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# ANTARCTIC PLANETARY TESTBED

A FACILITY IN THE ANTARCTIC FOR RESEARCH, PLANNING AND SIMULATION OF MANNED PLANETARY MISSIONS AND TO PROVIDE A TESTBED FOR TECHNOLOGICAL DEVELOPMENT.

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**This is a student project completed by Master of Architecture candidates at the University of Houston Sasakawa International Center for Space Architecture, which required a substantial amount of preliminary research and coursework beyond the scope of this report**


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# INTRODUCTION

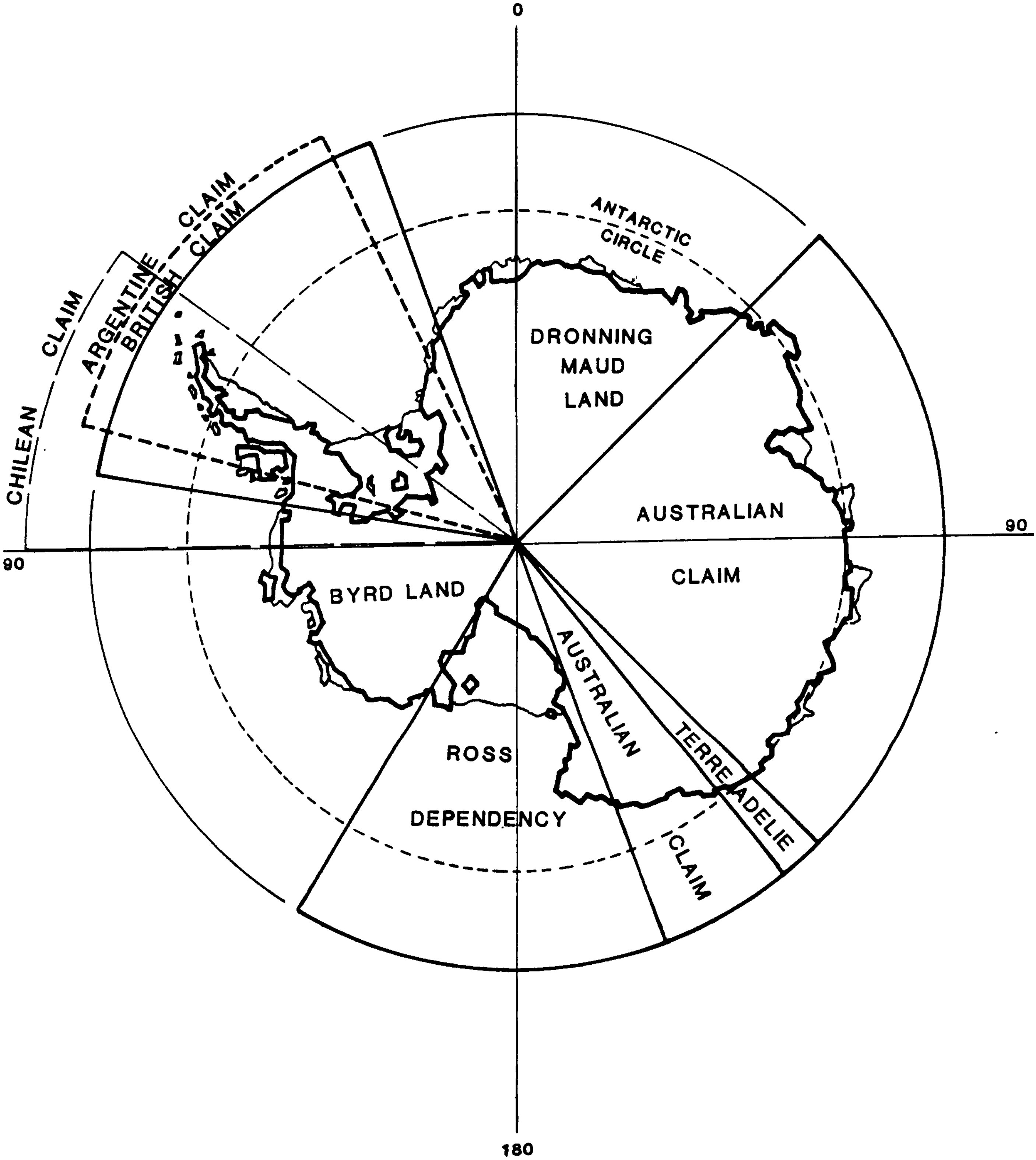
The Antarctic, (literally meaning "opposite the Arctic") generally refers to the regions surrounding the South Pole (King 1970). This includes the 5 $^{1}/_{2}$ million sq. mile Antarctic continent and the sub-frozen seas that surround it to about the 60$^{o}$ S. parrallel of lattitude Antarctica, the world's 5th. largest continent, is also the coldest and highest (average elevation of over 5,000 ft.). It is 95% covered with perrenial ice representing 90% of the world's total ice. (McPherson 1975).

The first exploration of the Antarctic circle by a white man was made by Capt. James Cook in 1773 but it was not until the 20th. century that serious exploration began into the Antarctic following expeditions by Englishman Robert Scott and later, Ernest Shackelton. As interest grew and multi-national explorations increased, various territorial claims began to be made on the continent (see map 1).

In the post World War II era and following the International Geophysical Year of 1957-58, under strong U.S. influence, the Antarctic Treaty, dedicating the continent to peaceful scientific investigation, went into effect in 1961. Thereafter, the United States, though not making any territorial claims, has maintained a strong presence on the continent with several bases supported through the National Science Foundation.

# INTRODUCTION

MAP 1



# INTRODUCTION

## ANTARCTICA AS A PLANETARY ANALOG

The notion of using Antarctica as a planetary analog is not a new idea. Ever since the manned space program gained serious respect in the 1950's, futurists have envisioned manned exploration and ultimate colonization of the moon and other extraterrestrial bodies. In recent years, much attention has been focused on a permanently manned U.S. space station, a manned Lunar outpost and a manned mission to mars and its vicinity. In fact The National Commission on Space appointed by President Reagan, recommended that a permanent lunar outpost and human visitation of Mars be realized early in the next century. Last year, NASA adopted expansion of our human presence into the Solar System as a major goal. This priority has recently received strong endorsement by a prominent NASA study team headed by former astronaut Sally Ride.

When such lofty goals are set, it is only prudent to research, plan and rehearse as many aspects of such a mission as possible. The concept of the Antarctic Planetary Testbed (APT) project is intendedto be a facility that will provide a location to train and observe potential mission crews under conditions of isolation and severity, attempting to simulate an extraterrestrial environment. Antarctica has been considered as an analog by NASA for Lunar missions (Johnson, R.W. *The antarctic Analogy for Lunar Exploration,* NASA), and has also been considered by many experts to be an excellent Mars analog.

Antarctica contains areas where the environment and terrain are more similar to regions on the Moon and Mars than any other place on Earth. These features offer opportunities for simulations to determine performance capabilities of people and machines in harsh, isolated environments. The initial APT facility, conceived to be operational by the year 1991, will be constructed during the summer months by a crew of approximately twelve (see Appendix 1 for a preliminary schedule). Between six and eight of these people will remain through the winter. As in space, structures and equipment systems will be modular to facilitate efficient transport to the site, assembly, and evolutionary expansion. State of the art waste recovery/recycling systems are also emphasized due to their importance in space.

# INTRODUCTION

**CHART 1**

| |
|---|
| **Antarctic - Planetary Analogs** |
| |
| ***Environmental Characteristics*** |
| *o Antarctica which averages approximately 8,000 ft. above sea level, is the Earth's highest and driest continent with a thin atmosphere most like Mars.* |
| *o Antarctica receives relatively high levels of solar radiation similar to conditions on the Moon and Mars.* |
| *o Antarctica, having temperatures as low as -100 O F, and even colder at the South Pole, has similarities to the Moon and Mars.* |
| *o Coastal Antarctic winds range from a 15 mph average, to 200 mph and more. Snow storms in these locations have similarities to dust storms on Mars.* |
| *o Antarctica and the Moon have locations with long days/nights which affect surface operations; as many as 3 months of darkness/extreme cold on Antarctica and 14 days on the Moon.* |
| ***Geological Features*** |
| *o Antarctica is a large, mostly virgin land mass, about the combined size of the U.S. and Mexico. It has a variety of landscape features from which to select sites for planetary mission simulations.* |
| *o Antarctica's rock bed terrain includes areas with sterile soils devoid of any life forms, similar to conditions on the Moon and Mars.* |
| *o Polar ice caps on Antarctica and Mars are rare in our solar system. Earth and Mars are the only planets possessing these features.* |

**CHART 1** continued.

| Program | Priorities |
|---|---|
| o | *Antarctica, like the planets, belongs to no nation. Current and future treaties governing its use can provide a model for cooperative international space initiatives.* |
| o | *The Antarctic ecosystems must be respected and protected. Similar conservation priorities apply in planning orbiting and planetary habitats.* |
| o | *Antarctica's remoteness imposes space-like living, work and resupply constraints. Facilities should be easy to construct, and self-sufficiency should be optimized.* |

# PROJECT OBJECTIVES

The major objectives for the APT are summarized under general headings in CHART 2. While these cover a wide spectrum of possibilities, the main focus of the project, as envisioned by the SICSA team, is in the following areas :

* SOCIAL RESEARCH EMPHASIS
* EARTH SCIENCE BENEFITS
* TECHNOLOGY DEMONSTRATION APPLICATIONS
* INTERNATIONAL COOPERATION

# PROJECT OBJECTIVES

**CHART 2**

| |
|---|
| |
| **Key APT Purposes** |
| |
| ***Social and Life Sciences*** |
| *o Psychological and social dynamics experiments involving mixed/international crews under severe, isolated conditions.* |
| *o Adaptation and performance assessments under harsh environmental conditions.* |
| *o Simulations of food production for self-sufficiency under isolated conditions.* |
| *Earth and Planetary Sciences* |
| *o Atmospheric, weather and meteorological studies applicable to Earth/planets.* |
| *o Geological, geophysical and physical chemistry research experiments.* |
| |
| ***Technology Demonstrations*** |
| *o Partially closed-loop life support systems.* |
| *o Waste reclamation, treatment and recycling systems.* |
| *o Advanced power generation and distribution systems.* |
| *o Excavation, mining and material processing systems/procedures under harsh conditions.* |
| *o Construction/assembly systems and procedures under harsh conditions.* |
| *o Automation/robotic system versatility and reliability under harsh conditions.* |
| |
| ***Training Ground for Planetary Missions*** |
| *o Crew observation for candidate selection and team a ssignments.* |
| *o Crew preparation for long-duration planetary missions under simulated conditions.* |
| |
| |
| |

# PROJECT OBJECTIVES

**CHART 2** continued.

| |
|---|
| ***International Model*** |
| o *Create and demonstrate participatory agreements which prepare the groundwork for future international initiatives.* |
| o *Encourage participation of international government and private sector organizations in advanced mission planning.* |
| o *Demonstrate economic and mission benefits to be gained through international investment and participation.* |
| o *Serve as tangible expression of commitment to future planetary initiatives.* |
| |
| |
| |

# PROJECT OBJECTIVES

## SOCIAL RESEARCH EMPHASIS

An important APT function will be to serve as a psychological and social research laboratory. In addition, realistic space mission simulations will afford opportunities for crew training and selection.

Extended lunar surface missions and long manned voyages to Mars and other planets will pose great psychological and physiological demands on crews. Abilities of the crew to work well as individuals and as members of a team under these prolonged, difficult circumstances is an urgent concern.

U.S. and Soviet space missions to date demonstrate that social interactions are often complex and problematic. Successful team efforts require that individuals like, respect and adjust to one another on a very personal basis. Learning to depend upon each other's judgement and technical knowledge is also essential. Such vital group "chemistry" is difficult to predict based exclusively upon psychological profiles of crew candidates.

Most available data pertaining to group dynamics under extended, harsh, isolated conditions is anecdotal and unreliable. While many Soviet space station crew experiences have been of relatively long duration, very little information revealing scientific details about crew interaction, adaptation and performance has been released. Submarine isolation data is not directly applicable since neither the characteristics or size of the crew populations are comparable. Lessons derived from conventional arctic and antarctic experiences have similar limitations due to differences in population groups and the nature of their activities.

APT research and demonstration programs will select crew populations and activities to match real mission conditions and objectives as closely as possible. The participants will be international in composition to reveal insights about ways culture differences and preferences can be successfully accommodated.

# PROJECT OBJECTIVES

## EARTH SCIENCE BENEFITS

Use of the APT facility for research which is not exclusively space-related can help to cover costs for program implementation and operations. While several nations currently maintain research stations in Antarctica, the APT will be unique as an international base, affording living and work accommodations for a wide variety of cooperative ventures.

A representative APT use is to provide a laboratory for field measurements of seasonal changes in the Earth's upper atmosphere, the stratosphere in particular. Purposes will be to advance our understanding of physical, chemical and meteorological processes that influence perturbations in ozone above Antarctica which were first observed by the British above their Halley Bay Station during the mid-l970's. Since that time, the October mean ozone level measured at Halley Bay has dropped between 40 and 50 percent. Potential enlargement of the 12 million km2 "hole" is viewed with alarm because atmospheric ozone is responsible for screening out more than 99 percent of the solar ultraviolet radiation that reaches the Earth's atmosphere APT research can focus international attention on natural and man-made ozone influences and countermeasures.

APT research can also direct international resources and concerns to other issues of global importance. The Antarctic continent is a major forcing system driving the Earth's weather systems. Accordingly, APT research can investigate and monitor air and ocean transport of radioactive particulates and toxic chemicals; magnetospheric phenomena and their relationship to the solar wind magnetosphere system; and influences of ice and other surface features upon past, present and future climate conditions.

APT studies of the Antarctic Plate can expand knowledge about the evolution of the Earth's crust and upper mantle structures. This can lead to a better understanding of the way mineral resources are distributed throughout our planet, whether or not they are to be exploited .

# PROJECT OBJECTIVES

## TECHNOLOGY DEMONSTRATION APPLICATIONS

Severe environment conditions on the Moon and Mars will pose hardships for people and machines. Failure to validate procedures and systems under realistic conditions is likely to be costly in terms of human life and/or failed missions. The APT facility will offer a valuable environment for realistic simulations and assessments.

The APT initiative will also provide incentives to advance valuable technologies for terrestrial uses. For example, critical APT performance and reliability requirements under extreme climate and working conditions will offer demanding tests and testimonials for companies developing commercial products. The APT's remote location and extended duration crew duty cycles will encourage innovations to achieve high yield, efficient food and energy production. APT's space-applicable methods to treat and recycle wastes will demonstrate that human settlements can be non-polluting and environmentally responsible.

A key technology development and demonstration objective will be to realize a high level of self-sufficiency through local growth and processing of food sources. Severe limitations upon environmentally conditioned volume and manpower will demand careful selection of nutritious, rapid-growth plants and animals that are easy and efficient to attend. Hydroponic agriculture and controlled pond fish and shrimp farming are candidate approaches. Organic wastes will be recycled for reuse to the extent possible.

Another priority will be to implement and evaluate autonomous power generation and storage systems. Candidate technologies include biomass systems that produce gas from organic wastes; fuel cells which produce electricity through a reverse osmosis process; wind turbines; and small nuclear generators.

APT operations will provide challenging applications for robotic and other automated systems. Experiments will include excavation to obtain and process mineral resource samples, in situ material processing, and construction techniques.

# PROJECT OBJECTIVES

## INTERNATIONAL COOPERATION

Enormous program costs required to establish a lunar base or to undertake manned missions to Mars will likely be too expensive for even the wealthiest individual nations to justify. International cost-sharing will enhance economic feasibility and also help to ensure that mission purposes will benefit the world community. Antarctica, an international territory, is an ideal place to demonstrate that such cooperative programs can work.

Exploration of the Solar System includes research to yield an improved understanding of planet Earth. The APT facility will support scientific investigations of causes and effects of weather patterns and atmospheric changes that influence our human destiny; forces and evolutionary processes that shape the composition and distribution of planetary resources; and ways to accomplish social progress and prosperity while also protecting fragile ecosystems. Such issues are of vital importance to all world populations. Accordingly, APT research is intended to involve scientists from many nations. Living and working together under remote, rugged conditions, the culturally mixed crews can investigate whether cooperation under difficult circumstances is possible and/or essential.

# PROJECT ASSUMPTIONS

Before compiling a design for the APT facility, the following general assumptions were made by the SICSA team :

1. All political and Scientific issues regarding settlements in the Antarctic Dry Valleys would be resolved, allowing the facility to be built in the Taylor Valley.

2. All proposed modifications to existing transportation vehicles will be made to accommodate the proposed modular designs.

3. Adequete funds will be available to execute this project.

4. Houston, Texas will be the home base of operations.

# PROJECT DESCRIPTION

The design and development of the APT project evolved from an outline facility program (see CHART 3). Based on these requirements and in full consideration of the APT objectives described earlier, site selection and project development occured as follows :

## SITE SELECTION

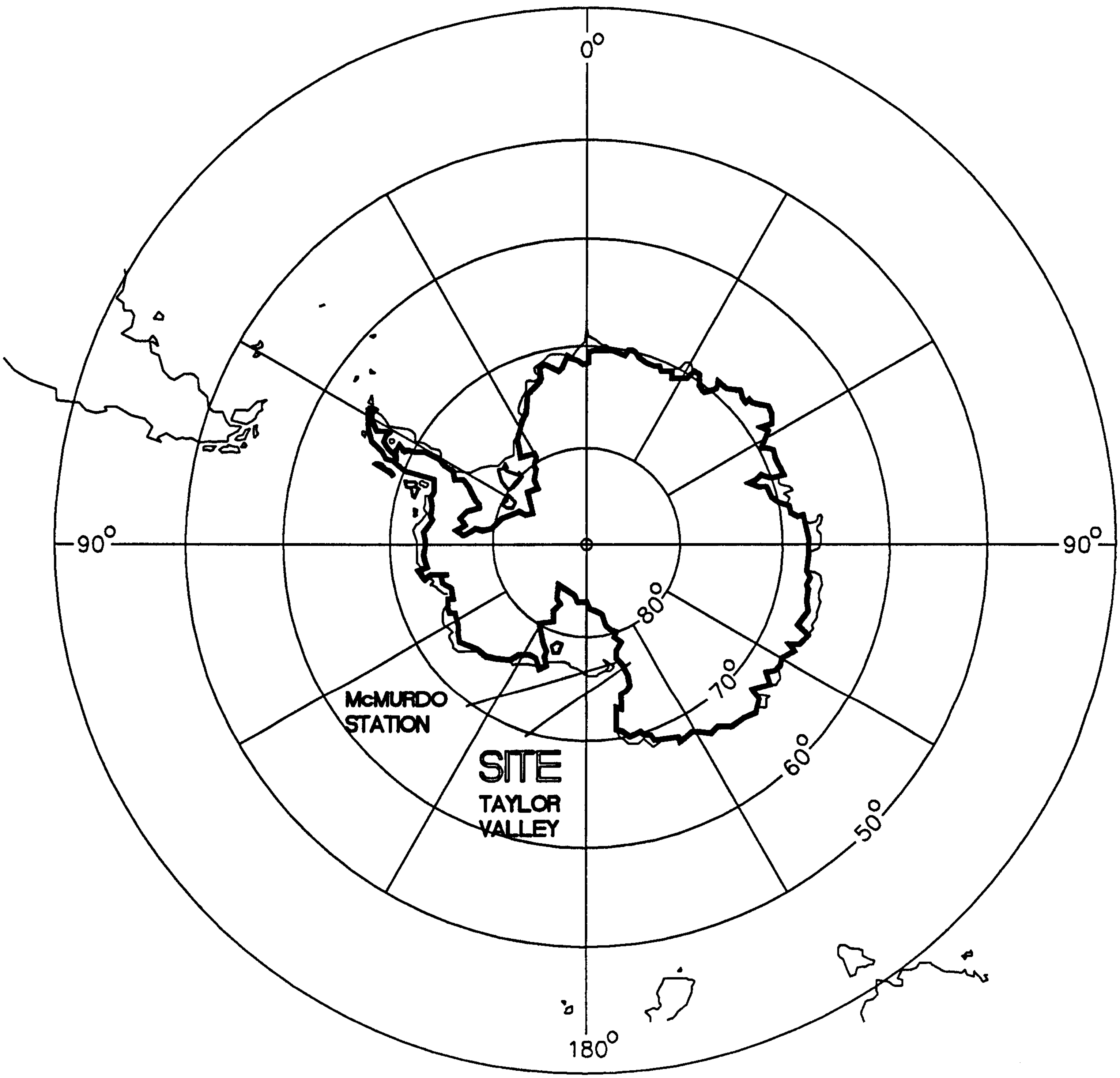
Initially, areas which were considered included the 'Dry Valleys', the Polar cap and Marble point on the Ross sea coast close to McMurdo base. Each site offered pros and cons depending on which goals were prioritized. An important APT planning and implementation priority was to minimize man-made disturbances to Antarctica's environment and ecosystems. Careful site selection therefore required avoidance of large transportation and construction equipment requiring extensive roadbeds; limiting crew population size; and emphasizing the reprocessing, reuse and control of waste materials. Similar considerations apply in planning orbiting and planetary habitats.

For the space mission analog, the 'Dry Valley' sites were the most favorable even though they present many environmental and political hurdles.

After reviewing several 'Dry Valley' sites, a site was selected in the Taylor Valley [ Between Lat. 77° 51' S & 77° 40' S. and Longit. 163° 00' E. & 163° 15' E. (see MAP 2) ]. The site's proximity to McMurdo station was a factor because of the range of a fully loaded Sikorsky S-64 'Skycrane' (see section on Transportation). After selection, the site's geological and environmental factors were evaluated and issues of design relevance and ecological sensitivity were identified.

# PROJECT DESCRIPTION

MAP 2



# PROJECT DESCRIPTION

**CHART 3**

| |
|---|
| **Program Outline** |
| |
| ***Building Systems and Equipment*** |
| o *Modular enclosure(s) of design and size to afford simple and rapid construction.* |
| o *Modular interior equipment systems enabling easy changeouts and expansion.* |
| o *All elements designed for transport by relatively small air and surface vehicles.* |
| o *State of the art systems to collect and recycle waste materials.* |
| |
| ***Living Accommodations*** |
| o *Crew quarters for 12 people (summer) and 6-8 people (winter).* |
| o *Means to reconfigure living spaces for planetary simulation experiments.* |
| o *Galley and wardroom comparable to size and menu provisions of Space Station.* |
| o *Basic exercise, toilet, shower and laundry equipment.* |
| o *Small health maintenance facility for routine and emergency medical care.* |
| |
| ***Research Accommodations*** |
| o *Facilities for human, animal and plant life science research.* |
| o *Utility interfaces to accept standardized space station-like experiment racks.* |
| o *Data busses and computing systems to control and monitor experiments.* |
| o *Laboratory space with work benches, information resources and storage.* |
| o *Maintenance and parts room with basic tools and calibration equipment.* |
| |

**CHART 3** continued.

| | |
|---|---|
| ***Grounds and Ancillary Structures*** | |
| o | *Greenhouse/biosphere for plant growth.* |
| o | *Staging area and equipment for Earth and planetary science experiments.* |
| o | *Mining and material processing/sample return simulation area.* |
| o | *Space construction and assembly simulation area.* |
| o | *Vehicle repair and storage facilities.* |
| o | *Helipad and fuel storage depot.* |

# PROJECT DESCRIPTION

## TRANSPORTATION LOGISTICS

APT's remoteness will create access problems which are similar in principal to circumstances encountered in planning future planetary bases. This isolation and the requirements it imposes upon APT development and operations are intentional, bringing levels of realism to the program which will maximize its value.

Important factors influencing transportation alternatives are the specific APT site location; minimum payload size requirements for initial base establishments and resupply seasonal weather and ice conditions restricting schedules; emergency rescue accommodations; and environmental safequards governing acceptable modes for personnel and cargo delivery to the base. Minimization of damage to the natural setting is highlighted as a priority concern.
The maximum size for and cargo item is assumed to correspond with capacities afforded by the Shuttle's 60 ft. long, 14 ft. diameter payload bay. This restriction is imposed to support compliance with existing standards applied to space systems.

APT transportation scheduling will be strongly influenced by severe weather conditions. Short summer "access windows" are analogous to space mission constraints. Large freight ships with ice strengthened hulls can travel to Antarctica from about mid-December to early March. Other marine freighters, under escort by Coast Guard Icebreakers have access to some antarctic ports from late November to April. Air travel is less dependent upon seasonal weather conditions but is more expensive. A Popular Antarctic aircraft is the Lockheed C-130 Hercules.

Access to the APT site from the nearest ship port and/or airfield constitutes the most challenging problems. Helicopters offer versatility and require minimum site accommodations but are hampered by extreme weather conditions. Accordingly, supply and crew rotation events are planned to be limited primarily to warm summer months.

# PROJECT DESCRIPTION

After reviewing the transportation modes, the following were selected to meet our requirements :

HOME BASE (HOUSTON, TX.) TO McMURDO STATION

Ocean going, ice-strengthened cargo ships and other marine freighters under escort by ice breakers.

McMURDO STATION TO A.P.T. SITE

An assortment of helicopters performing tasks as follows :

- SIKORSKY S-64 'SKYCRANE' : Major component delivery vehicle.
- BELL UH-1 'IROQUIS' : Liaison and routine supply.
- SIKORSKY 'SEA KING' : Standard supply and re-supply missions.

***NOTE***: The selection of the Sikorsky S-64 imposed a significant limitation on the size and configuration of the base module. Each cargo module is nominally 28' L x 8' W x 8' D. While these dimensions differ from the Shuttle cargo bay, the final assembled configurations of the SICSA modules will maintain a reasonable and realistic analog to Shuttle derived modules.

The second aspect of the transportation logistics issue is the consideration of the vehicles which will be utilized in the base itself. These have been preliminarily identified as the following :

One (1) Tracked vehicle for personnel and cargo Taxi duties.

Two (2) Heavy duty 4WD Trucks.

One (1) Heavy duty combination wrecker / crane.

One (1) 4WD light vehicle.

One (1) Front end loader / Bulldozer.

# PROJECT DESCRIPTION

## POWER SUPPLY

This is another vital area of exploration with close parallels to space missions, both in typology and methodology. After reviewing a variety of candidate systems ranging from diesel generators to Fuel cells, the following systems are being proposed in a chronological sequence of implementation :

| | | |
|---|---|---|
| YEAR 1 | Initial Base Set up : | Conventional diesel and start up wind generators. |
| YEAR 2 - 5 | Base established : | Wind Power combined with Fuel cells to make up peak demand. Diesel generators will back-up. |
| YEAR 6 + | Growth beyond 20 persons (winter): | Nuclear generator with wind and diesel backup. |

Other systems reviewed included BIOMASS and a unique look into Geo-magnetic power generation, but none of these were seriously persued.

## WASTE MANAGEMENT

The purpose of addressing this issue is to stimulate a working 'Closed Loop System' which can not only be a planetary analog but an effective system would offer tremendous benefits on Earth.

It is the hope of the APT design team that a system would be put in place that will recycle or convert (into something useful) as much waste as possible and also provide an 'internal' disposal mechanism for 'dead waste'. This is a challenging area since no totally closed loop systems exist as a unit. Continued research and study into this area is required before any specific system(s) are identified.

# PROJECT DESCRIPTION

## FOOD PRODUCTION

The scope of an agricultural facility to support the APT base is intended to be similar to a proposed Lunar Farm (Pollette, T., 1988). Techniques such as Hydroponics are to be utilized along with methods developed in the BIOSPHERE and similar projects. It is not intended that the APT agricultural facility support a population greater than that of the base itself.

## CONSTRUCTION MATERIALS AND METHODS

The initial APT development will be constructed by a crew of approximately one dozen people during the Antarctic summer. Six to eight members of this international group will winter-over to establish permanent base camp operations. Later expansion stages may ultimately produce a small settlement of about 50 people. The construction systems were evaluated according to a set of design guidelines presented in CHART 4.

### Construction Precedents

There are presently more than 40 manned scientific stations in Antarctica. The largest is the U.S. McMurdo Station, a scientific base and transit center which can accommodate more than 200 people during the winter and more than 1000 during the summer. The antarctic stations vary in size, facilities provided, and construction.

During the International Geophysical Year (1957-58), 50 antarctic stations were operating, including 47 year-round facilities. The cost of establishing and maintaining these stations ran as high as $1 million/person for the Amundsen-Scott base in 1957. Construction approaches differed with national preferences. British and Norwegian expeditions favored conventional frame buildings. The French used prefabricated pressed steel huts. American, Australian and Soviet huts were typically built on rock sites using prefabricated aluminum or plywood panels clamped together to form flat-roofed box-like buildings. Most common construction today makes use of steel frames covered with laminated aluminum-fiberglass panels.

# PROJECT DESCRIPTION

While these conventional materials have been successfully used in the Antarctic, it is the intent of the APT project to utilize materials and methods which bear resemblance to those proposed for extra-terrestrial bases. It is also an APT objective to utilize modular systems with the basic modules derived dimensionally from the existing Space Shuttle payload bay of 14' dia. x 60' L. While differences occur, the dimensional analogs have been respected as closely as possible.

The materials and methods were studied in light of the following criteria :

* Weight.
* Strength and Durability.
* Economics.
* Insulation value.
* Ease of fabrication.
* Ease of erection / assembly.
* Ease of maintenance.
* Flexibility.
* Deformation under temperature variation.
* Availability.

# PROJECT DESCRIPTION

Based on the review and evaluation, the following materials are being reccommended for the uses indicated below :

| | |
|---|---|
| ALLUMINUM ALLOY TUBING | Structural framing members. |
| HONEYCOMBE 'SANDWICH' PANELS WITH KEVLAR REINFORCED LAMINATION. | Module Skin Panels. |
| MULTI LAYERED POLYESTER FABRIC INFLATIBLE STRUCTURE. | Vehicle Storage and Agricultural facility. |
| TRIPLE GLAZED, LAMINATED & COATED GLASS. | Windows. |
| FIBER-COATED METAL STRUTS | For wind resistance. |

# PROJECT DESCRIPTION

**CHART 4**

| | |
|---|---|
| | **Design and Construction Guidelines** |
| *Safety* | |
| o | *Design and select materials to reduce fire hazards in the dry antarctic climate.* |
| o | *Securely anchor building to with stand high wind speeds.* |
| o | *If located in a locale with snow, provide means to raise the structure or another device to prevent blockage of entries.* |
| o | *Design for snow loads (if appropriate).* |
| o | *Provide emergency health care equipment and supplies.* |
| o | *Provide a safe haven with emergency rations separate from the main crew living facilities.* |
| o | *Provide backup power and communication systems.* |
| o | *Design for easy maintenance and repair of all life/safety-critical systems.* |
| o | *Provide means for emergency crew evacuation by air and/or land.* |
| *Economy* | |
| o | *Emphasize modularity and easy to assemble construction systems.* |
| o | *Size modules and other construction/equipment elements for transport by most economical means.* |
| o | *Provide well insulated, tight construction to minimize heat loss.* |
| o | *Provide economical, local energy source heating and power systems.* |
| o | *Provide means to treat and recycle waste materials to the extent possible.* |

# PROJECT DESCRIPTION

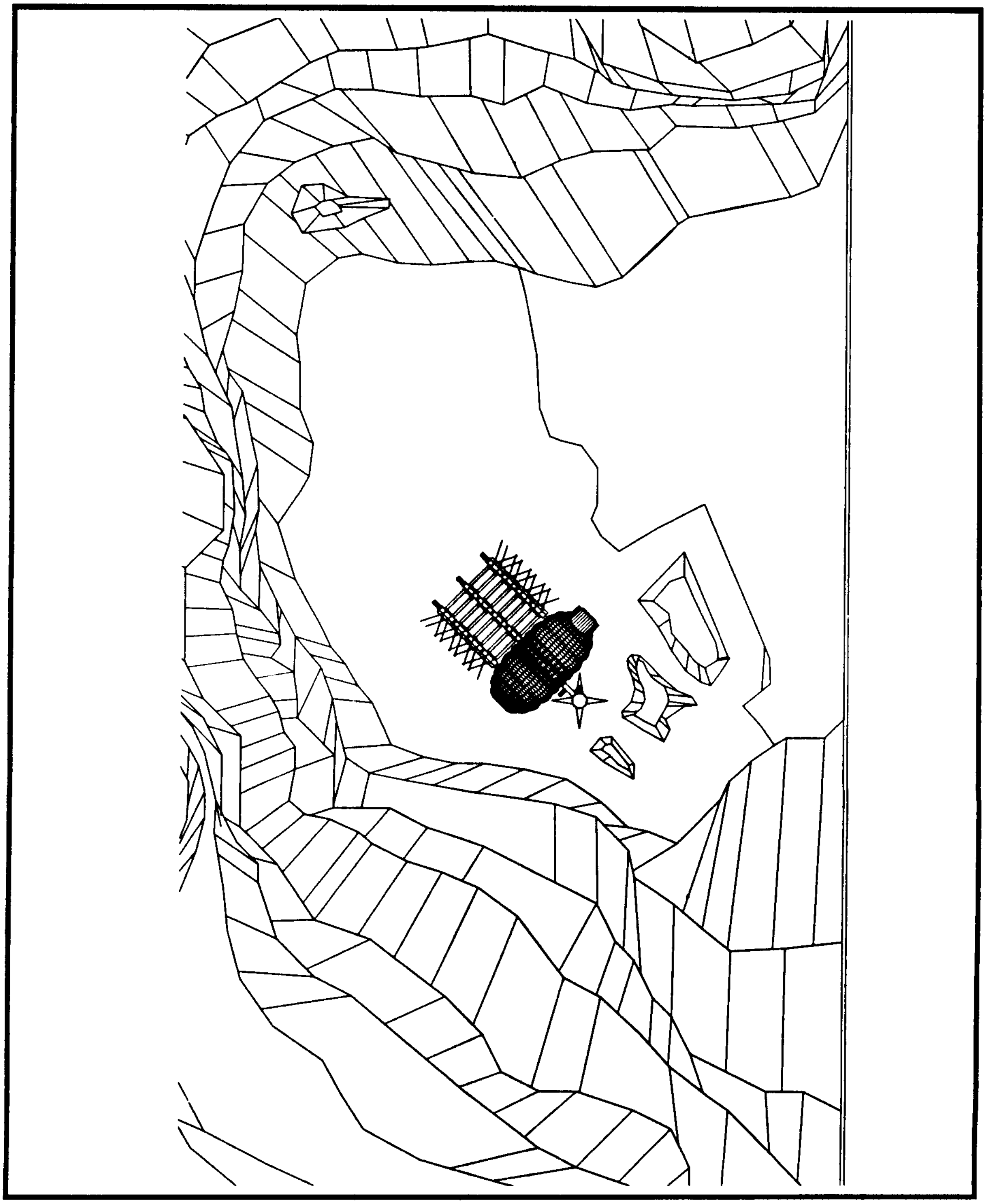
**CHART 4** continued.

| | |
|---|---|
| ***Mission Simulation Applicability*** | |
| *o* | *Size and configure facility modules to conform with Shuttle payload limitations.* |
| *o* | *Provide means to reconfigure interior spaces and equipment for changing demonstration requirements.* |
| *o* | *Simulate and provide facilities for simulating construction/assembly procedures to the extent possible.* |
| *o* | *Duplicate space habitat environment and functions to the extent practical.* |
| | |
| | |

# PROJECT DESCRIPTION

## ANTARCTIC PLANETARY TESTBED

## SITE PLAN



# PROJECT DESCRIPTION

## THE FACILITY MASTER PLAN

The APT facility is composed of the following modular components:

Eight (8) Main Activity Modules with side racks.

Six (6) Type 'B' Central Circulation Modules.

Two (2) Type 'C' Central Circulation Modules.

Four (4) Type 'A' Side Circulation Modules.

Four (4) Type 'A2' Side Circulation Modules

One (1) Observation Tower.

One (1) Combined Agricultural facility / Vehicle Storage. (Inflatible Structure).

These are illustrated schematically in FIG. 1.

FIG. 2 shows the proposed APT base final configuration while FG. 3 - FIG. 4 show sectional details.

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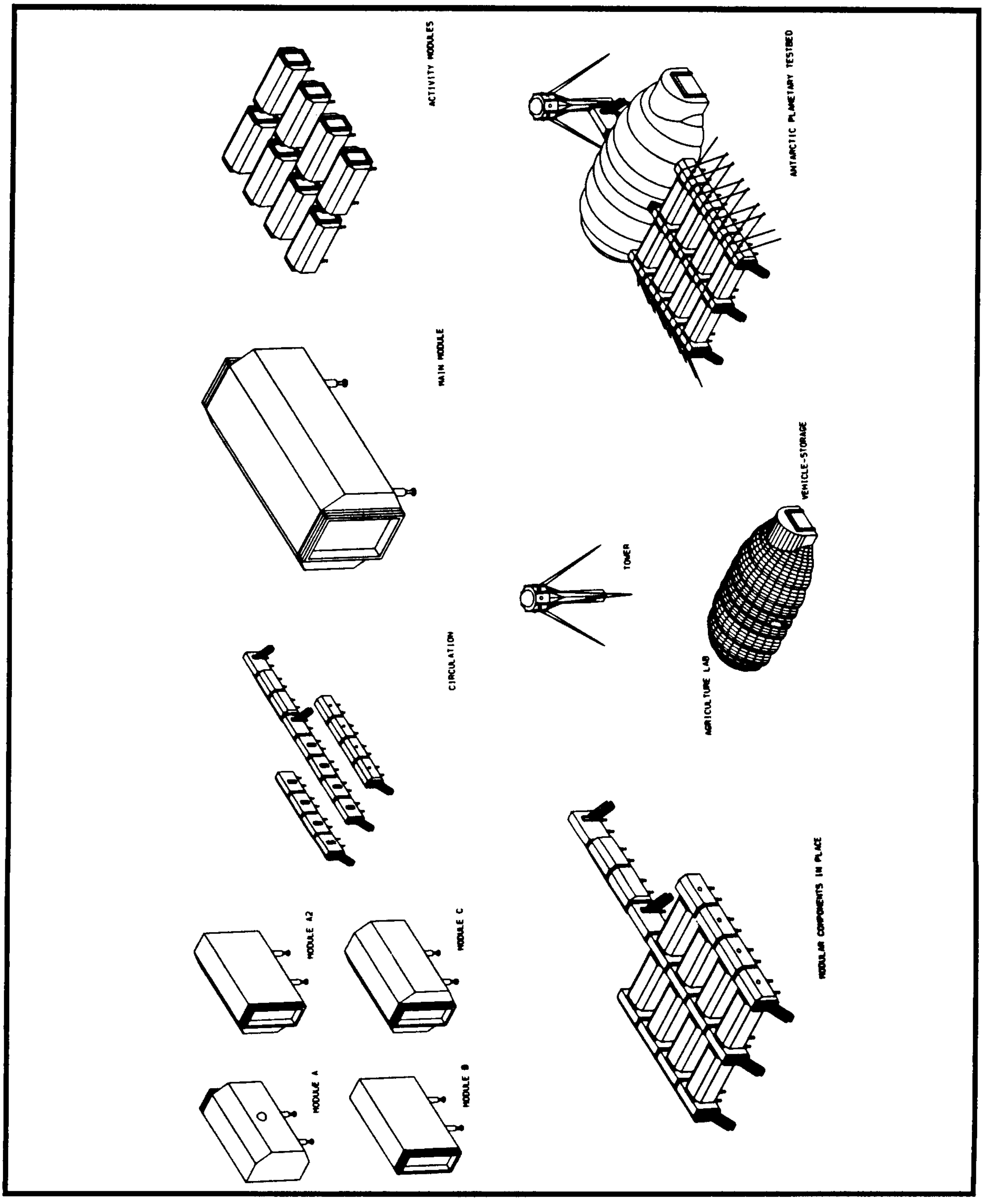
FIG. 1



# PROJECT DESCRIPTION

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FIG. 2

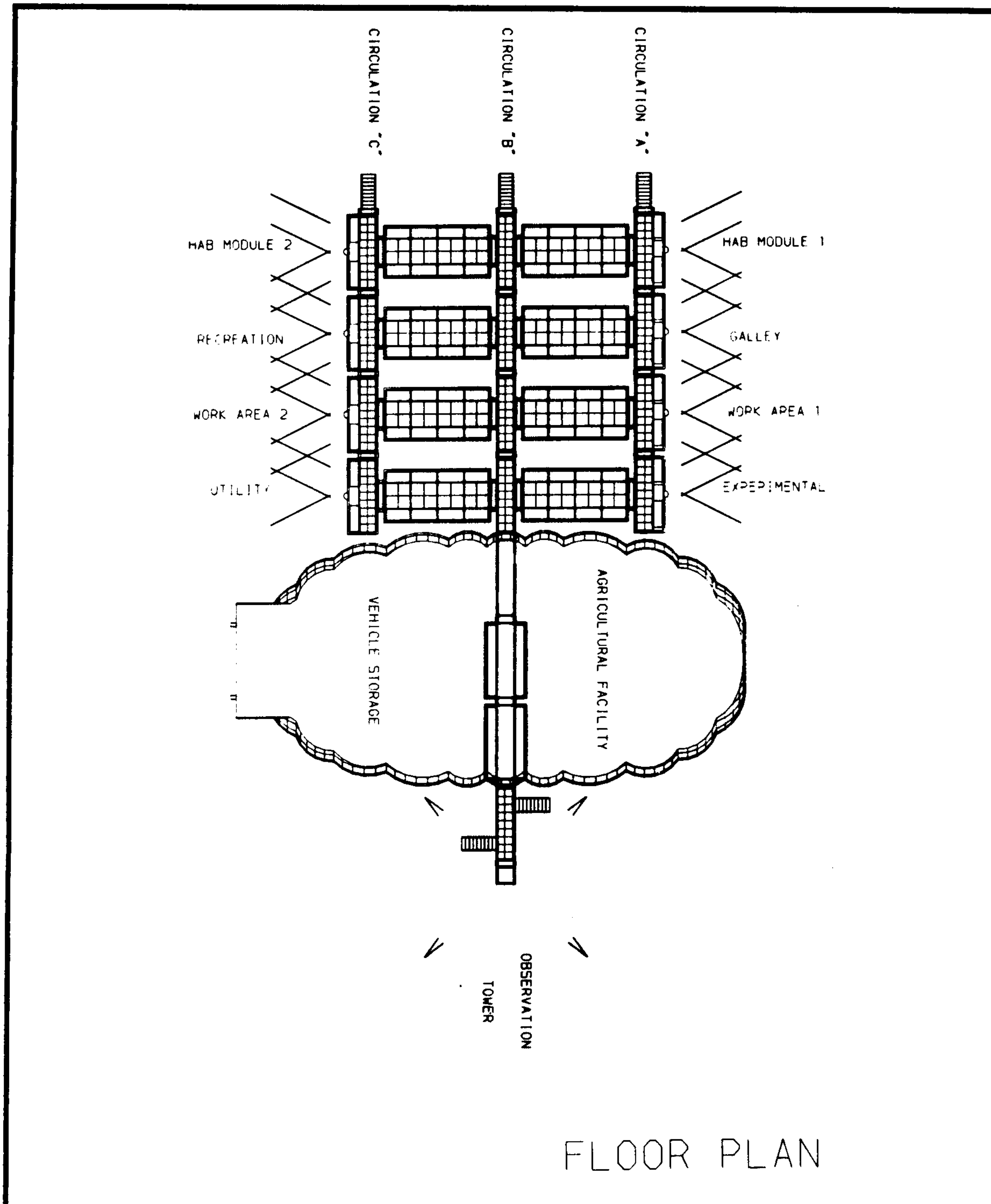
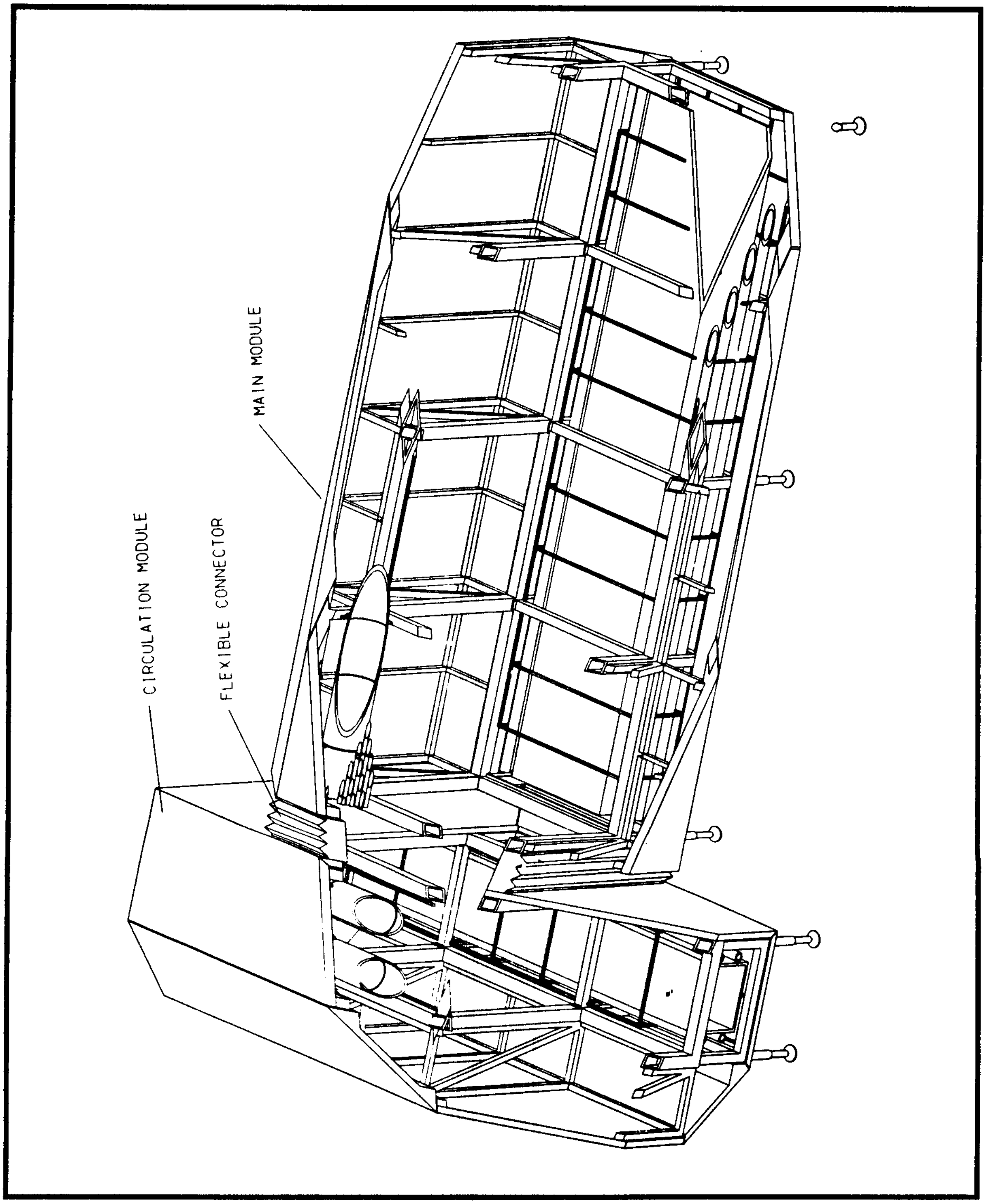


FIG. 3



# PROJECT DESCRIPTION

## THE BASIC MODULE

Much of the design work concentrated on the basic Module. The main challenge here was to achieve the space station dimensions while utilizing a highly restrictive helicopter payload delivery system. In response, a telescoping Module was deceloped with external side attatchments. This module grows from a nominal 27' x 8' x 8' closed dimension to a nominal 30' x 14' x 13' deployed interior dimension including the flexible connector pieces. The module's 'growth' sequence is illustrated in FIG. 5 and FIG. 6 shows a cross-sectional detail of an assembled module.

***DESIGN CLARIFICATION***: While the masterplan proposed here requires many facilities and systems, design work, as of this report date has been limited to the basic Module system and overall project definition as outlined earlier.

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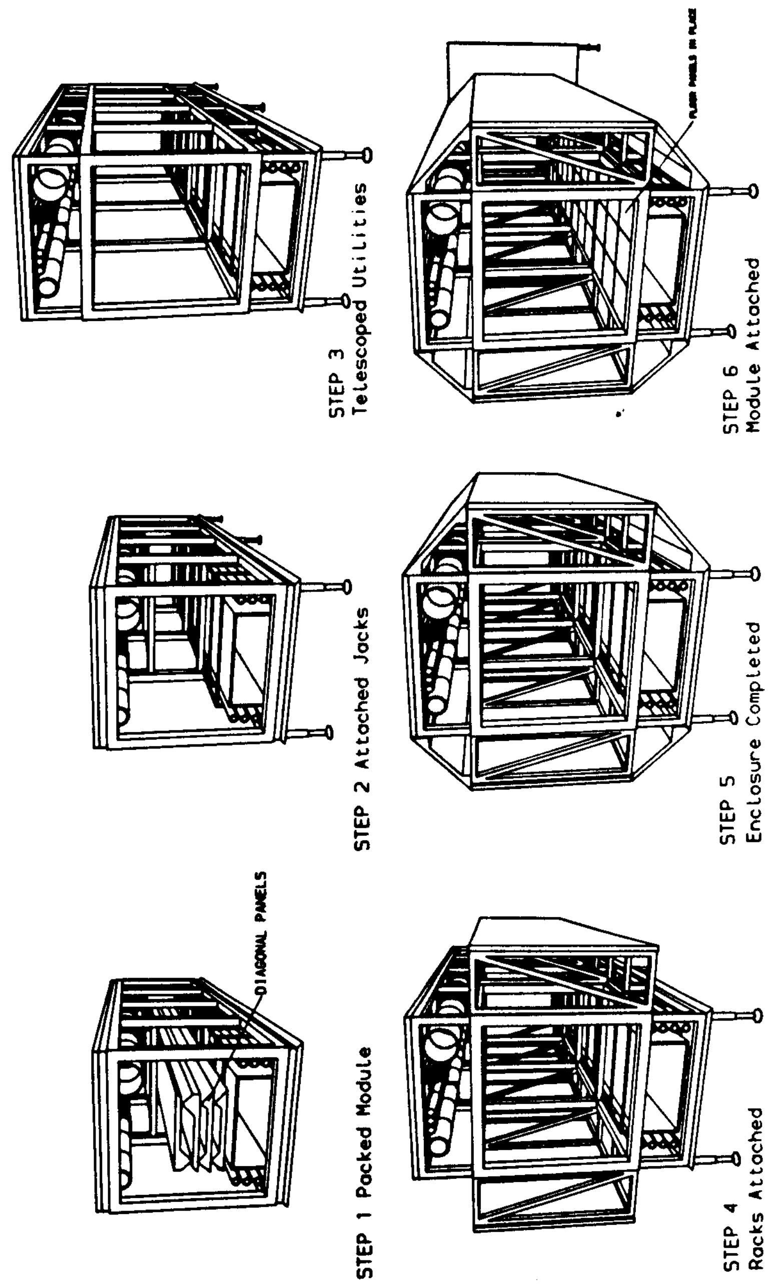
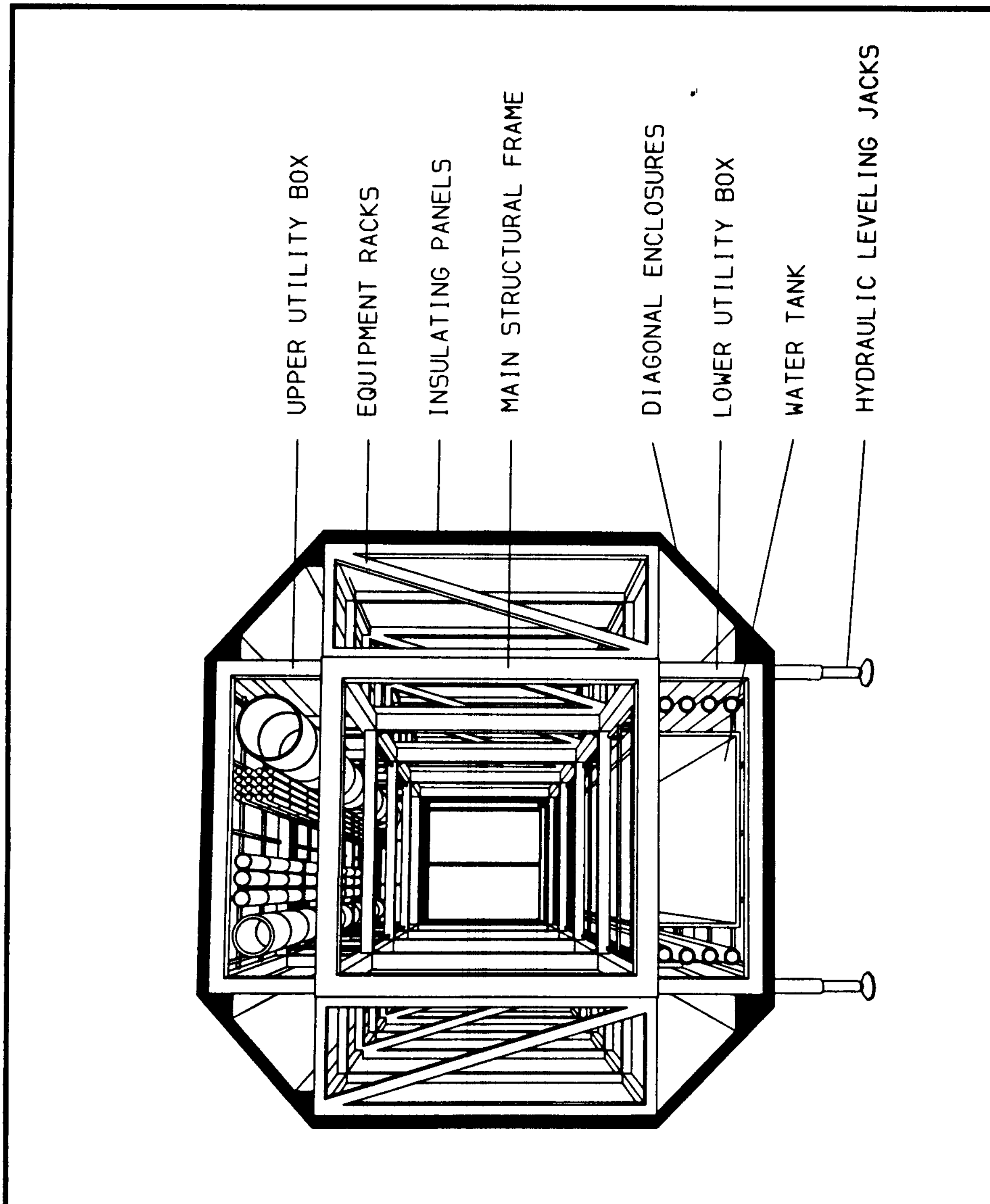
FIG. 5


STEP 1 Packed Module
DIAGONAL PANELS
STEP 2 Attached Jacks
STEP 3 Telescoped Utilities
STEP 4 Racks Attached
STEP 5 Enclosure Completed
STEP 6 Module Attached

# PROJECT DESCRIPTION

**FIG. 6**



# CONCLUSION

Based on the research into this project as of this report, there appears to be a genuine justification for a planetary testbed facility. However, in the opinion of this team, the analogs for space could be equally well served in other locations such as remote desert sites or under water - thereby eliminating the increased expense which an Antarctic facility such as the APT would incurr. Having granted this, we note and emphasize that it is the added terrestrial benefits of this proposed project in Antarctica that make it superior and merit it serious consideration.

# OUTSTANDING ISSUES

1. Sizing and engineering of all mechanical, structural and hydraulic components of the basic module and the 'Module Manoeuvring "DOLLY" System'.

2. Detailed design of the agricultural facility, vehicle storage facility and the observation tower.

3. Evaluation and sizing of energy and waste management systems.

4. Development of a water re-cycling system.

5. Detailed engineering design of the hydraulic jack supports and struts.

6. Interior design of the habitation and activity modules.

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# APPENDIX 1

## PRELIMINARY SCHEDULE