6.0 *Dymaxion* Proposed Lunar Habitat And Research Facility

6.1 Master Plan

The 'dymaxion' lunar base scheme borrows from Buckminster Fuller's term meaning to seek the most advantage with minimal input. Design for an extreme condition such as the Moon (and Mars) certainly demands such efficiency. An effort is made in this concept design to explore advantages and trade-offs utilizing this design principle in the context of a lunar base.

The base consists of two zones a work zone and a habitation zone (Figure 6.1-1 and 6.1-2).

The work zone consists of :

- 3 SSF tubes (4.5 m in diameter x 14.5 m in length) for research functions
- mission control hub (4.5 m in diameter).

The habitation zone consists of :

- 3/4 inflated sphere, 5 m in radius: habitation inflatable
- central mast (multi-purpose: structural load bearing, circulation, HVAC)
- external viewing cupola

6.2 Construction Sequence

6.2.1 Telerobotic Pre-Flo

The delivery of the base is completed in 3 loads of one SSF tube each, (with complements) (Figure 6.2.1-1).

The first carries the mast within its interior circulation space. The mission control hub remains integrated with the mast through-out delivery and deployment. After landing, the mast and hub unit are telerobotically disconnected from the research tube and uprighted, mission control hub down, and locked to the end the SSF research tube. A high performance

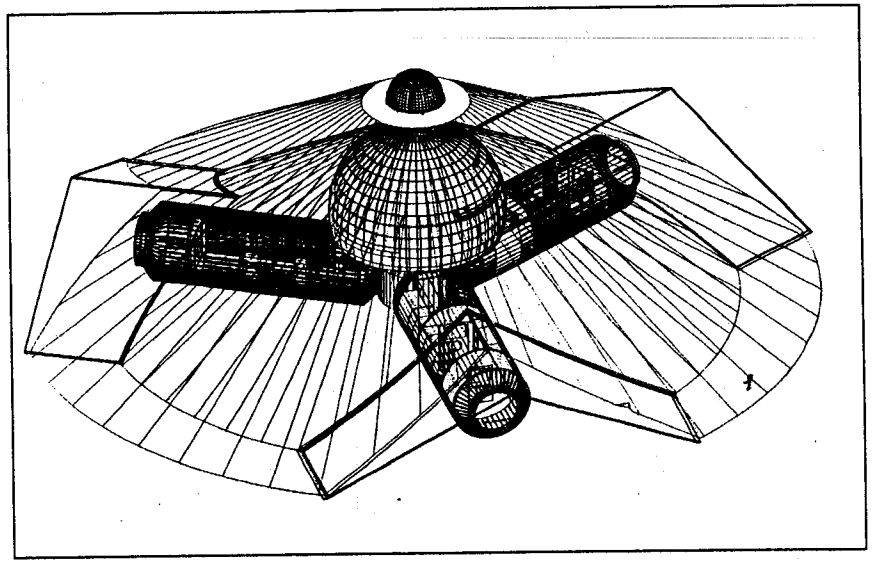

Figure 6.1-1. Exterior isometric illustrating the base components: tubes, dome, cupola, and shielding system.

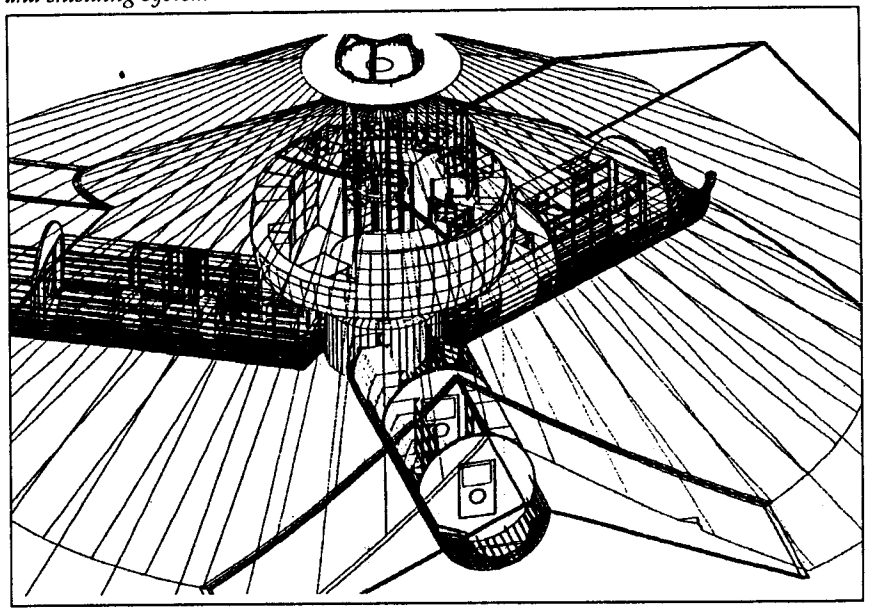

Figure 6.1-2. Section isometric illustrating levels of work and relaxation.

Kevlar composite canopy is deployed from the head of the mast and anchored into the lunar substrate — forming a conical geometry.

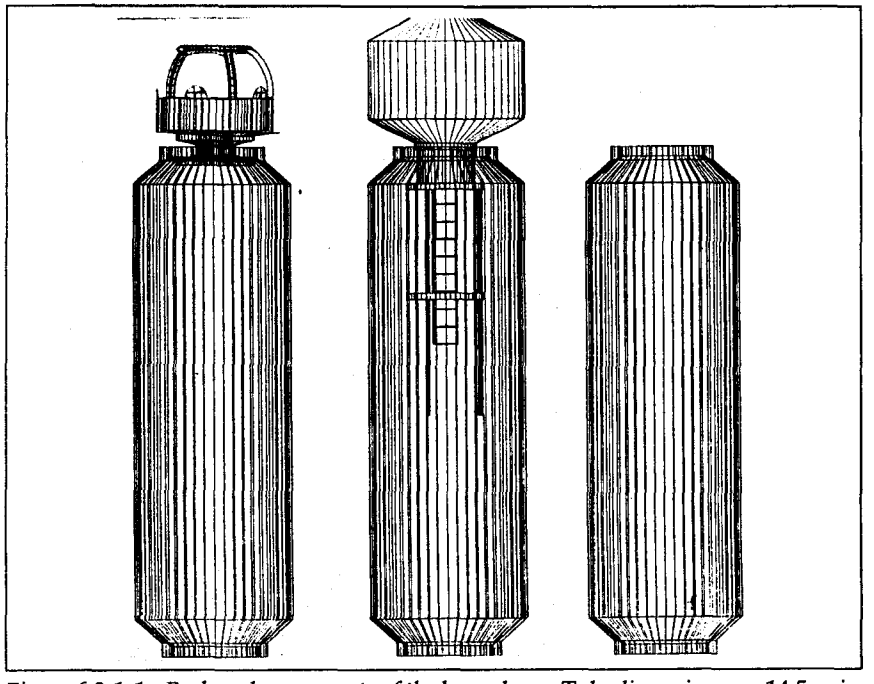

Figure 6.2.1-1. Packaged components of the lunar base. Tube dimensions are 14.5 m in length, 4.5 m in diameter (SS-Freedom- derived).

6.2.2 Telerobotic Shielding Phase

Shielding for the habitat/research center is achieved by loading the tensily stressed canopy with a 2.5 m blanket of regolith. The regolith is collected via telerobotic controlled rover/machinery, screened, and then advanced via belt driven shovels up the vertical center of the mast. Through an opening at the apex, regolith is unloaded unto the exterior of the canopy. The "fabric" (specifically Kevlar) is abrasion resistant, tensily strong, and light-weight. The angle of repose of the regolith (30-35 degrees) mandates the slope of the canopy (Figures 6.2.2-1, and 6.2.2-2).

The canopy is anchored to the lunar surface with screw-type (auger) anchors, which reach below the powdery regolith to the rocky substrate, 2.5 cm to 7.5 cm below the surface. Two to three meters of regolith evenly distributed on the canopy provide adequate shielding from the wide range of radiation and micro-meteorites visited upon the site (Figures 6.2.2-3 and 6.2.2-4).

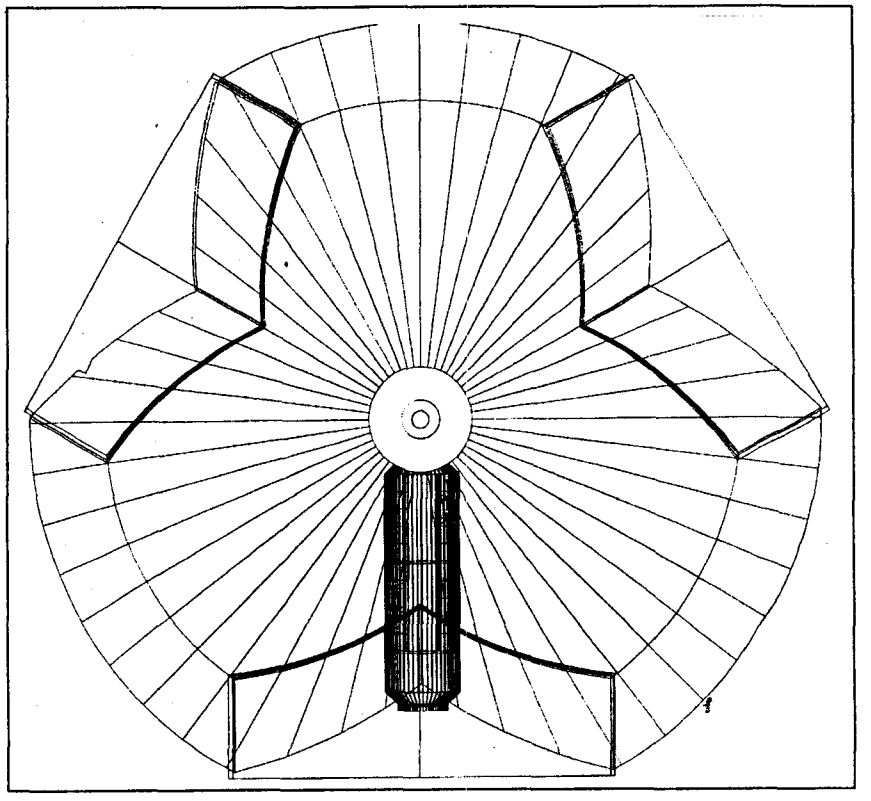

Figure 6.2.2-1. Plan of telerobotic shielding phase. Camopy has been deployed, mst head and regolith layer has been added.

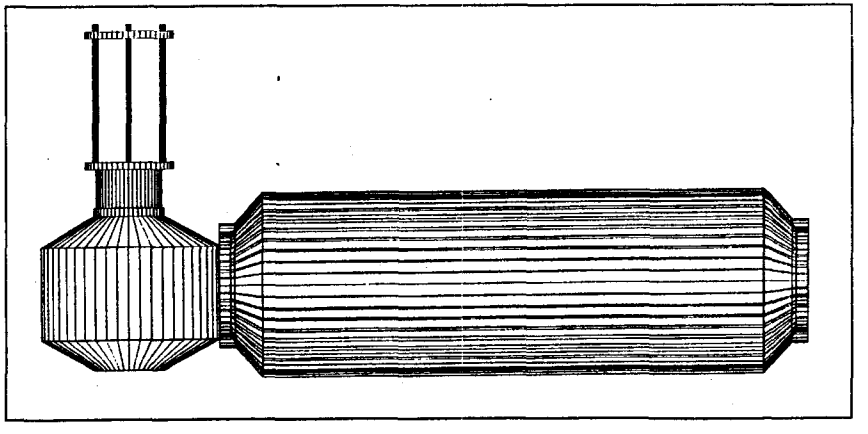

Figure 6.2.2-2. Elevation of first SSF-rerived tube with mast uprighted.

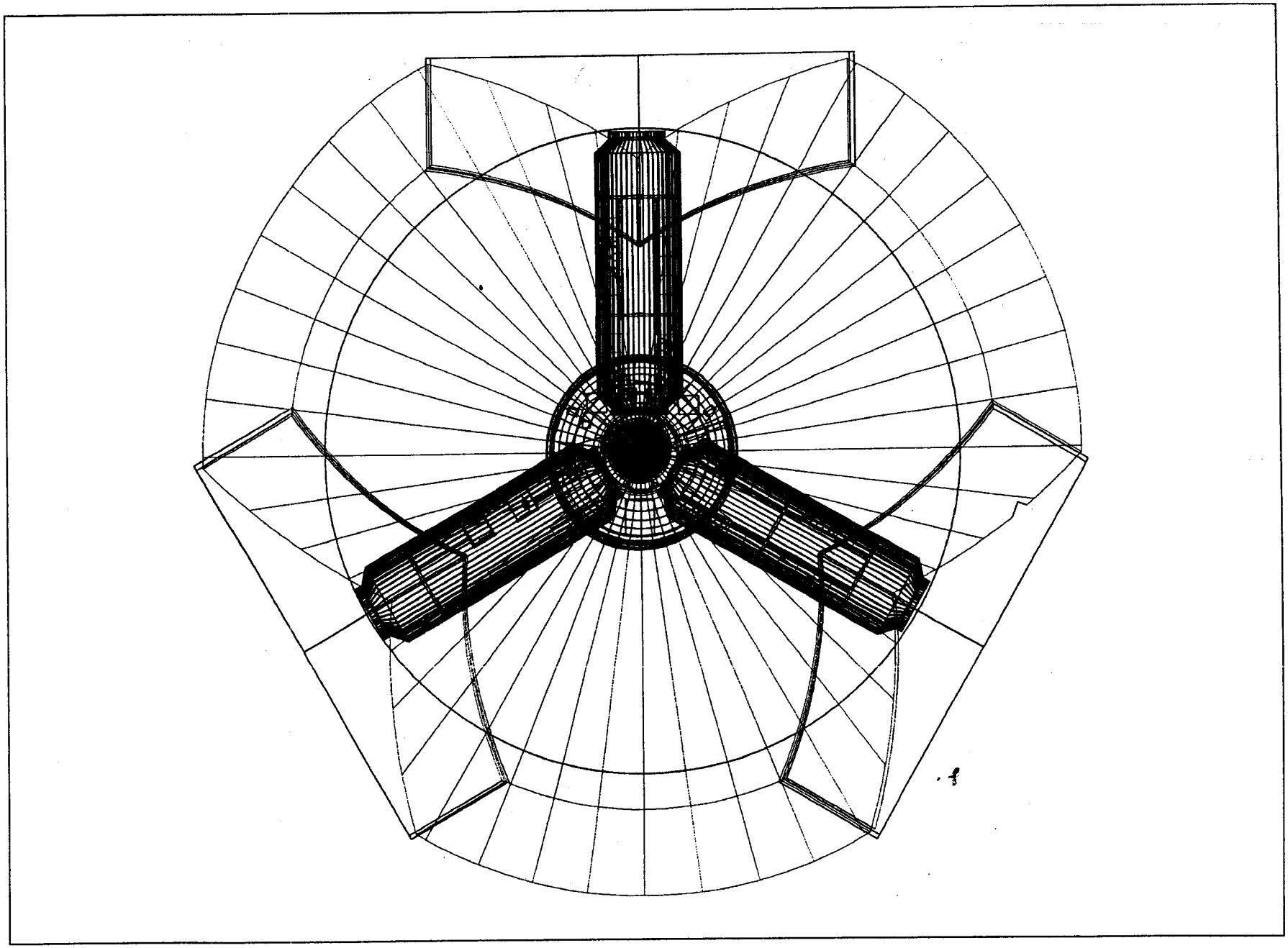

Figure 6.2.2-3. Plan view of completed base.

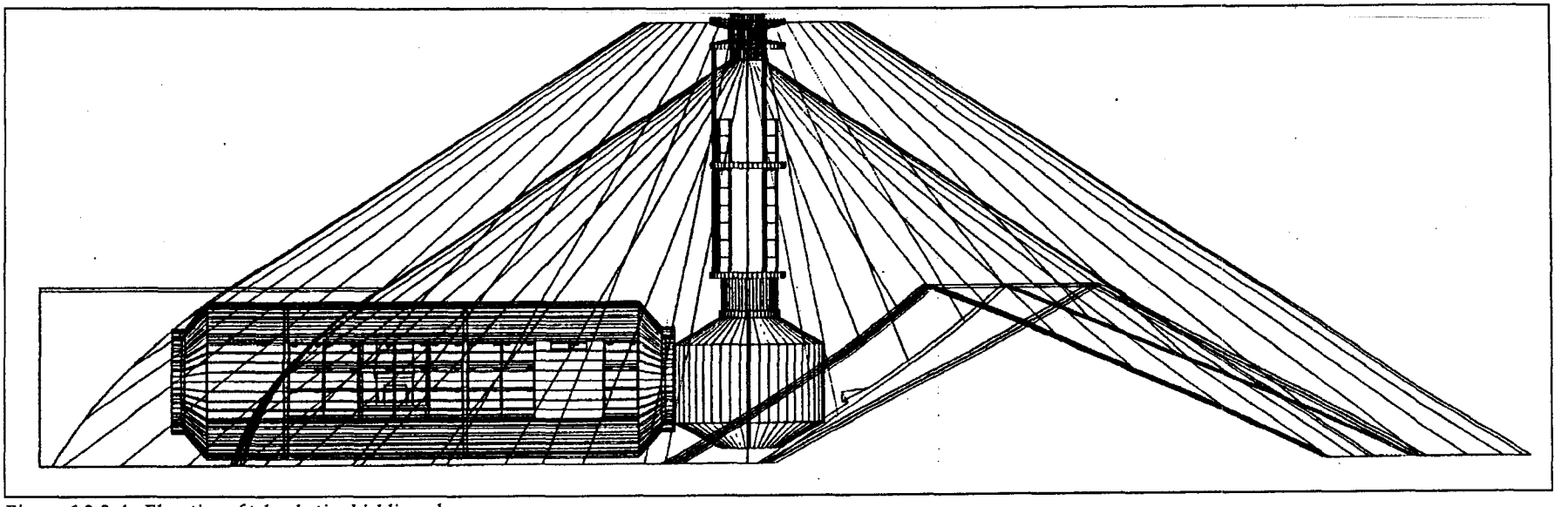

Figure 6.2.2-4. Elevation of telerobotic shielding phase.

6.2.3 Continued Crewed Construction

The construction sequence continues after the shielding phase is complete. Two crewed SSF research modules are integrated with the mission control hub through hanger openings in the shield. Meanwhile, the habitation level inflatable has been deployed from the mast and is undergoing outfitting. The central mast provides a 'package' for the primary element of the habitat level. Composed of 3 graphite fiber epoxy tubes, the mast carries the load of the regolith shielding, provides a vertical circulation corridor, and provides a backbone for the HVAC components, electricity, water, communications, and environmental controls.

The base is complete when all 3 research modules are integrated with the mission control hub, the habitation level is outfitted with crew quarter and supports facilities, and all 12 crewmembers are on site. The telerobotic shielding phase provides a "hardened" shelter for the safe reception of the crew.

6.3 Interior Components and Dimensions

6.3.1 Research Laboratories

The three research lab modules form arms off the central mission control hub at 120 degrees equally (Figures 6.3.1-1 and 6.3.1-2). Located at the end of each arm, opposite the hub, is an air lock which acts as an emergency safety zone. Each air lock houses communications, emergency supplies, and 6 suits. Should an emergency situation cause for the closure of any one arm, the remaining two arms continue to provide for the 12 crew members. In addition, the three modules can be closed off between labs.

Flexible connectors between the modules and the central hub circumvent the transferal of vibrational energy. Likewise, the connector between the hub and the habitation inflatable above are also flexible.

The major circulation route in/out the base is through the high use/high circulation /contact module: the exercise/personal hygiene laundry mod (Figure 6.3.1-3).

A dust-off enclosure is placed at its entry. Focusing the dust-off at this point eliminates the redundancy of dust-offs at all arms ends. Exits would still occur at the other ends, however if all entries are handled at one dust-

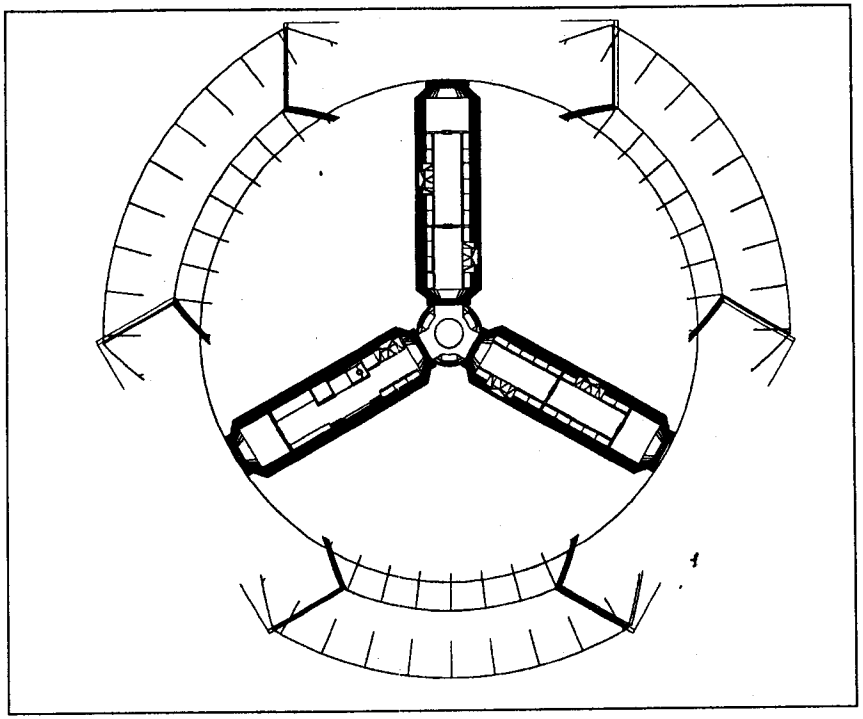

Figure 6.3.1-1. Section plan of first level work zone.

off installation, energy and material are conserved (Figure 6.3.1-4).

6.3.2 Mission Control

The mission control hub, 4.5 m in diameter, is delivered on it's side attached to the end of the first research module. The hub is the pivotal gateway between the lower work environment of the research modules and mission control functions and the upper habitation inflatable. Centrally located, the hub coalesces the activity of the base as well as providing a center of communications and a telerobotic workstation. Entrance to the upper habitation level is assisted by a pull-down ladder.

6.3.3 Habitation Inflatable

The habitation inflatable is a deck and a half. The central mast provides vertical circulation. Horizontal circulation radiates outward at each level. The habitation inflatable houses crew quarters and crew-support facilities (Figure 6.3.3-1. and 6.3.3-2).

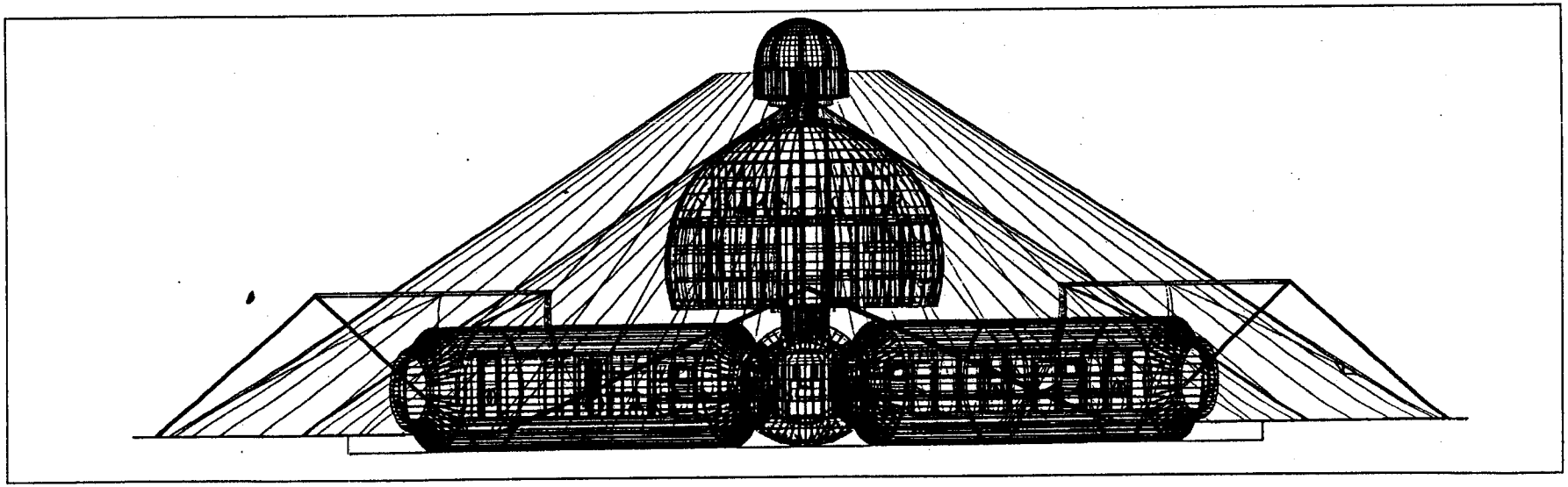

Figure 6.3.1-2. Elevation of completed base.

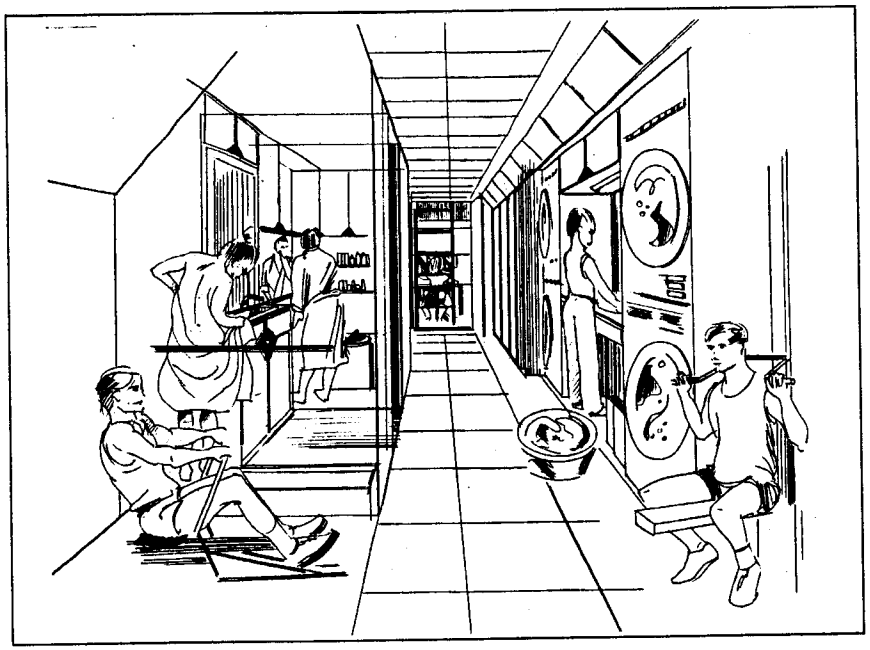

Figure 6.3.1-3. Interior perspective of research module containing plant growth lab.

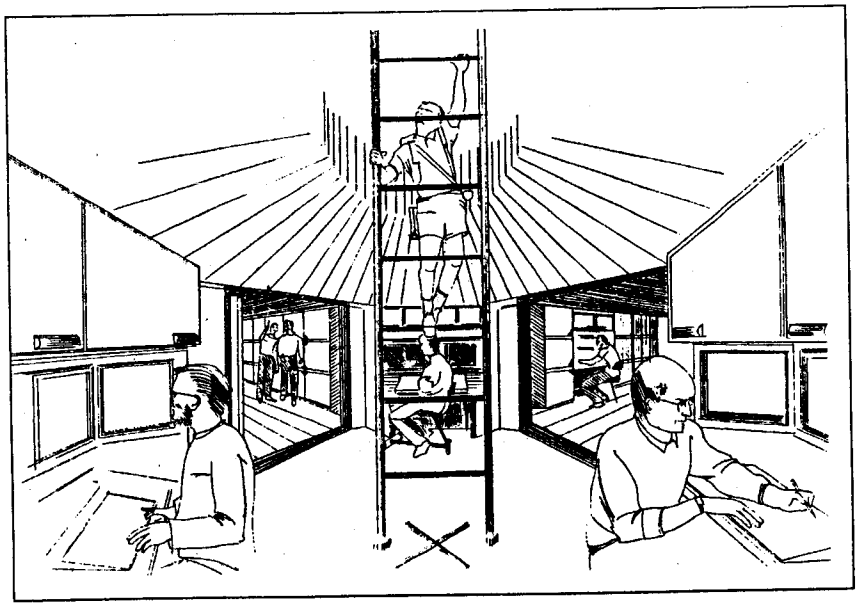

Figure 6.3.1-4. Mission control hub.

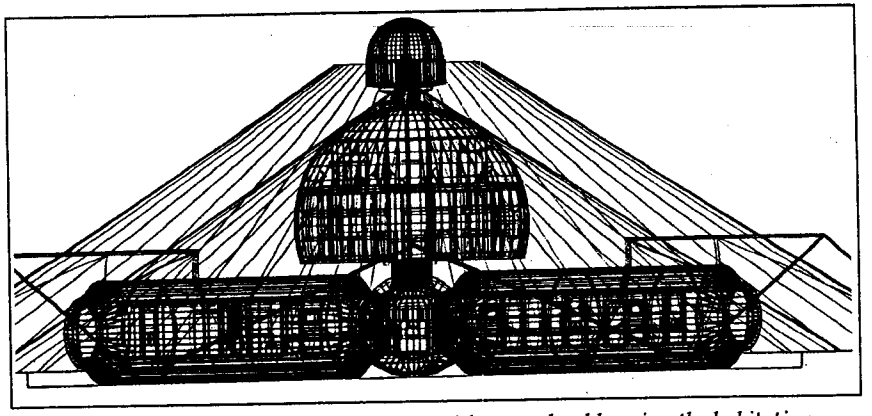

Figure 6.3.3-1. Section of base components with upper level housing the habitation area. Translation to the habitation level is gained through the mast vertical circulation.

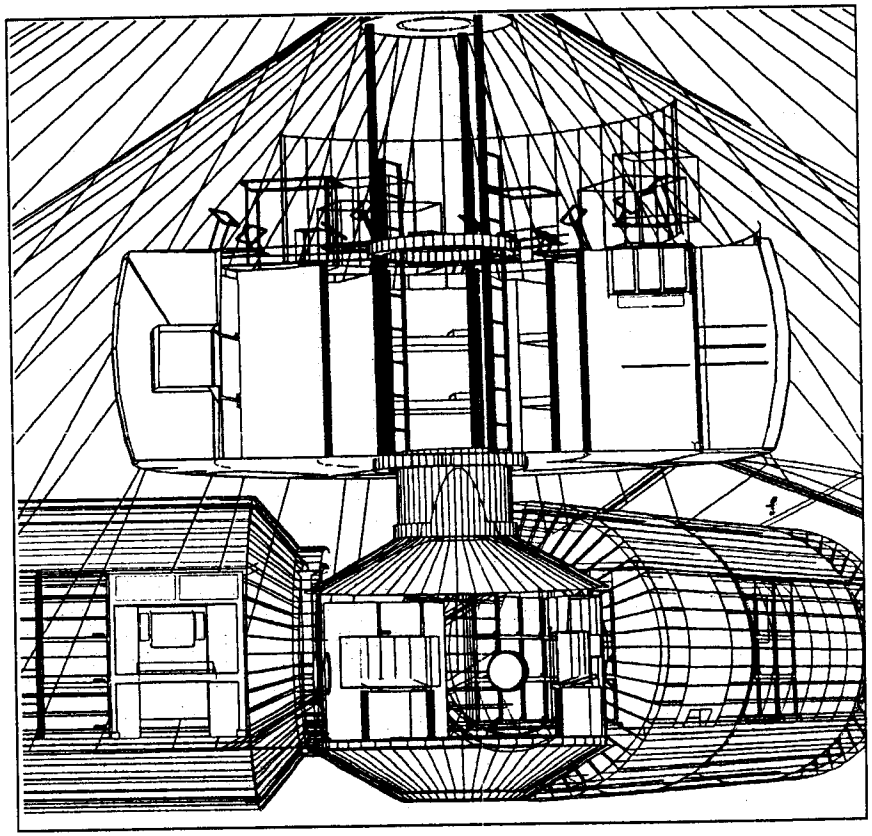

Figure 6.3.3-2. Section of mission control hub and habitation inflatable.

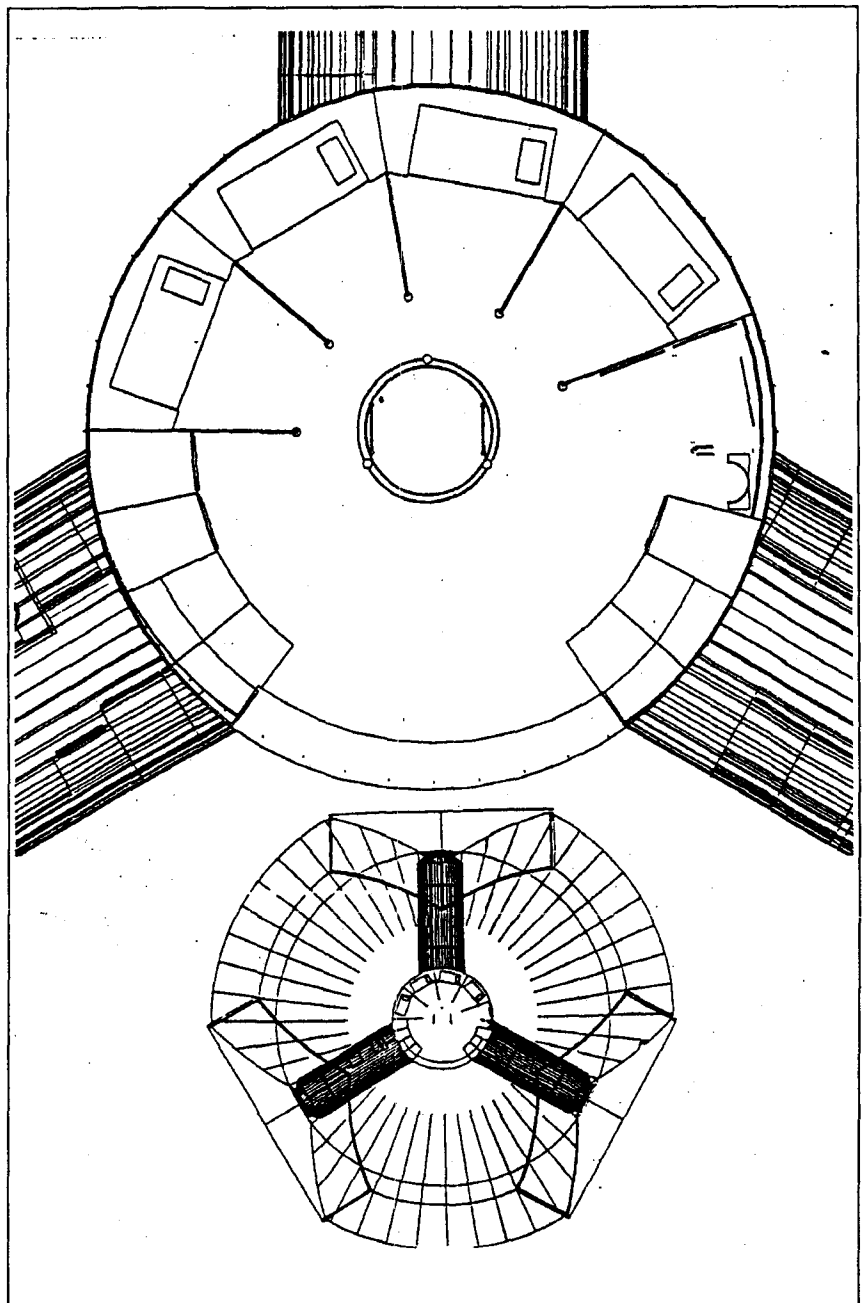

Figure 6.3.3.1-1. Plan of habitation level showing crew quarters and crew support.

6.3.3.1 Crew Quarters

Crew quarters are located beneath the upper deck and shielded acoustically on each end with food storage and personal hygiene. Four rooms provide a triple bunk each for a total of 12 beds. On a split shift, 6 on 6 off, the uninhabited bunk space in each room would be shared by that room's occupant(s).

Personal storage is housed with in each bunk compartment. Clothes hooks line one common wall to the entry, with a closet on the opposing wall (Figure 6.3.3.1-1).

6.3.3.2 Crew Support

The main floor also houses the large common area-(food preparation, galley, recreation, meeting area). Storage racks, delivered with the SSF modules and circulation (dead space), are brought up through the mast and situated along the interior of the inflatable. The racks provide storage while also protecting the inflatable from trauma. A multi-purpose fold away table located midway in the public-active semi-circle provides for eating, meetings, recreation. A projection screen on the interior of the inflatable's skin above the table provides a concave screen for a variety of applications. Exterior viewing via fiber optics, earth communications, and recreation viewing (such as movies, education) are possible (Figures 6.3.3.2-1 and 6.3.3.2-2).

The upper half deck is a passive recreation area for reading , quiet socializing, meditating, music enjoyment as well as a place for expanded plant growth. The open plan allows for creative reconfiguration. The balcony overlook offers a vantage point over the activity below. A storage zone rings the perimeter of the deck, enclosed by a suspended curtain.

The mast is capped off with a 3 m-diameter exterior viewing cupola, accessible through a hatchway at the top of veritcal circulation corridor. The cupola also provides protection for sensitive research instruments (Figure 6.3.3.2-3).

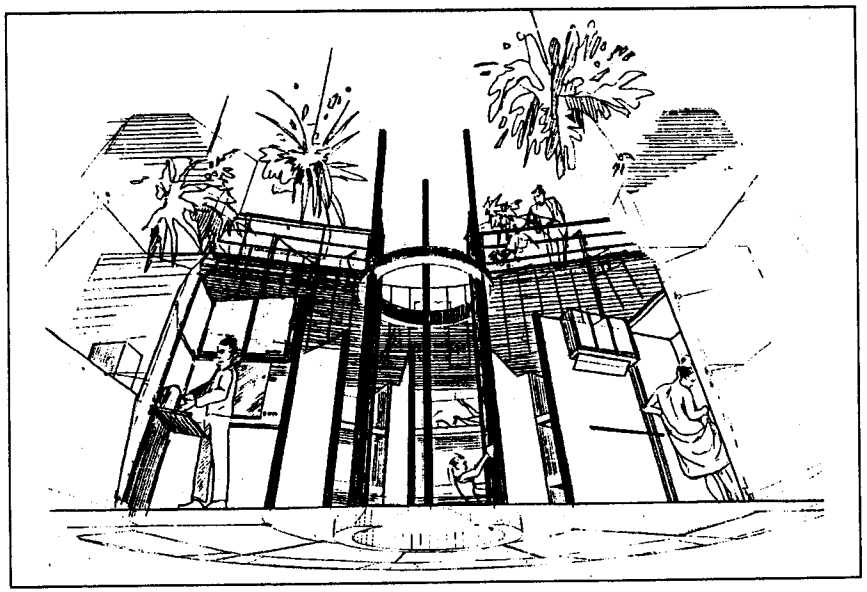

Figure 6.3.3.2-1. Interior perspective of habitation inflatable looking towards the crew quarters and upper recreation loft.

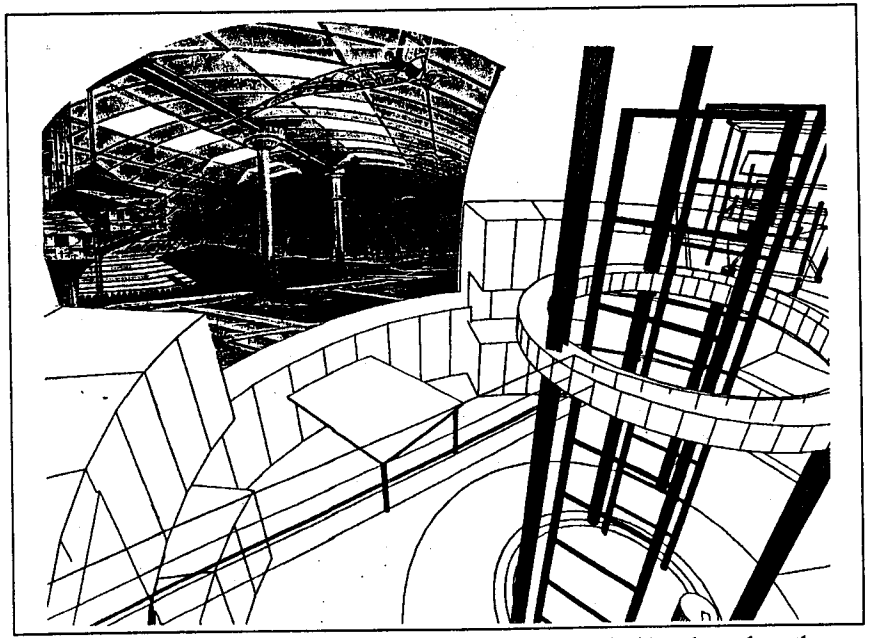

Figure 6.3.3.2-2. Interior perspective of habitation inflatalbe looking down from the balcony into the multi-purpose galley/food preparation/recreation space.

6.4 Critical Design Features of *Dymaxion*

6.4.1 Shielding

Regolith shielding will perform the important task of protecting the crewmembers, equipment and logistics. Key features of the *Dymaxion* concept include:

- telerobotic shielding phase
- canopy utilizes regolith angle of repose
- minimal structure required for shielding — thin canopy and anchors, mast double functions
- one point regolith dispersal
- ease of inspection - research modules and inflatable exterior
- open-plan under canopy (aside from central mast), allows for reconfiguration of components, as well as providing additional storage (unpressurized)

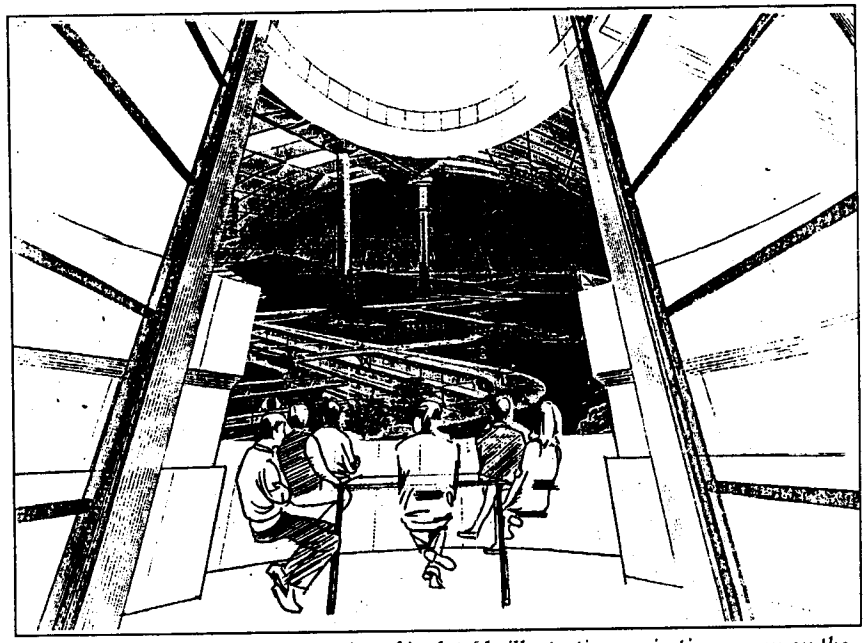

Figure 6.3.3.2-3. Interior perspective of inglatable illustrating projection screen on the interior surface of the inflatable.

- 2.5 m thickness of regolith blanket (provides adequate protection from micro meteorites and radiation)

6.4.2 Packaging

- base requires 3 payloads
- mast and inflatable delivered within first module's circulation space
- mission control hub delivered attached to mast, delivered with first load
- known SSF (space station freedom) module technology
- minimal additional packaging
- components can be dis-integrated from the base and set up elsewhere

6.4.3. Zoning

Separation between:

- work environment (lower) and habitation (upper)
- crew quarters (private) and crew supports (public)

In addition:

- hatches within research modules separate labs
- flexible connectors between research modules and mission control hub, and hub to habitation level. Dampens the transferal of vibrational energy.
- safety (zones) located at each end of research module arm (airlocks)

6.4.4. Multi-functioning

- central mast performs as structural pillar, circulation corridor, HVAC frame
- interior of inflatable serves as viewing screen (habitation level)
- multipurpose area of (galley, wardroom, recreation)
- modularity of racks, components

6.4.5. Variety of Spaces

- double height space of habitation inflatable
- upper "loft" and viewing balcony (quiet recreation area)
- research lab situations
- crew quarters/support situations
- exterior viewing cupola

6.4.6. Interior Spaces

- minimizes circulation; the research labs are in the 2 m- width corridor which double functions as a work area; inflatable : circulation radiates off central mast corridor
- research modules and mission control hub (linkage): ease of visual and verbal communication and reference (line of sight)
- crew quarters: expandable bunk situation (split shift)

6.4.7. Additional

- flexible to a range of site conditions (doesn't require extensive site preparation)
- main entry through one module: focuses dust-off and traffic (corridor)
- reconfiguration possibilities: post-occupancy scenarios/ industrial applications
- advantages of the inflatable: packaging, volume to weight yield, conforms to pressurized environment, ease of set-up, deployment time

6.5 Quantitative Volumetric Dimensions of Dymaxion

6.5.1 Laboratories

plant	20 m^2
geomorphology	20 m^2
life science	20 m^2
micro- biology	20 m^2

6.5.2 Mission Control

telerobotic workstation	2 m^2
mission control	4 m^2

6.5.3 Crew Quarters

personal quarters	25.5 m^2
hygiene(lower)	4 .0 m
(upper)	5.5 m^2

6.5.4 Crew Support

galley	13 m^2
food storage	10 m^2
health maintenance	12 m^2
laundry	4 m^2
exterior viewing	6 m^2

6.5.5 Service

safehaven (air locks)		36 m^2
storage (upper loft)		15 m^2
	NET	255 m^2
x multiplier (25%)		63.75 m^2
	GROSS	318.75 m^2

Quantitative General Dimensioning

Canopy

interior volume	4069.44 m^3
radius	18 meters
height	12 meters
slope	33 degrees
surface area	565.25 m^2

Regolith

volume	4787.69 $meters^3$ (depth of 2.5 meters)

Sphere (3/4)

radius	5 meters
volume	392.5 $meters^3$
surface area	147.2 $meters^3$

Gross Volumes

inflatable	392.5 $meters^3$
hub	47.5 $meters^3$
h mods	596.4 $meters^3$
Total1036.6 $meters^3$	

Gross volume of cone	4069.44 $meters^3$
Gross volume of regolith	4787.69 $meters^3$