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PORTABLE HABITAT FOR ANTARCTIC SCIENTIFIC RESEARCH (PHASR)

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Abstract

The Portable Habitat for Antarctic Scientific Research, PHASR, is designed as a versatile, general purpose habitat system that addresses the problem of functional space and environmental soundness in a partially fabric-covered shelter. PHASR is used for remote field site applications that call for an easily transportable, compact habitat that can be quickly deployed. PHASR will also provide four scientists with a comfortable and efficient use of interior space.

PHASR is a NASA/USRA Advanced Design Program project conducted at the University of Houston College of Architecture, Sasakawa International Center for Space Architecture (SICSA). This report is prepared for NASA/USRA.

Introduction

The need for an environmentally safe portable field habitat for use in the Antarctic was realized after research for an Antarctic Planetary Testbed (APT) as well as a South Pole Station was undertaken by SICSA. Currently, the United States uses 2-man tents and huts for field research in the dry valleys and on the ice. The 2-man tents are 6 ft by 6 ft double-walled canvas with a 15 cm airspace. When using these tents, researchers place cold weather sleeping bags on the ground or ice. Cooking is done on a portable diesel stove. Huts of canvas and wood are constructed if the project is expected to last more than one season. The size is dependent upon the number of crew members. As research efforts in the Antarctic increase, better habitation must be considered. The range of research performed in the Antarctic includes biomedicine, geology, geophysics, meteorology, etc. A habitat that is flexible enough to meet the requirements of a variety of scientists and to provide an atmosphere conducive to that research is greatly needed. With importance being placed on preserving and protecting the Antarctic environment, it is imperative that a habitat be designed that supports these efforts as well.

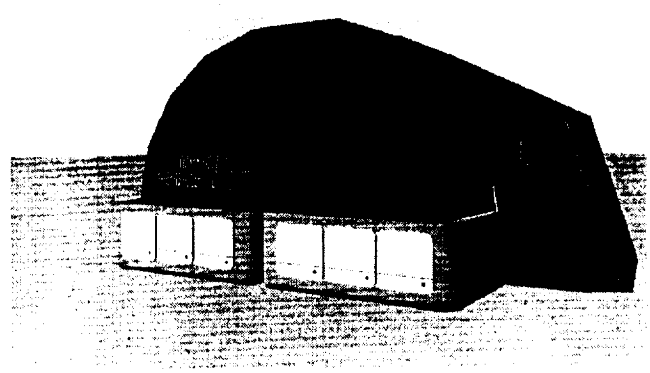

Fig. 1 3-D computer model of a deployed PHASR

Requirements

To meet habitat objectives, it was determined that PHASR should meet the following design requirements:

1. Ergonomically responsive
2. Easily transported by a broad range of transport methods

3. Easily deployed/assembled
4. Easily recovered and reusable
5. Environmentally safe

Design

An investigation of the different geometric shapes feasible to form the exterior of the habitat was undertaken. To accomplish this, a volumetric trade-off study was used to determine which shapes performed best. Design studies were evaluated on the basis of wind and snow load, solar capability, volume, deployment, and rib structure. This study helped to justify many of the beginning design decisions that were made. The shape chosen for PHASR met minimum space requirements for a crew of four and also gave them maximum standing space.

Issues deemed necessary for the design include an ergonomic interior and the need for self-containment. By providing modules that break apart and reassemble to form an actual "interior," an ergonomic situation is achieved. Modules also contain fresh water and gray water storage so that the Antarctic environment remains unscathed. The system proposed in PHASR will provide better crew comfort, flexibility, and variability in the interior elements. PHASR contains the following four zones:

- Zone 1 - Workstation
- Zone 2 - Galley Area
- Zone 3 - Hygiene Area
- Zone 4 - Crew Quarters

Also, dividing PHASR in half separates the public and private areas that will assist in noise control and ease of circulation. A general configuration was established from information produced in the volumetric design studies. Then crew tasks and operations were considered.

The determination of characteristics of crew tasks and operations required to perform functions included frequency, duration, sequence, and volume. Also considered were special environmental requirements, privacy, and personal space requirements.

With the incorporation of the information above, the layout of PHASR maximizes the amount of horizontal and vertical space, accommodates the expected levels of activity at each station, provides the ability to isolate the work environment from the more private rest/relaxation areas, and provides a safe, efficient, comfortable work and living environment.

Zone 1 - Workstation

The workstation area is located in the front of PHASR. It provides general scientific and technical support functions such as communications and lap-top computer systems.

It is within the workstation area, aside from "extravehicular" activity, that the majority of stress-related duties will occur. The workstation area can accommodate a crew of four.

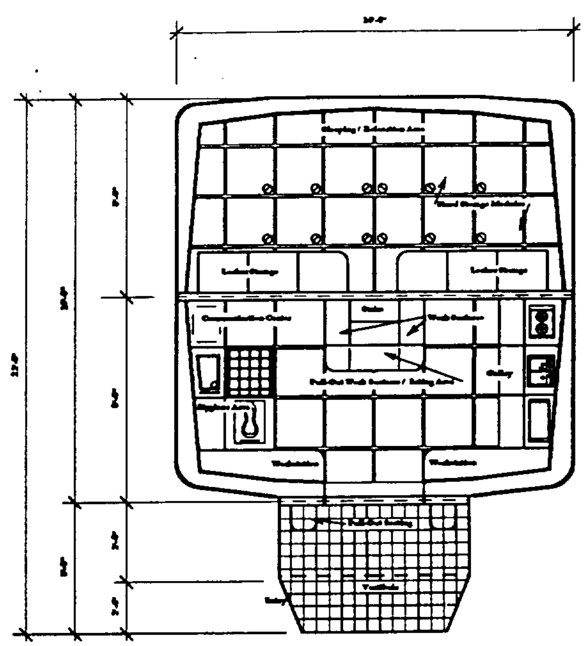

Fig. 2 Plan of PHASR

Preliminary concepts for the workstation area focused on creating a workspace geared toward individual tasks and team task configurations. Because space was limited, foldout and pullout work surfaces were used for additional desk space. The work surfaces near the stairs may be used if a group discussion area is desired. These are some examples of PHASR's flexible working and living spaces that can be easily adapted to specific needs of different scientists. In addition, the geometry of the stacking interior elements were used to create unity between the interior and exterior.

Workstation requirements include:

- Ergonomic support of work activities
- Efficient use of volume
- Separation between work and sleeping/recreation
- Areas of privacy
- Vertical storage
- Capability for small repairs
- Capability for data processing

The workstation components include:

- Communication center
- Audio transmission
- Intercommunication system
- Computer
- Maintenance center
- Equipment stowage

The four workstations provide computer capability for documenting and processing research. The communication center provides audio communication and intercommunication. The seating system for the workstation consists of roll-up stools for easy storage. The sleeping area may be separated from the work area by a flap of fabric to ensure crew members of privacy when they are on different schedules.

Zone 2 - Galley Area

Food preparation is performed on a surface that covers the sink. Additional food preparation surface is located to the side of the galley area near one of the main workstations. Fresh water and gray water are stored under the sink area. Utensil storage and the trash compactor are located under the counter-high modules. The dining area is formed by the foldout work surfaces that are attached to the main work surfaces by the stairs.

PHASR's galley must function as the primary source for preparation, storage, and disposal of food and waste. A small amount of food can be stored here, but larger amounts of food are stored in modules located in the sleeping side of the habitat.

The main requirements for the galley follow:

- Cooking
- Cleaning
- Hand washing
- Food preparation
- Water stowage

The components for the galley include:

- Ambient storage
- Refrigeration/freezer storage
- Food and beverage storage
- Toaster oven
- Electric coil burner
- Food preparation area
- Trash compactor/disposal
- Sink
- Water stowage modules

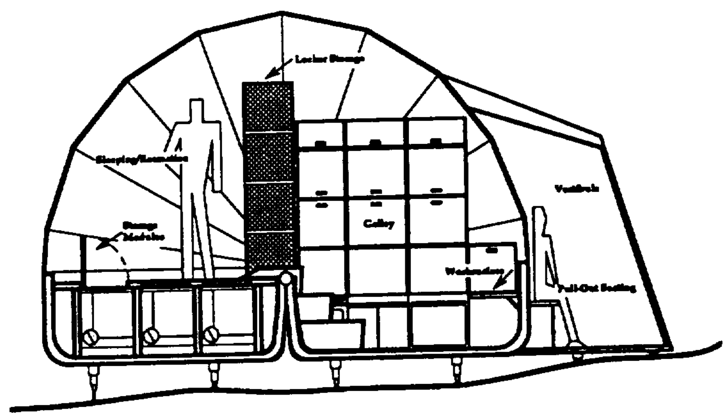

Fig. 3 Section toward galley

Zone 3 - Hygiene Area

The hygiene area in PHASR contains some stationary elements and numerous stacking modules. It contains a toilet, cleansing area/shower, and sink.

Requirements for the hygiene area include:

- Full-body cleansing
- Hand/face cleansing
- Oral hygiene
- Personal hygiene
- Urination/defecation

- Sufficient ventilation
- Waste stowage

The components of the hygiene area are the:

- Shower
- Sink
- Personal hygiene stowage
- Toilet

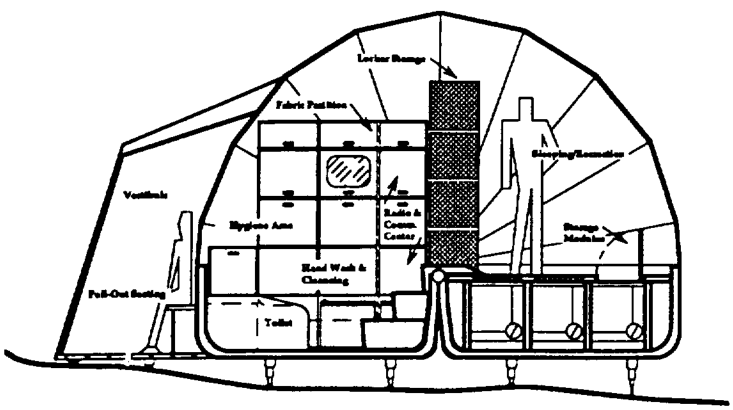

Fig. 4 Section toward hygiene area

PHASR's restricted volume of 931 cubic feet will mandate strict personal hygiene standards for biomedical and psychological reasons. Personal hygiene conditions in PHASR will significantly affect the compatibility achieved between crew members.

The hygiene facility is an important part of a crew's daily schedule. Foremost, this system should be simple, easily maintained, and easily repaired. A variety of waste management systems have been considered. The advantages and disadvantages of storing waste as compared to an incinerator toilet were investigated.

Zone 4 - Crew Quarters

The crew quarters are designed to be closed off from the rest of the module if different schedules are desired by the crew members. The sleeping compartment will have a TV, VCR, stereo, and personal storage. The sleeping area also provides vertical lockers from stacking components and storage modules under the floor.

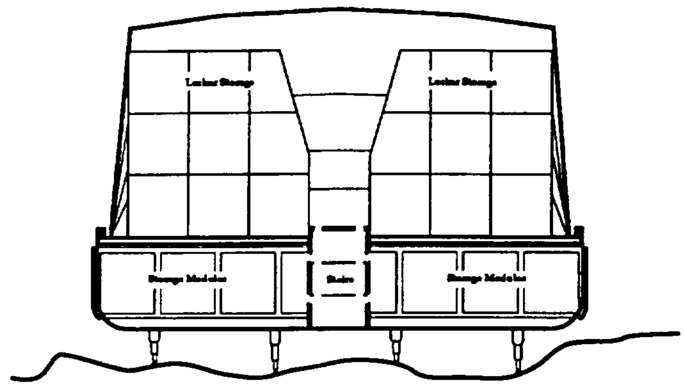

Fig. 5 Section toward crew quarters showing lockers

The requirements for the crew quarters include:

- Sleeping area for four people
- Accommodation for different physical sizes
- Community storage
- Private storage
- Recreation and leisure space
- Dressing/undressing area

The components of the crew quarters area are:

- Storage modules in floor
- Lockers from stacking components
- Cold weather sleeping bags
- Storage for portable TV, VCR, and stereo

Transportation

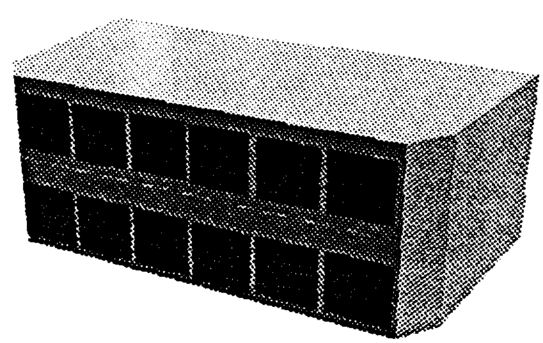

Fig. 6 Packaged PHASR

PHASR folds up into a packing size of 8' X 16' X 6'. It fits onto 1/6 of a standard pallet for the C-130 or C-141 aircraft and weighs under 2500 pounds fully packed.

Assembly

Under normal conditions, it is estimated that PHASR can be fully deployed from the bare ground, leveled, and its furnishings assembled in 2-3 hours. Furniture modules contain simple slip-fit or drop-in type connectors. Some components are hinged. PHASR is leveled to adapt to a variety of terrain with a system of jacks and shocks. Although PHASR is designed primarily for use in cold weather, a double-layered, light-colored fabric could be used for hot climates. Also, a thick Styrofoam shell that is assembled on-site might be used in conjunction with the proper air conditioning system.

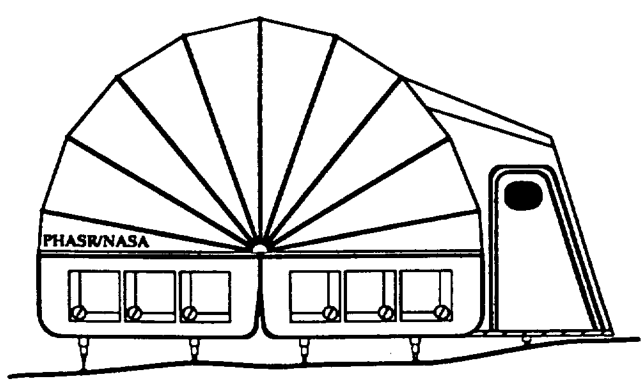

Fig. 7 Elevation of PHASR

Recovery

PHASR's furniture modules are designed to be disassembled and packed so that PHASR can be closed — much like a suitcase — and airlifted to another location. This allows PHASR to be a reusable habitat, unlike some of the more semi-permanent structures used in the Antarctic today.

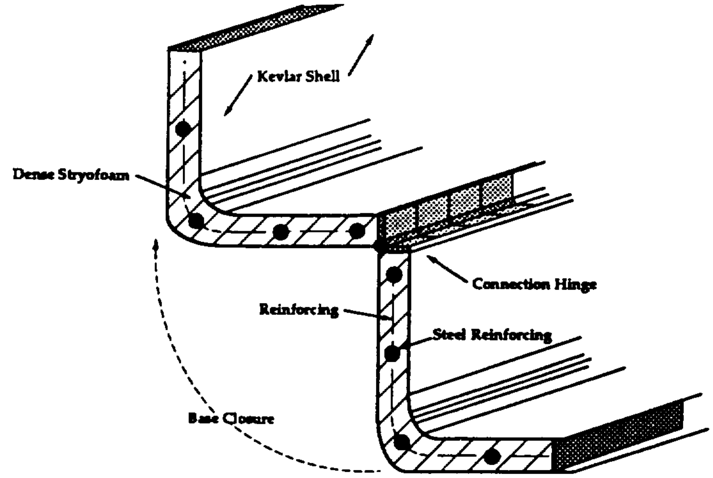

Fig. 8 Cross-section of PHASR structure showing connection hinges

Environmental Safety

Solar Gain

Since PHASR is primarily passively solar heated, it is designed with a minimal use of seams and openings to prevent air infiltration. The dark fabric covering is automatically stretched rigid over the structural supports when PHASR is deployed. This combination, fabric and support ribs, is the tensioning system which forms PHASR's interior volume. The covering system and insulated shell have been designed to give PHASR a solar savings of 80 to 85% using direct gain from the 24-hour Antarctic summer sun. This translates into approximately 4,200 BTU's per day to heat PHASR.

Heat-gain calculations were approximated by using the LCR method. Calculations were made by using a 0.6 factor for infiltration at 20° for tight construction in a 15 mph wind. An absorption rate of 0.82 was used for the dark blue fabric of PHASR. The habitat fabric was calculated as solar glazing with a 4-inch airspace for an insulating property. This yields an R-value of 1.23. The base of the habitat was calculated with the R-value of 45. This is the minimum specified for the dense Styrofoam fill of PHASR's shell. Calculations were done for three months with an average of 27° (the average temperature in January at US research base McMurdo).

Power Systems

Power is supplied by a hybrid system of solar photovoltaics and wind generation. The combination of wind and solar power meets our needs of at least 1500 watts in an average 12-15 mph wind at 0° C. Currently specified is a wind system that provides a rated power of 1000 watts with a generated wind speed of 5-7 mph. This particular wind system has a shipping volume of four cubic ft and a weight of 70 lbs. Supplemental power will be provided by photovoltaic arrays. PHASR's solar arrays are 47.25 in X 21.00 in X 1.50 in and provide 70 watts of power.

Material Specifications

Materials considered for PHASR include Kevlar for the shell of the base with a dense Styrofoam fill. The Styrofoam would be reinforced with a steel alloy.

Initially sought for PHASR was a clear fabric for the outer layer of the tent and a black fabric for the inner layer. This would give the maximum passive heat gain for the interior. However, heat-gain calculations showed that two layers of dark blue fabric would trap enough heat to be sufficient. It is imperative that the fabric specified for PHASR be able to withstand intense ultraviolet light, excessive bending, and extreme cold. Although we have looked extensively at a nylon because of its weight, it would need to be coated to withstand Antarctica's high ultraviolet light. PHASR's structural support system (ribs) are aluminum alloy or graphite. Both are ideal materials because of their weights.

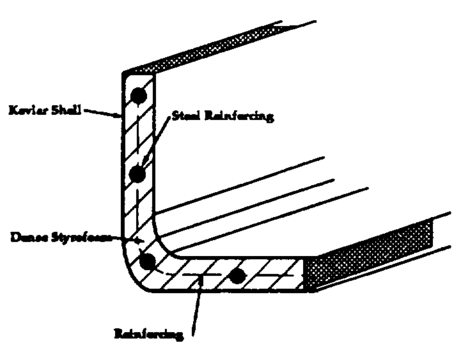

Fig. 9 Cross-section of Kevlar shell

Materials considered for the hard surfaces in the interior need to be nonporous, nonvaporous, lightweight, and easy to maintain. Nylon mesh can be used for many of the shelving units, while a graphite substance would be best for the harder surfaces.

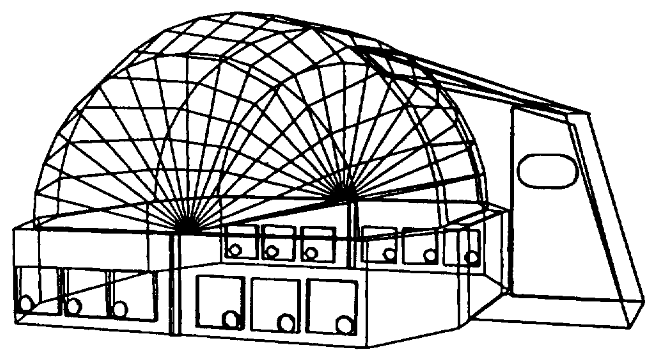

Fig. 10 Wire frame computer model of PHASR