Facilities Plan and Protocol for the Support of the National Science Foundation-Sponsored Greenland Ice Sheet Project Two: Deep Ice Core Drilling Effort

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FACILITIES PLAN AND PROTOCOL FOR THE SUPPORT OF THE NATIONAL SCIENCE FOUNDATION – SPONSORED GREENLAND ICE SHEET PROJECT TWO: DEEP ICE CORE DRILLING EFFORT

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1. INTRODUCTION

The Polar Ice Coring Office (PICO) is operated under contract by the University of Alaska for the National Science Foundation (NSF) Division of Polar Programs. One of PICO's responsibilities is to provide logistical support and field operations management to NSF-sponsored research programs in Greenland. In addition to PICO's main office at the University of Alaska Fairbanks, it operates a field office at Sondrestrom Air Force Base in Greenland.

A major activity of the Polar Ice Coring Office is to supply logistical services for the second year effort of the Greenland Ice Sheet Project (GISP-2) which includes the development of a deep ice coring drill and the support system associated with it. The program objective of GISP-2 is the recovery of a high quality, continuous ice core through the Greenland Ice Cap (3,200 m). Analysis of the ice should provide a record covering 200,000 years or more of paleoenvironmental history.

2. FACILITIES

A goal of PICO, associated with its support of this large multi-institutional and interdisciplinary research program (GISP-2), is to establish effective design criteria which might be applied to polar research programs (elsewhere in future years). These criteria include the design of structures, provision of fuel and subsistence materials, water supply, waste management and pollution control. PICO's many years of support of small field projects and the GISP-2 program affords it an opportunity to investigate new technologies to improve field research safety and productivity.

2.1 The GISP-2 Camp

The GISP-2 camp is located near the summit of the Greenland Ice Sheet (72°35'N, 38°27'W at 3,200 m elevation). The drilling structure and subsurface core processing facilities are the focus of GISP-2 interest. Because it is imperative that all due caution be observed to ensure that the ice cores will not be contaminated from anthropogenic sources, these two facilities are sited in a zone of restricted surface activity (clean air zone).

2.1.1 Drill Shelter

The drill and its support system must be sheltered. Because of its size (about 25 m), the drill and drill support system with its 30-m tower will be housed in a 16-m-diameter geodesic dome constructed of lumber and glassfiber coated panels.

We consider the geodesic dome to be an effective structure for field operations on the basis of space utilization, ease of erection and cost.

The geodesic dome fulfills two requirements (Fig. 1). The free span of the geodesic dome provides unrestricted open space to house the drill and its support system. Such a large structure located in an area of drifting snow is a nucleus for snow drift accumulation. Accumulation of snow and the control of drifting snow is of great concern to effective camp management. Single-story structures, for example, left unattended may be buried under snow completely within one year.

Figure 1. A geodesic dome allows a drift-free zone to surround it. This dome is currently buried under 5 m of snow. Window glass in the frame has not cracked, demonstrating negligible strain. The dome is a 10 m, 3 Frequency Daystar.

Past experience with dome structures has shown that the wind tends to scour snow away from the periphery of the base of the dome. Thus, drifting is confined to locations farther away from the dome, providing extended access to the facility with reduced snow removal requirements.

2.1.2 Ice Core Processing and Storage Trench

Once the ice is retrieved, it must not be allowed to undergo any extensive thermal or mechanical shock. Soon after the core is removed from the core handling system, it is relocated in the core processing facility. This facility is located in a trench cut in the snow and covered with a roof (timber and plywood).

An excavated subsurface passageway connects the drill shelter to the core processing facility and storage areas. This buried facility allows working temperatures to be maintained in a desirable range (-15°C). This facility contains about 290 sq. meters of cold laboratory space. Additional buried and isolated laboratory space is provided for experiments.

The main GISP-2 support camp is located about 350 m downwind from the prevailing wind direction from the science facility. The GISP-2 support camp comprises three types of structures:

- Two 10-m-long air-transportable power and bath modules provide utilities, domestic potable water and bathing modules.
- Berthing, shop and storage facilities consist of insulated fabric-covered structures. This type of structure is light weight and assembles quickly and easily.
- A single semipermanent structure (Fig. 2) will be constructed of pre-engineered wall and roof panels. This approximately 16×8 m building will be erected on top of a 4-m-high steel superstructure and packed snow berm. The use of pre-engineered panels facilitates construction on-site with a limited trained work force. The facility is elevated above the snow surface to provide unrestricted access to the building throughout the life of the project. This structure is provisioned with its own power and utility services.

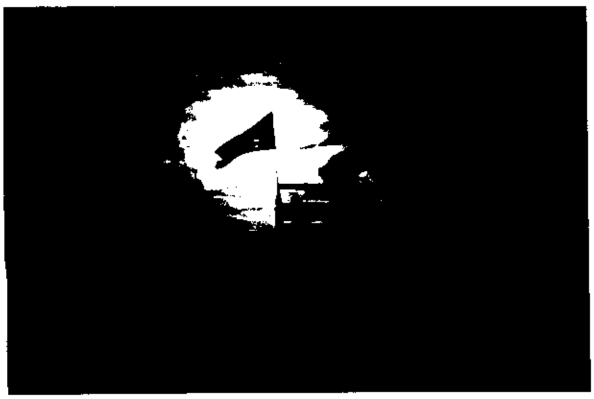

Figure 2. Steel legs are positioned on a snow berm to support the GISP-2 administration and dining facility on the Greenland Ice Cap. The building is prefabricated and will be placed on the legs during summer 1990.

3. COMMUNICATIONS

High frequency (HF) packet radios provide primary communications between the GISP-2 camp and the PICO office at Sondrestrom Air Force Base. Packet HF radios greatly improve the efficiency and accuracy of information transferred from the field over traditional HF voice communication systems, especially at these high polar latitudes. Status reports, resupply requests, and occasional drawings are transmitted with low error rate to and from the site.

Back-up communications to the site are provided via an INMARSAT Standard C Telex system. This satellite communications system is intended to support camp operations during periods of increased atmospheric disturbances that may render HF radios useless. This function is particularly useful when there is a requirement to pass aviation weather in support of aircraft operations. The added benefit of satellite communications is access to the world telecommunication network from even the most remote polar regions.

4. AIR SUPPORT

All cargo and passengers delivered to site are transported by air. Air support is provided by the U. S. Air Force, 109th Tactical Airlift Group (109th TAG) . The 109th TAG operates four LC-130 ski-equipped Hercules aircraft (Fig. 3).

Figure 3. Ski-equipped LC-130 flights from the 109th TAG New York Air National Guard supply the research sites on the Greenland Ice Cap.

With a flight distance of nearly 720 km, the LC-130 can deliver five tons of cargo to site landing in the open field. With a prepared landing strip, the cargo delivery is increased to 12.5 tons. Over the course of the project, it is worth the effort and resources required to maintain a prepared landing strip. Given the elevation of the site (3200 m), a 60×3000-m landing strip is required.

In addition to the LC-130 aircraft, minor resupply, passenger movements and possible medical evacuations will be accomplished via Dash-6 Twin Otter aircraft. However, the combined effect of high elevation and distance to the site render the Twin Otter's effective payload to near zero as the aircraft must be completely refueled on site.

5. MODULAR DESIGNS CONSIDERATIONS FOR FUTURE POLAR OPERATIONS

Although the technology associated with scientific research activities in the polar regions has advanced, field facilities and logistic support systems have lagged. Planning for the GISP-2 program incorporates new technologies. However, PICO personnel in association with faculty of the University of Alaska Fairbanks School of Engineering and a local architectural firm (GDM, Inc.) discussed future improvements with the following criteria /1,2/ in mind:

- Cost effectiveness: To be cost effective, facility and logistic support systems must be flexible in use and reusable in different seasons and locations.
- Health and safety design: This is of prime importance. Materials for construction must be nonflammable, nontoxic, resistant to chemicals in laboratories and easily cleaned and maintained.
- Transportability: Physical size of any single module should conform to transport by LC-130 aircraft. Dimensions should be set at 8' wide by less than 8' high by 40' long (2.34 m by 2.34 m by 12 m). The weight limitation is 19,000 lbs (8,550 kg) for ski-equipped aircraft.
- Erectability: Facilities and support systems should be quickly erected.

- Energy efficiency: Most existing systems are energy inefficient. Alternative energy sources and materials should be considered.
- Climatic design: Modules should be designed for use in a wide range of climates, for example -73°C to +37.8°C. Wind load design should be 120 mph (190 km/hr) with snow loads established at 80 psf (400 kg/m^2).
- Functionality: The facility and systems must be flexible in use and usable over several seasons at different locations.
- User recognition: Comfort and well-being to the user and staff has to be provided. Private industry in northern Alaska has found that workers' efficiency and morale can be significantly enhanced with improved working and living conditions.

A prototype system has been developed (GDM, Inc., Fairbanks, Alaska) that meets the above design criteria. This prototype has the capability of providing not only temporary remote support, but also the potential of being adapted for more permanent facilities /3/.

5.1 Modular System

The basis of this system (GDM, Inc., Fairbanks, Alaska) is an 8'× 8'×20' (2.4 m×2.4 m×6 m) module shell common to all functional units. Size selection is based on basic ISO container requirements and the ability to load two modules into a LC-130 aircraft. This module is a light weight, composite structural shell attached to a structural base and frame. Added to the interior of this shell is rigid insulation and wall finish. Through use of this construction material, a highly durable, integrated structural system is achieved at a relatively low weight and small sacrifice of interior space. The weight of a standard unit is approximately 4,000 lbs (1,800 kg). A lighter weight module is available for special use.

Standard module shells can function as separate units or in combination to form a larger entity. Individual modules are hardwall units composed of thin fiberglass/rigid foam structural panels integrated with a metal structural frame. The foundation system can be handled by forklifts, overhead crane or towing.

With the exception of the specialized mechanical module, others can be easily modified or retrofitted to meet specific needs. Each unit is designed with solar panels and gel cells; but the whole system is easily backed up with a generator sized to supply basic energy needs. In large camp systems, a mechanical module houses the main generator to which each module is connected.

Each module is provided a gravity waste and potable water system with the capabilities of networking in a large camp facility. Holding tanks collect wastewater until removed from the site for disposal.

The primary heating system consists of diesel fired heaters placed in the mechanical areas. All fuel requirements of the system are based on diesel for commonality of fuels. Fresh air intakes and other venting requirements are achieved through the use of a non-snow clogging design developed by GDM, Inc. (Fairbanks, Alaska) and used successfully for a number of years on arctic projects. There are no penetrations through the module's roof system; rather they are designed as side mounts or beneath the unit. As an integrated system, placement of individual modules in a camp setting is governed by prevailing winds, anticipated scientific activities and logistical activities to insure non-contamination of critical environments.

One of the most critical and expensive aspects of scientific research in the polar regions is the logistical support. New technologies today make it possible to provide scientific and life support systems that are more cost effective and 'user-friendly' than conventional systems using older technologies. All systems must be designed to be reliable and easily maintained by the user.

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