far more modern and comfortable facility — as well as being a safer facility — yet is supported by a country with a population roughly one-third that of Los Angeles.

Even recognizing the pioneering nature of Antarctic research and those who pursue it, U. S. facilities in Antarctica, especially at the South Pole, are, in the judgment of the Panel, far below the standards that we demand in our most basic working and living environments within the U. S., including Alaska. Not only are these facilities in Antarctica extremely costly to maintain, but many fail to meet fundamental safety criteria and construction codes and are becoming a growing impediment to the continued conduct of world-class research. Review of maintenance plans and examination of cost data as well as on-site inspections have caused the Panel to conclude that it is impracticable simply to further stretch the life of the current infrastructure at the South Pole.

Many of the facilities at McMurdo Station show serious signs of deterioration. While McMurdo especially, and the U. S. Antarctic Program generally, have made exemplary progress in such areas as waste management, major systems need systematic upgrading to maximize efficiency, minimize operating cost, protect the environment and assure safety. An example is the station's 17 above-ground, steel, bulk fuel storage tanks that were installed between 1955 and 1968. Two additional tanks were built in 1993. The tanks have a combined capacity of 8.7 million gallons. Inspection of the older tanks during the 1992-1993 summer season revealed a large number of fabrication defects and subsequent areas of damage (Exhibit 50). As a result of the inspection, one tank was

Exhibit 50

Most of McMurdo's tank farm is old, and many tanks require repair or replacement to safeguard the fuel supply (delivered once per year by ship) and the local environment.

taken out of service and has not been used since. The inspection report recommended replacing all of the tanks as soon as is practical. Bulk fuel storage needs secondary containment to protect the environment from fuel spills. Complete secondary containment would be difficult and expensive to apply to the tanks currently located on hillsides above the station, yet effective secondary containment should be incorporated.

The kitchen and dining hall in building 155, which feeds everyone on the station, has health-related deficiencies. Building 58, the mechanical equipment center, presents a fire- and life-safety risk. Warehousing is in 15 dedicated buildings and 10 other buildings with some warehouse space; none has sanitary facilities, and the disparate locations require extra vehicle use and employee time. The energy efficiency of many facilities is low; maintenance of numerous poorly insulated, small structures consumes additional fuel.

6.5 Provisions for Capital Asset Replenishment

The Panel concludes that the lack of a clear process to systematically identify and budget for capital renewal of Antarctic facility components has led, and will continue to lead, to erosion of the USAP physical infrastructure. A major issue is the inability within the NSF budgeting process to make provisions for out-year funding that can be dedicated to systematic infrastructure modernization. These costs cannot be accommodated on a year-to-year *ad hoc* basis by merely curtailing research activity during the years when major failures occur or investment demands become otherwise acute. Most major infrastructure modernization projects will by their very nature be multi-year and represent significant costs, the burden of which should be spread over time or otherwise funded.

6.6 Life-Extension of Existing South Pole Facilities

The fundamental infrastructure of the current South Pole facility was constructed in the 1970s. It replaced the original South Pole Station which was built in the era of the International Geophysical Year; that is, the late 1950s. The original station had a useful life of approximately 20 years. It was built on-grade, was plagued with drifting snow, became buried, eventually failed structurally and has now been buried completely by snow — nonetheless having served as the first permanent research platform and habitat at the Pole. The current station was also built on grade but uses metal arches and a geodesic dome as its fundamental structural components. The dome provides a relatively large, covered area protected from winds and drifting snow (Exhibit 51). The adjacent arches provide strong structures able to better withstand snow burial for major support components such as power generators, fuel storage and maintenance.

As the research activity at the Pole expanded, three modern elevated structures (Exhibit 52) were constructed, one for berthing and the others for science, and a water well system (Exhibit 53) was added that In

Exhibit 51

Snowfall at the South Pole is less than a foot a year (which compacts to four inches of ice), but drifting is continuous and any surface object accumulates drift. The geodesic dome was built on the surface in the early 1970s; the footings now are some 20 feet below the adjacent drift. The upper picture shows upwind drift, with typical wind scour. The weight of downwind drift (which does not scour) in 1989 snapped the steel foundation ring, since repaired. It is becoming increasingly difficult to control the drift with dozers. As has happened with earlier Antarctic facilities built on snow, the surrounding terrain of gradually rising snow (lower photo, made February 1997) will eventually collapse against the dome and other structures and will impose unacceptable loads.

Exhibit 52

Elevated structures at South Pole Station. Modeling and analysis provide convincing evidence that structures on stilts will minimize snow accumulation. This astronomy research facility with two telescope platforms, the Martin A. Pomerantz Observatory, was dedicated in 1994. Closed-cell-foam insulation and solar panels dramatically reduce fuel requirements. The observatory is across the skiway from the dome and its associated central station facilities.

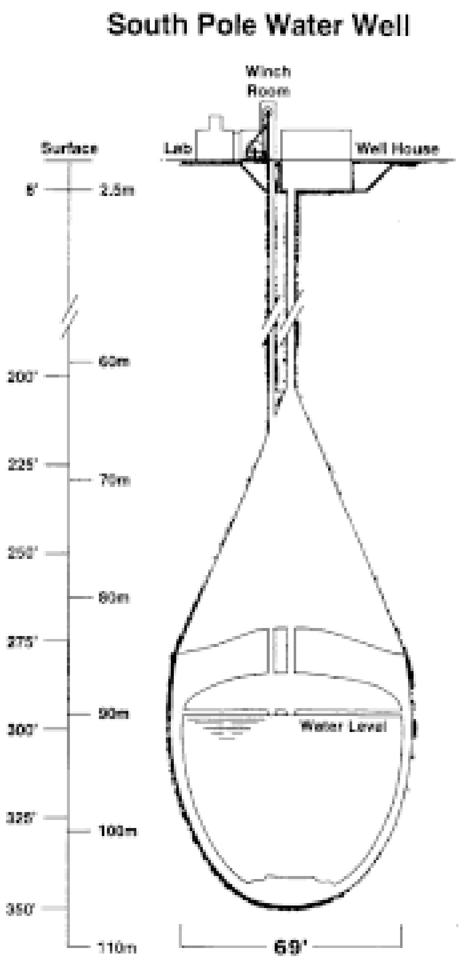

Exhibit 53

South Pole water well. South Pole Station sits on an unlimited supply of clean, fresh water— all of it frozen. Until 1994, traditional surface snowmelter technology was employed. This approach was labor intensive, cumbersome, and created a safety issue during daily trips to the "snow mine" in the austral winter. It only minimally met station needs.

Subsurface water reservoirs were first built in the 1960s for camps in Greenland. A similar design for South Pole was installed in 1992-93. The concept involves melting firn/ice at depth, creating a reservoir that can be pumped to the surface as needed. The impermeable firn/ice is both a container and an insulator. Being isolated, such a water well is less prone to contamination than is surface snow.

The well was made using a hot water drill to bore a one-ft. diameter hole to a depth of 230 ft. At this depth, the hot water jet melted an initial "bulb" of water. The drill was then replaced with a pump and a heating element consisting of an isolated circuit of fluid whose temperature is raised by heat exchangers on the exhaust stacks of the station's power plant. A numerical thermal model was developed to describe the relationships among water temperature and mass, reservoir size and depth and rate of change, and energy requirements as a function of time. The model shows that reservoir characteristics are strongly influenced by the rate and timing of potable water removal during the lifetime of the reservoir.

In early 1997 the reservoir was stable with an 80 ft. diameter and a 50 ft. height; the base of the bulb was 325 ft. below the snow surface. The reservoir contained about 180,000 cu. ft. of water compared to 70,000 cu. ft. of annual consumption. Waste heat from the power plant was more than adequate to maintain or grow the reservoir. Records from the first two years indicate that the well can be sustained for at least ten years. The well has reduced the cost per gallon of water from 75 cents to 10 cents and the annual cost from $422,000 to $57,000. Micrometeorites recovered from the well are being used in research.

Exhibit 54

These insulated canvas and wood structures, called Jamesways, were developed by the Army in the 1950s for use in the Korean War. Although heated, they lack plumbing and other amenities, but they can be assembled and taken down quickly and are air-transportable. The USAP still uses them for temporary camps at remote locations and for summer and emergency housing at South Pole Station.

dramatically increased the water available for use under the dome. Expansion of the summer population was handled through the use of Jamesway (Quonset-hut-like) structures for berthing (Exhibit 54).

There has been a continual evolution of the major utility and life support systems as the demands placed upon them grew with the increased level of activity at the station. These changes have been in the form of add-ons as opposed to replacements of major components. Simply stated, many of the major components of the current South Pole Station are at the end of their operational life.

The South Pole Station core facility, now in place for nearly 25 years, would take at least eight years to replace due to the short construction season and complex logistics train. The structural characteristics of geodesic domes have many advantages over standard post and beam construction, but are subject to structural failure if differential foundation settlement occurs. Several structural members did in fact fail in the late 1980s due to differential settling. In 1989, a major project was undertaken to repair and re-level the dome. Since that time, the snow elevation on the dome has been carefully controlled and annual surveys are performed to monitor the structural integrity of the facility. Currently, the elevations of the dome footings are within acceptable tolerances, but with each passing year the snow management effort grows and the probability of large differential settling increases. Consideration has been given to raising the dome, but that would only delay the structural failure of the dome and not correct the other basic deficiencies in the station.

The major structures at the pole in most cases do not meet current construction codes that serve as minimum standards in the U. S. Although some of the substandard conditions in the existing facilities are attributable to the trend toward more stringent codes and some can be eliminated through upgrading, to do so requires further investment in aging structures that have limited additional life expectancy and entail high maintenance costs. The already planned and funded upgrade of the vehicle maintenance facility, power generation plant, and fuel storage facility are critical to the continued use of the station, but they too do not address the underlying issue of the overall deterioration of the facilities in an unforgiving environment.

6.6.1 Cost Assessment Working with Decision Support Associates, Inc., the Office of Polar Programs developed an analytical model to conduct cost/benefit comparisons for various options for either rehabilitating the existing South Pole Station or building a new station. These studies combine conventional cost/benefit analysis and Monte Carlo computer simulation. Using standard failure probability distributions for each significant component of the station, 1,000 simulations were run for each option to determine the median expected cost and the 20 percent and 80 percent confidence intervals. All of the options considered assume the replacement of the garage (Exhibit 55), fuel storage (Exhibit 56) and power plant, as already approved in the FY97 budget for the South Pole Safety and Environment Upgrade Project, and therefore do not include the costs of these upgrades.

Exhibit 55

The South Pole Station garage (shown) is crowded, poorly ventilated and seriously contaminated with grease. Administrative measures, such as limiting mechanics' hours, have been taken to preserve worker safety and health. The Congress provided funds to the NSF in FY97 to replace this structure with a more suitable facility that will add to the efficiency and safety of station operations.

Exhibit 56

Nine 25,000-gallon rubber bladders were installed during construction of the 1970s Existing Station to hold more than a year's supply of diesel fuel. Funding for replacement of the bladders with steel tanks was provided in FY97.

the cost analysis of options involving construction of a new station, a total of $5 M for temporary quick fixes of random failures in the existing station has been included. Normal maintenance has not been included in any of the initial costs used to compare various options. However, for comparison of total life cycle costs (FY98- FY25), operating and maintenance costs were included throughout the period.

Four principal options for preserving a viable South Pole presence have been considered by the Panel, and appropriate cost data have been developed in conjunction with each option.

- *Option 1 -* Rehabilitate the Existing Station
- *Option 2 -* Rehabilitate the Existing Station and Incorporate Safety Features
- *Option 3 -* Construct an Enhanced New Station (Option defined prior to this review)
- *Option 4 -* Construct an Optimized New Station (Reduced cost relative to above Enhanced Station)

For the purposes of comparing the four options, all costs are expressed in FY97 dollars ... that is, no provision is made for future inflation.

The costs and benefits of each of these four alternatives are discussed in the following four sections of this report. Unless otherwise noted, all costs in Section 6.6.1 are in FY97 dollars to simplify the comparison of the various options. Thereafter, in addressing the matter of actually programming funds, then-year dollars will be displayed.

6.6.1.1 Rehabilitated Existing Station In this option, the life of the Existing Station (Exhibit 57) is extended by replacing systems as they fail or, where possible, as they approach failure. The features and

Exhibit 57

Existing Station (1989 photograph). The geodesic dome and the arches shelter mechanical systems and insulated structures within. This core facility has been in use since 1975. The arches had not yet been completely covered by drift when this photograph was made. Photo © 1989 Neelon Crawford.

capabilities of the replacement systems would be similar to existing systems, except that the new items would, where practicable, be upgraded to comply with current safety codes and standards. Most noteworthy, however, is that under this option certain aspects of the station — fire suppression systems, confined space in the utilidor, and emergency egress from the dome and arches — would remain unchanged due to the impracticality of upgrades. Under this option, the installation of replacement systems is constrained to fit within the existing dome and arches. The electrical systems would be replaced insofar as practicable to meet current industrial standards but no new capabilities or capacity would be provided.

The cost model for the Rehabilitated Existing Station was based on statistical predictions of the useful life of 20 individual systems. As already noted, the three most urgent system replacements (power, fuel storage, and garage) funded under the FY97 appropriations are not included in the cost model, although the implementation work remains to be accomplished. Of the remaining 17 systems, 10 have "most likely" failure dates prior to 2003 (Exhibit 58).

Since many of the existing systems are nearing the end of their useful life, it is likely that some will fail before their scheduled replacement. If a temporary fix can be made to allow a malfunctioning system to operate until a replacement system is available by sea transport, as is assumed herein, the median expected total cost of this option (FY97 dollars) is $79M through 2002. The corresponding cost through 2025 is $135M. Were this life extension option to be chosen, the most economical and effective strategy would be to begin

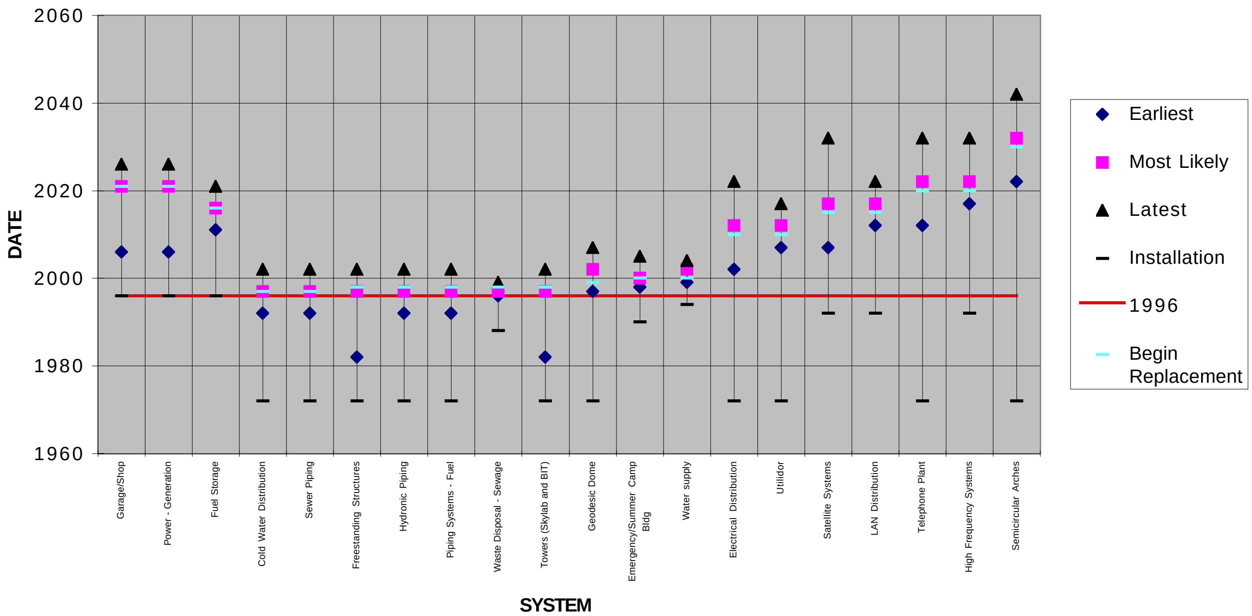

Exhibit 58

This graph predicts the earliest, latest, and most likely year of failure of 20 existing South Pole Station systems. It is part of a study performed by Decision Support Associates for the National Science Foundation.

replacing systems before their most-probable failure dates. This approach was used in developing the costs that form the basis for comparing the various options.

6.6.1.2 Safety Upgraded Station This option is identical to the Rehabilitated Existing Station option except that station-wide fire suppression is provided, exit stairways are added to the dome and arches, and, because of extremely confined space, the undersnow utility corridor (utilidor) (Exhibit 59) is replaced. The median total expected cost (FY97 dollars) is $88M through 2002 and $144M through 2025.

6.6.1.3 Enhanced Station The Enhanced Station option resulted from a long-term planning effort over the past several years to provide a facility that would offer the most potential for science productivity at the South Pole (Exhibit 60). It provides for living accommodations, science laboratories, communications, and administrative areas to be relocated to an elevated three-building complex adjacent to the existing facilities. Industrial functions such as the garage, power plant, fuel storage, sewage treatment, and warehouses variously remain in the existing arches or new arches. All current open storage is relocated so as to reside within the arches, and all existing buildings and utilities within the dome and arches are removed from the continent. Electrical and electronic systems are replaced with state-of-the-art equipment. The dome is dismantled and removed from Antarctica in keeping with established environmental practices. Exhibits 61 and 62 compare the design parameters and capabilities of this option with those of the current station.

Exhibit 59

The utilidor, or utilities tunnel, through the ice beneath Amundsen-Scott South Pole Station is -50˚F. Plumbing leaks in this aging system must be stopped quickly to minimize the buildup of additional ice on the floor. Because of the confined space, tools and parts must be brought into the utilidor by hand.

The proposed concept utilizes two forms of modularity. First, the structural system will be modular and panelized to facilitate standardization of components. Because of size limits of the LC-130 transport aircraft, modular “room size” building blocks cannot be

Exhibit 60

Enhanced Station option (artist's conception). Dashed lines indicate the arches of the Existing Station (by then to have been buried by drift); the arches are used in the Enhanced Station for storage and other functions. The Existing Station's dome is removed from Antarctica.

used, but the floor and roof panels will conform to a standard module size of approximately 7-1/2 ft. wide and up to 34 ft. long. The second level of modularity will be on a much larger scale. Each wing of the two main elevated buildings will be modular in nature to allow phased construction and ease of modification should that be desired in the future.

The cost model for the Enhanced Station is based on a rather detailed estimate generated in 1995, modified to exclude the aforementioned $25M cost of the new power plant, garage, and fuel tanks that have already been funded in FY97. The median expected cost for the Enhanced Station is $150M through 2002 and $189M through 2025.

6.6.1.4 Optimized Station The Optimized Station option is similar to the Enhanced Station option except that as a cost saving measure the elevated complex is reconfigured to two buildings rather than three and various systems are reduced in scope or deleted to reduce costs (Exhibit 63). The below-grade elements are unchanged from the Enhanced Station

Service Provided	1996 Conditions	Enhanced Station	Optimized Sta.
Population			
Science Personnel - Summer	43 scientists	46 scientists	Same
Support Personnel - Summer	67 persons	64 people	Same
Construction Personnel -Summer	65 persons	None	Same
Winter Population	26 total with 7 scientists and 19 support	50 total with 19 support. Additional mix of population will depend on science tasking	Same
Fuel storage capacity			
Diesel Fuel	225,000 gallons (bladders), being replaced with 300,000 gallons (steel)	400,000 gallons (steel)	Same
Area Comparisons (sq.ft.)			
SPSE			
Heated Space	N/A	15,274	15,274
Unheated Space	N/A	11,117	11,117
SPRP			
Heated Space	N/A	79,688	74,554
Unheated	N/A	30,104	28,324
Totals			
Heated Space			
Science	11,500	16,126	15,754
Support	32,894	78.836	74,074
Unheated Space	57,753	41,221	39,411
Combined Total	***102,147***	***136,183***	***129,269***
Satellite Communications			
ATS -3	6 hrs @ 1.2 kb/s, no internet capabilities	6 hrs @ 1.2 kb/s, no internet capabilities	Same
LES-9	7 hrs @ 28-36kb/s, internet capabilities	7 hrs @ reduced rates	Same
GOES -2		5 hrs @ 64 - 128 kb/s	Same
GOES 3	5 hrs @ 512-1,544kb/s, internet capabilities	5 hrs @ 128 kb/s, internet capabilities	Same
LAN access	Limited science and support areas	All science and support facilities as well as access being available in bedrooms	Same
LAN Distribution	Simple IEEE 802.3 Ethernet, limited subnetting; mixed coaxial/fiber backbone, non redundant	High bandwidth, high reliability backbone with fully managed components, state of the market design	Same
Telephone	Ham and satellite patch capable	Direct public network telephone via satellite, duplex	Same

Exhibit 61

Capabilities of Existing, Enhanced, and Optimized South Pole Stations. In area comparisons, SPSE (South Pole Safety and Environment Enhancement) is work funded in FY97. SPRP (South Pole Redevelopment Project) is the work considered for funding in FY98-FY02.

Service Provided	1996 Conditions	Enhanced Station	Optimized Station
Water Distribution	Dome and arches. Summer camp has individual systems in bathroom modules	Habitat and science areas in the elevated facility	Same
Electrical Distribution	Upgrades have corrected code deficiencies. Limited EMI suppression. Limited flexibility	Improved distribution with enclosed cable trays, designed EMI mitigation system, efficient, clean electrical distribution	Same
Emergency /Summer Facilities	Upgrades ongoing to emergency power and berthing facilities but they remain marginal. Snow drifting maintenance concerns. Substandard exiting from sleeping rooms and no fire suppression	Emergency facilities will be provided within the elevated facility with the emergency power plant and berthing with in a single wing. All berthing facilities within the elevated facilities will have fire suppression	Same
Main Station Facilities	Below grade habitat needs replacing due to aging, thermal efficiencies and non-compliance with current codes	All habitat facilities will be above grade maximizing the use of renewable energies, minimizing drifting, thermally efficient, and in compliance with current building codes	Same except delete fuel cell and wind turbine. Photovoltaic and other renewable projects remain
Geodesic Dome	Existing structure is a snow drift concern, a fire /smoke concern and has limited usable space within the facility	The enclosed heated space existing within the dome would be provided in the elevated structures	Same
High Frequency systems	Manual HF radio operations, aging infrastructure, SSB PTT voice	Automatic HF radio system, new infrastructure	Same
Arches	Current arches are effective enclosed cold facilities	New concept maximizes the efficient utilization of the existing structures	Same
Sewer Collection	Sewer is undergoing constant maintenance of four isolated systems	New distribution systems will be incorporated in the elevated facilities and connected to subsurface utilidors reducing the number of systems	Same
Sewage Disposal	Discharge into four sewer sumps in the snowfield	Based on results of environmental studies and technological advancements, sewage disposal systems may be incorporated into the station. One sewage sump will service the entire station	Continue with current procedures
Utilidors (sub-grade utility ducts	Space limited; violates OSHA standards for confined space	Maximize use of enclosed passageway in elevated station and arches. Utilidors where required will meet confined space requirements	Same
Water Supply	Current facilities require three water supply systems to accommodate summer camp and the one in the main station	The water supply for this facility will come from a single treatment source. The supply will be the sub-snow-surface water well	Same
Precision Approach Radar	None, removed in the 95/96 season	Replace system that was identified in the 1994 programming documentation	Deleted
Hydroponics	80 sq.ft.	480 sq. ft	300 sq.ft.

Exhibit 62

Design parameters of Existing, Enhanced, and Optimized South Pole Stations. EMI = electromagnetic interference. SSB = single sideband. PTT = push to talk.

option except for the sewage treatment and alternate energy arch, which are deleted.

Exhibit 64 summarizes the $30M reduction in cost relative to the Enhanced Station due to reduced requirements, lower cost of implementation, and deletion or deferral of energy technology and environmental technology development.

6.6.2 Comparison of Costs Exhibit 65 compares the costs of the various options considered by the Panel.

Sensitivity analyses were conducted to determine confidence levels for the cost estimate associated with each option. It was found that these variances are essentially the same for each case considered, with the 80 percent confidence level adding approximately $6M in each instance. The Panel has not included any contingency provision, although it notes that this represents a departure from commercial practices.

The Panel concluded, as will be discussed in Section 7, that the most cost effective alternative, in terms of function and total cost to the government, is

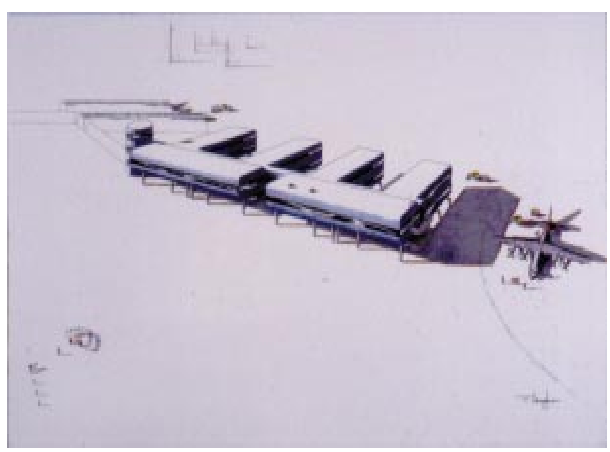

Exhibit 63

Optimized Station option (artist's conception). Dashed lines indicate the arches of the Existing Station (by then to have been buried by drift); the arches are used in the Optimized Station for storage and other functions. The Existing Station's dome is removed from Antarctica.

$M	Items Reduced or Eliminated
Reduced requirements	
1.5	**McMurdo aircraft fuel storage.** With the reduction in fuel usage at McMurdo during the past four years due to better energy efficiency, additional projected storage requirements have been eliminated.
5.6	**Precision radar.** Extensive review of the requirement for precision radar landing assistance at South Pole has been ongoing for two years. The Navy and Air National Guard concluded in 1995 that the precision radar may not be beneficial, and have been operating without precision radar for the past season without adverse impacts on safety or operations.
0.7	**Mobile laboratories.** Two mobile laboratories, one for chemistry and one for snow and ice research, were identified as a requirement by the science community in 1989, but current funding will not allow expansion in these fields at present.
1.9	**Tunnel to dark sector.** A personnel tunnel between the main station and the dark sector was determined in the early 1990s to be desirable for safety reasons. The tunnel would also function as a utilidor for power and communications. Experience during the past 3 winters has shown that personnel can commute to the dark sector on foot without a tunnel, and utility cabling can be buried. The tunnel is desirable, but is not an absolute requirement.
Value engineering	
10.6	**Number of buildings in station.** Floor plans were revised to consolidate functions, improve space utilization, and reduce utilities/mechanical requirements relative to the earlier three-building design. The greenhouse was reduced in area. The 1,200-line-item schedule and estimate were revised for the two-building concept. The ability to expand the station at a future time still exists, but expansion will be slightly more difficult.
0.7	**Marisat.** Marisat, to a considerable extent, duplicates capabilities that will be provided by the GOES satellite system which is included.
0.4	**Aviation computing.** This requirement can be met with the proposed new station computing system.
Energy/environmental technology deferral	
2.0	**Fuel cells.** The technology of fuel cells that operate on JP8 has not yet advanced sufficiently to allow their deployment as part of a new station. The Office of Polar Programs will continue to monitor their development and use them when cost effective.
1.8	**Wind power.** Recent analysis indicates that wind turbines at South Pole are probably not cost effective. Photovoltaic and solar heating appear to be cost effective and remain in the plan.
4.6	**Sewage treatment.** NASA is developing a prototypical sewage treatment system for South Pole Station. The system is in a preliminary development stage and its performance is unverified at this time. The cleaner effluent produced by wastewater treatment would still be discharged into the ice sheet. Wastewater treatment would increase operations and maintenance cost for relatively modest environmental gain. The Office of Polar Programs environmental officer agrees that sewage treatment can be deferred and incorporated at a later time using proven technology. The Memorandum of Agreement with NASA needs to be reviewed to clarify NSF obligations on this development project.
$29.8M	**Total cost reduction**

Exhibit 64

Reductions (in FY97 dollars) from the Enhanced Station option to achieve the Optimized Station.

	Through 2002 (construction and quick fixes)	Through 2025 (construction, quick fixes, operation and maintenance)
Rehabilitated Existing Station	$79M	$135M
Safety Upgraded Station	88M	144M
Optimized Station	120M	159M
Enhanced Station	150M	189M

Exhibit 65

South Pole Station median expected cumulative costs (FY97 dollars). Costs through 2002 include construction and quick fixes of systems that fail in the existing station while it is still in use. Life-cycle costs through 2025 include construction, quick fixes, operation and maintenance. Note that the life-cycle cost difference between the Safety Upgraded Station and the Optimized Station is approximately 10 percent.