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Special Design Project Issue

SICSA OUTREACH

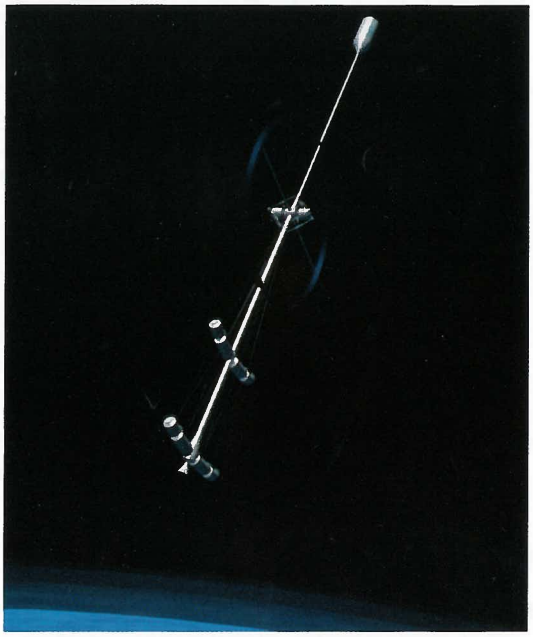
Sasakawa International Center for Space Architecture

Variable-G Life Science Facility

SICSA is pursuing requirements definition and concept studies for a ***Variable-Gravity Life Science Facility (VGLSF)*** to support research and planning for manned planetary missions. The project is sponsored by ***NASA-Johnson Space Center's Space and Life Sciences Division.*** Technical support has been provided by NASA-JSC's ***Advanced Projects Office***.

The VGLSF would be used primarily for research to determine how much gravity, if any, is required to maintain acceptable levels of crew health and performance during, and immediately following, extended planetary voyages and surface missions.

Design principles or actual systems applied to the VGLSF might be incorporated into planetary vehicles that rotate to simulate essential gravity levels. This will enable the VGLSF to be used as an advanced missions testbed and crew training facility.



Computer-Generated View by Symbolics, Inc.

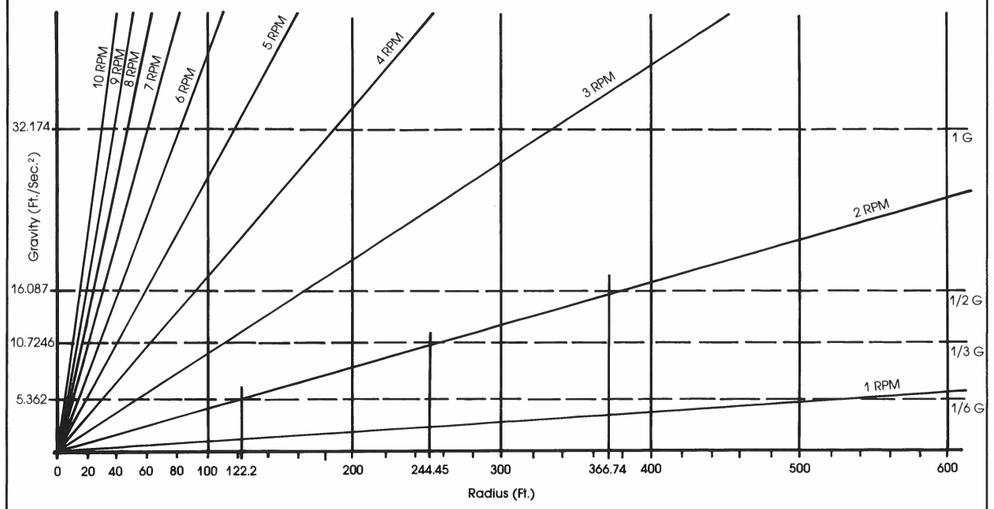
Initiated in January, 1987, the VGLSF project has involved faculty and students in the ***Experimental Architecture*** graduate program. The work has been undertaken through the auspices of NASA-JSC Contract NAS9-16593. Current work is being supported by a 12 month contract extension and budget supplement issued in May, 1987.

SICSA is grateful for contributions of the late Dr. Philip Johnson who acted as NASA Project Monitor and technical resource for this effort.

VGLSF Purposes

- Support long-duration human, animal and plant science experiments in simulated gravity.
- Demonstrate technology and docking/ logistics transfer procedures for rotating spacecraft.
- Provide a testbed and training facility for future planetary vehicles.

A Publication of the University of Houston's College of Architecture



GRAVITY/RADIUS/RPM CHART

Formula for the Rate of Acceleration: $A = w^2R$

A = rate of acceleration (1G = 32.174 ft./sec.²)
w = angular velocity (1 RPM = 0.10472 radian/sec.)
R = radial position (feet)

Simulated Gravity Levels as a Function of Rotation Radii and Rates

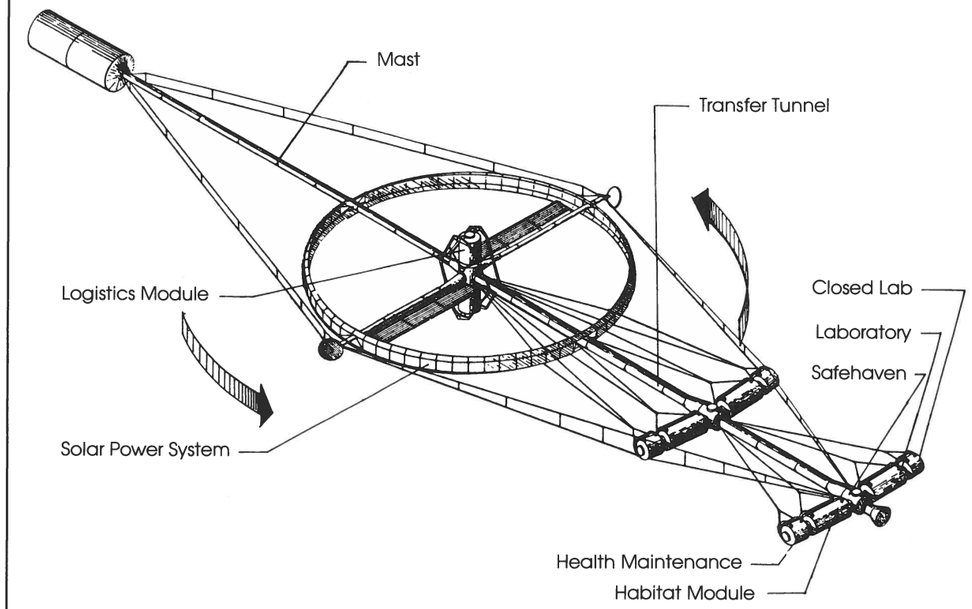
Background

Much remains to be learned about the effects of prolonged periods of weightlessness and reduced-gravity upon human health. U.S. Skylab missions and Soviet experiences have demonstrated deconditioning influences of extended microgravity exposure, including reductions of bone calcium, muscle and blood cell mass, cardiopulmonary strength and immune system effectiveness.

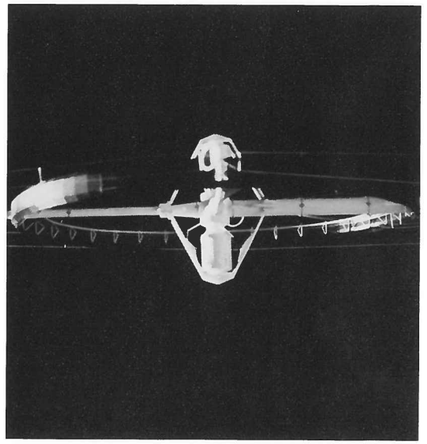
Apollo mission observations indicated that partial gravity may help to alleviate some of these problems. Crew members who landed on the Moon appeared to have less heart atrophy and excrete less calcium than their orbiting companions. The missions were too short, however, to support quantifiable conclusions. A VGLSF can provide hard data.

Key Medical Questions

- What relationships exist between specific health problems and extended exposure to different gravity levels?
- Can partial gravity prevent or decrease physical deconditioning?
- Under what conditions can people remain healthy during long voyages to Mars and lunar surface missions?
- Can health and productivity be improved by simulating gravity onboard a rotating spacecraft?
- What rate of rotation is optimum for crew health and comfort?
- Can simulated gravity benefit plant and animal reproduction/growth in space?



Variable-Gravity Life Science Facility Elements



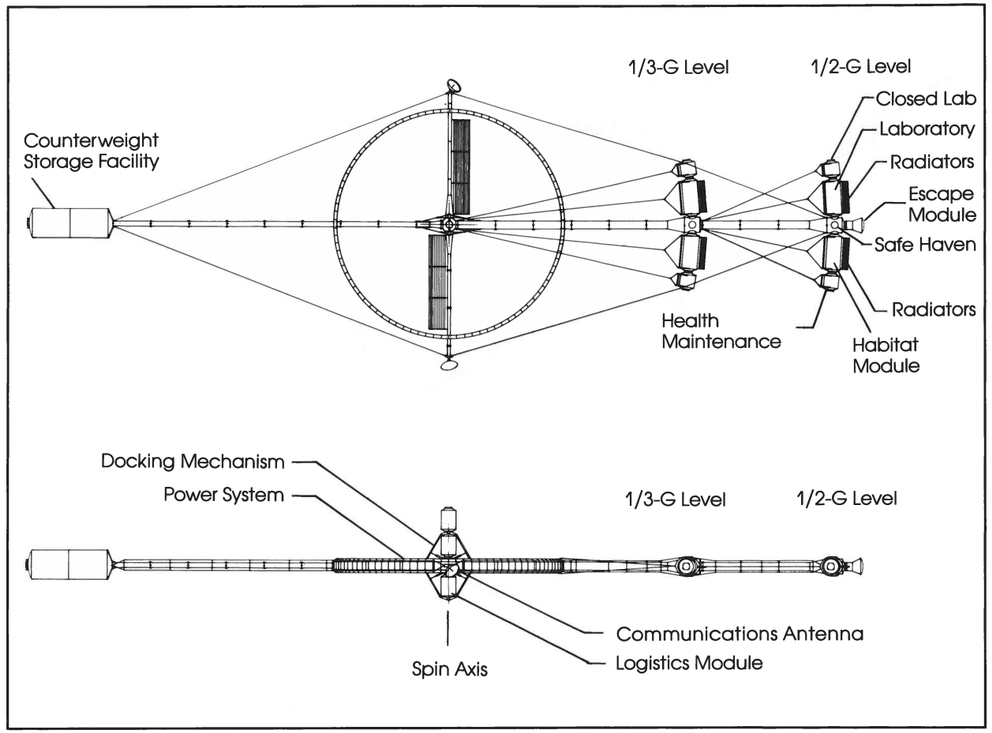
Logistics Modules at Central Hub

Orbit, Orientation and Rotation

The VGSLF is proposed to operate in a 28 1/2 degree inclination orbit at an altitude of 150-200 nautical miles. The spacecraft would rotate in a "bicycle wheel" orientation with respect to Earth to maintain stability.

A relatively slow 2 rpm rotation rate is proposed to simulate gravity. Modules are to be located at two positions along the spin radius: at 244.45 feet (1/3-G), and at 366.74 feet (1/2-G). These gravity levels can be adjusted upwards or downwards by changing the spin rate (refer to the chart on the opposite page).

Shuttle Orbiter docking occurs at the central Hub where Logistics Modules are attached. A special rotating Logistics Module transfer system avoids the need for complex docking maneuvers.



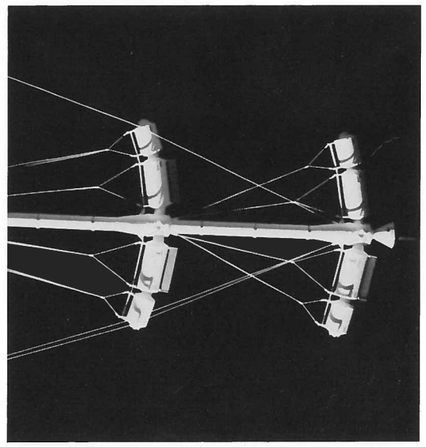
VGLSF Elevation Views

Configuration

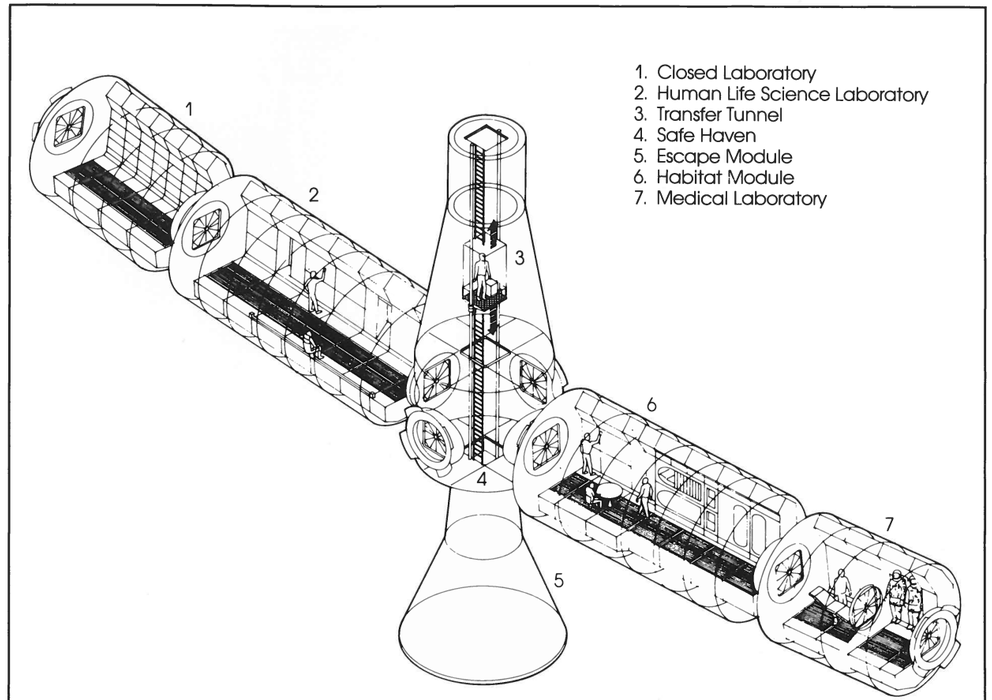
Primary VGLSF elements are the structural ***Mast, Transfer Tunnel*** and tension cables that form the main infrastructure; ***Habitat,*** and ***Laboratory Modules;*** central ***Hub*** with ***Logistics Modules;*** a crew ***Escape Moldule;*** a ***Counterweight Storage Facility*** and a photovoltaic ***Power System.***

The 8 foot diameter Transfer Tunnel connecting the Hub with partial gravity living and work modules is pressurized to enable "shirt-sleeve" transfer of people and equipment. The 5 foot diameter counterweight support mast and two 3 foot diameter cross-bracing masts are not pressurized.

Water used for balancing mass is pumped from the Counterweight Storage Facility for use where required, and is reclaimed for recycling.



Cables Attached to Cradle Fixtures Resist Loads



1/2-G Level Facilities

Crew Accommodations Each Level

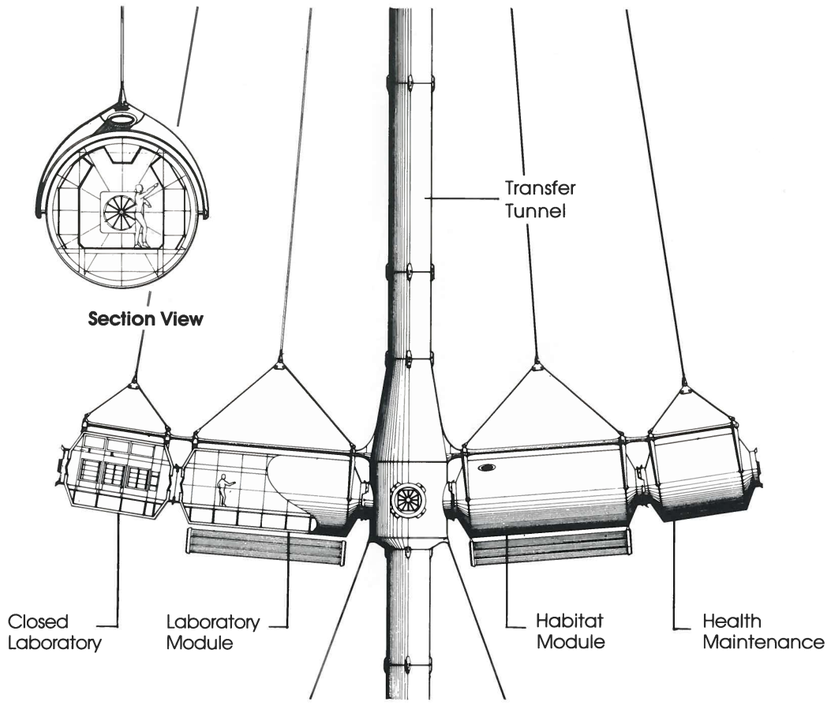
- Galley and wardroom for food preparation, dining and assembly.
- Exercise and health monitoring devices.
- Laundry and utensil wash equipment.
- Waste management compartment and treatment systems.
- Shower and personal hygiene.
- Crew quarters with personal stowage.
- Storage racks and spare parts/tools.
- Environmental control and life support systems.

Modules

VGLSF modules are proposed to be of standard Space Station size and structure with geometric adjustments at berthing ports to create slight angulation along the rotation arc.

Habitat Modules at 1/2-G and 1/3-G positions will each provide accommodations for separate crews of 3-5 people who will simultaneously occupy the facility for periods sufficient to enable comparative health evaluations.

Closed Laboratories at both G-levels will accommodate animal and plant experiments, preventing contamination of the connecting Human Life Science Laboratory. Medical Laboratories and Escape Modules will support crew health and safety.



1/3-G Level Facilities

Research Priorities

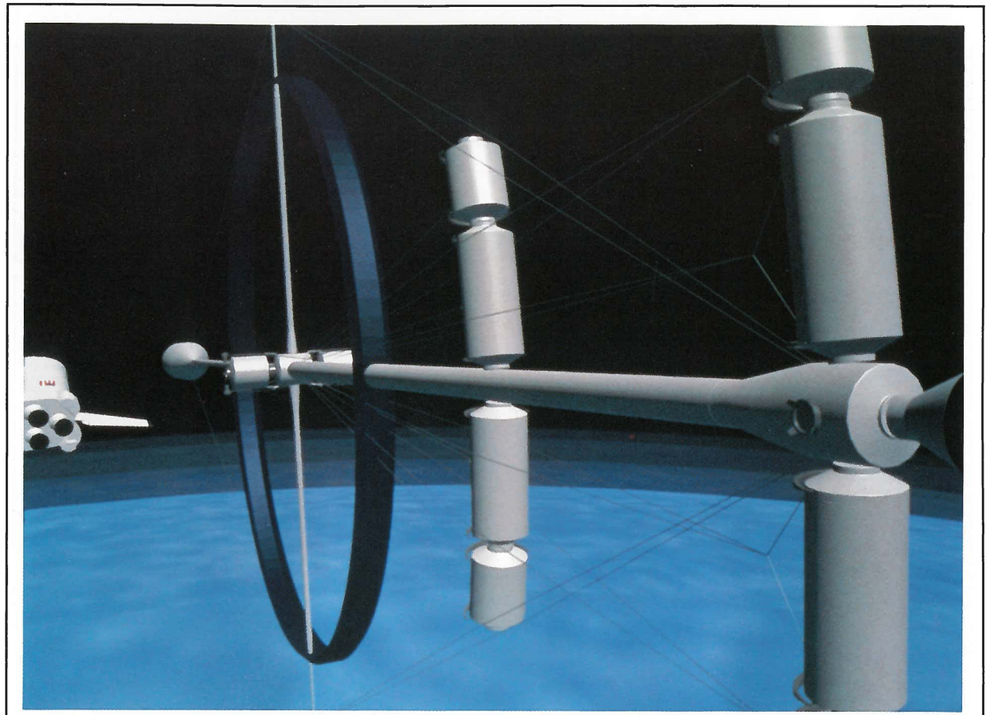
Important research priorities will be to determine how long people can remain on the Moon; abilities of people to undertake useful work following long voyages to Mars; and efficacious countermeasures to avoid or reduce atrophies caused by low-gravity conditions.

Overcoming long-term microgravity exposure through exercise alone may be impractical because of the many hours required and difficulties in achieving total body conditioning. Pharmacological countermeasures are untested and methods that apply anabolic agents are believed unsafe.

Research accommodations to support extended-duration human, animal and plant experiments are essential to provide reliable solutions and data.

Human Research Accommodations

- Experiment equipment for measuring tolerance to angular velocity, pulmonary function, blood chemistry, postural balance, gross and fine motor performance and other conditions.
- Biotelemetry and data recording systems.
- Exercise equipment and health monitoring devices.
- Experiment work station with tools and equipment storage.
- Air quality monitoring and revitalization systems.



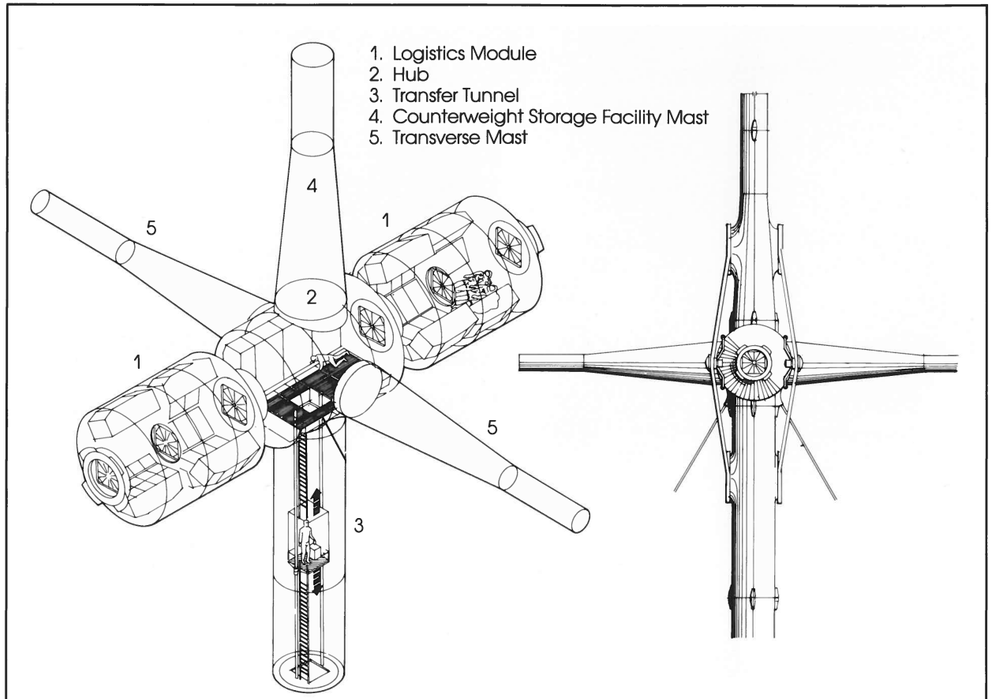
View Emphasizing Pressurized Modules and Transfer Tunnel (Computer-Generated Image by Symbolics, Inc.)

Animal Research Accommodations

- Advanced small animal holding facility with automatic separation/collection of urine and feces.
- Large primate holding facility with automatic separation/collection of urine and feces.
- Vestibular research facility.
- Specimen centrifuge and freezer.
- Accelerometer measurement system.
- Dynamic environment measuring system.
- Biotelemetry and data recording systems.

Plant/Aquatic Research Accommodations

- Plant containers with automatic watering and nutrient supply.
- Aquatic animal holding facility with provisions for air/water/gas exchange control; removal of toxic metabolic by-products and automated food dispensing.
- Zoned lighting and temperature controls.
- Specimen research centrifuge/storage.
- Waste management and water recovery purification systems.
- Experiment monitoring and recording systems.

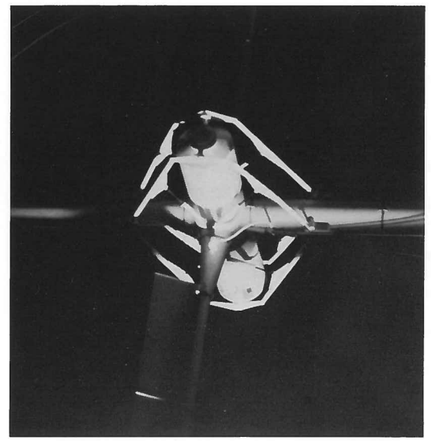


Zero-G Center of Rotation

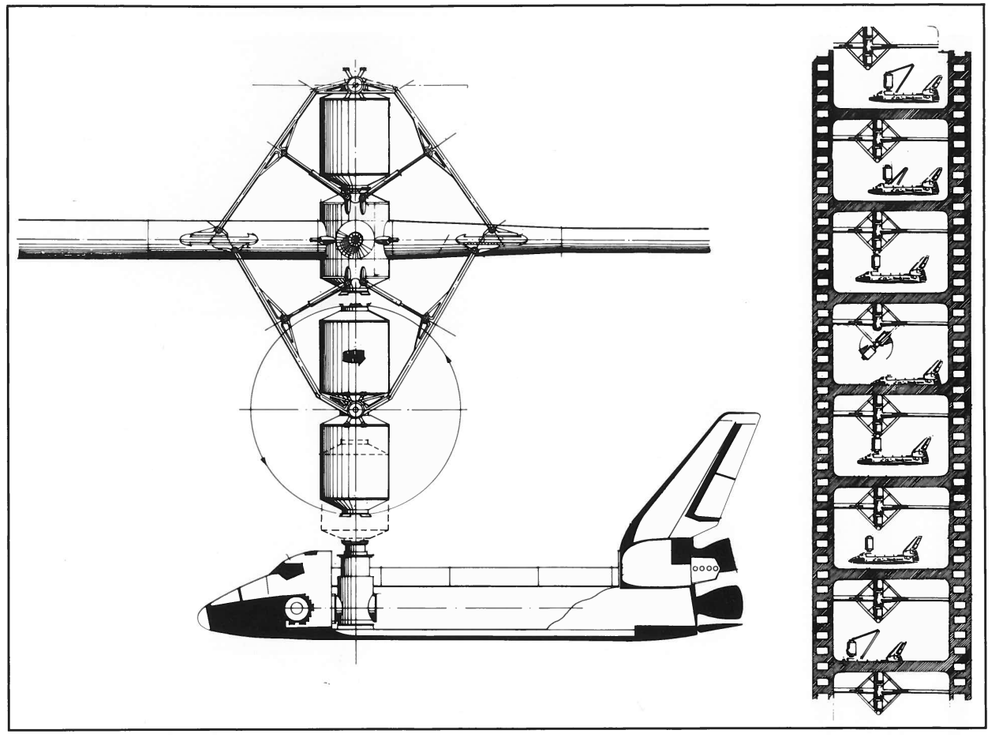
Center of Rotation

A pressurized Hub at the VGLSF's center of rotation provides two berthing ports to receive Logistics Modules. The Hub terminates the passageway that connects with and supports the simulated-G modules and carries the Counterweight Storage Facility mast and smaller transverse masts.

The Logistics Modules, which are changed-out during regular Orbiter visitations, contain expendable provisions (such as food and research supplies) and auxiliary equipment. Their microgravity location facilitates manipulation of materials and equipment items of large mass into the VGLSF's Transfer Tunnel. Once in place, the items can be easily translated into the Habitat and Laboratory Modules.



Logistics Modules at Hub



Logistics Module Exchange Concept

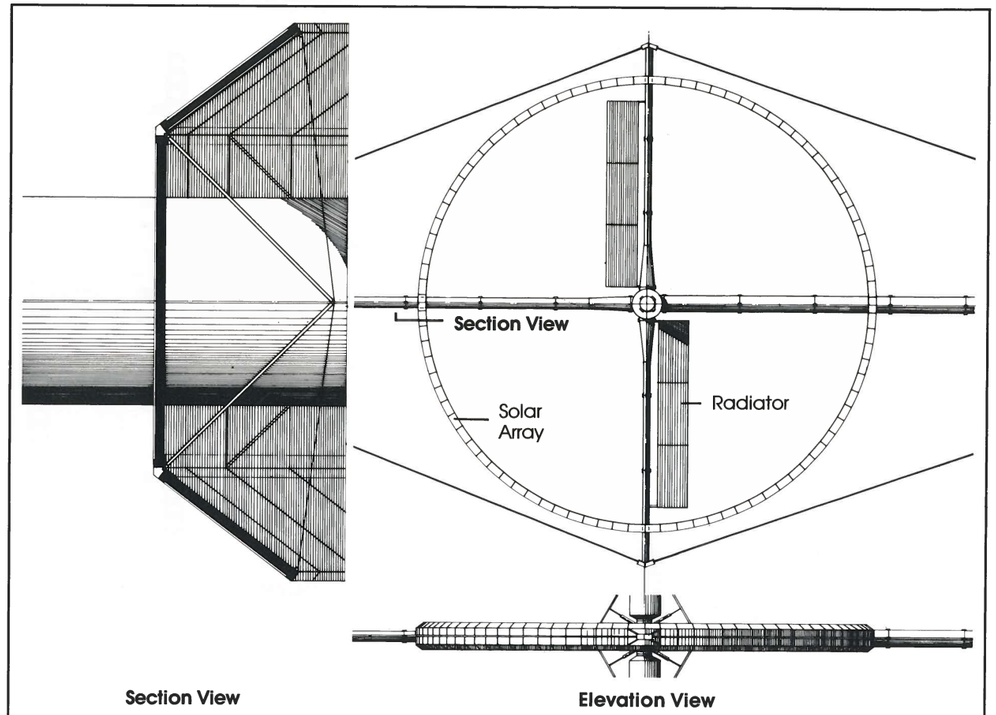
Exchange Sequence

1. Spent Logistics Module is uncoupled from VGLSF berthing port by transfer fixture and counter-rotates.
2. Fresh Logistics Module is attached to counter-rotating transfer fixture turntable.
3. Orbiter releases fresh Logistics Module and the spent and fresh modules are flipped for transfer.
4. Spent Logistics Module is passed from transfer fixture to Orbiter payload bay by the Remote Manipulator System (RMS).
5. Transfer fixture de-rotates the fresh Logistics Module and attaches it to the VGLSF.

Logistics Module Exchange

A provision is made for Shuttle Orbiter docking and Logistics Module exchange without difficult maneuvers or complicated mechanisms while the VGLSF is rotating. The unberthed end of each Logistics Module is attached to the motor-driven turntable on a transfer fixture. The fixture has another turntable to accept a replenished Logistics Module and a pivoting "flip-over" mechanism.

During an exchange operation, the transfer fixture clears the uncoupled module away from its berthing port, flips it over 180°, and counter-rotates it to have zero differential angular motion relative to the Orbiter. Replenished modules are attached to the VGLSF in the reverse of this procedure.



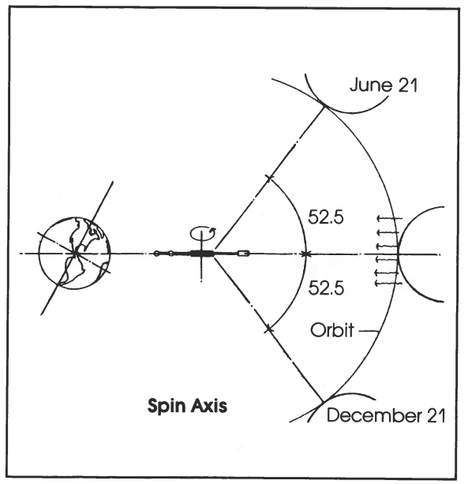
Power System Concept

Power System

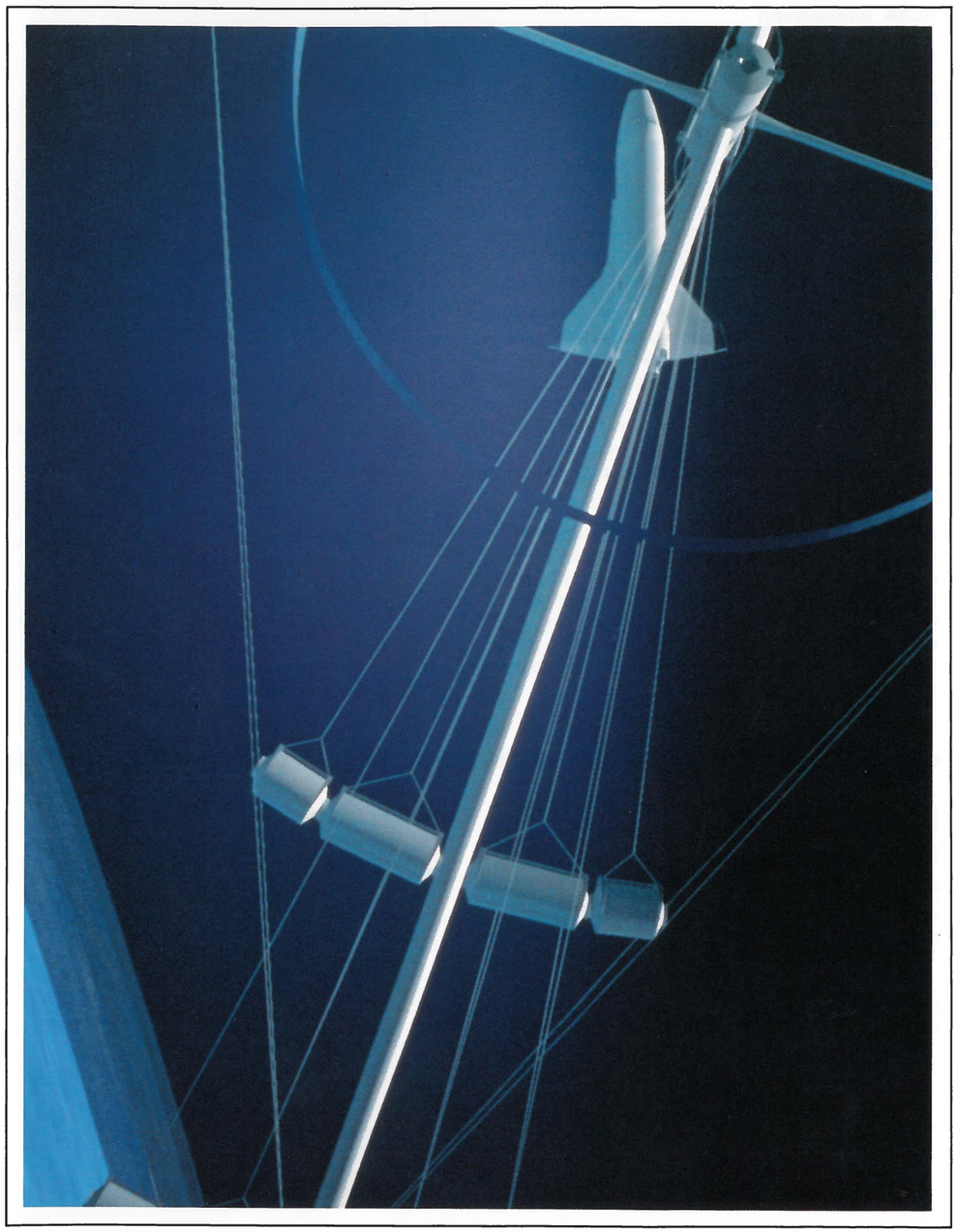
The VGLSF power system is a circular arrangement of photovoltaic cells. The configuration is oriented to achieve optimum exposure to the sun throughout seasonal changes of relative sun positioning.

The solar panels are to be packaged for launch in an "accordion" fashion and deployed in quadrant sections. A lightweight, hinged, locking framework structure fixed to the VGLSF masts provides support and attachments for the panel arrays.

Radiators attached to the masts dissipate heat produced by power generation. Body-mounted radiators attached to Laboratory, Habitat and Health Maintenance Modules dissipate heat produced by onboard activities and equipment.



Seasonal Relationships to Sun Position



Computer-Generated View by Symbolics, Inc.

SICSA Background

SICSA is a nonprofit research, design and educational entity of the University of Houston College of Architecture. The organization's purpose is to undertake programs which promote international responses to space exploration and development opportunities. Important goals are to advance peaceful and beneficial uses of space and space technology and to prepare professional designers for challenges posed by these developments. SICSA also works to explore ways to transfer space technology for Earth applications.

SICSA provides teaching, technical and financial support to the ***Experimental Architecture*** graduate program within the College of Architecture. The program emphasizes research and design studies directed to habitats where severe environmental conditions and/or critical limitations upon labor, materials and capital resources pose special problems. Graduate students pursue studies which lead to a Master of Architecture degree.

SICSA Outreach highlights key space developments and programs involving our organization, our nation, our planet and our Solar System. The publication is provided free of charge as a public service to readers throughout the world. Inquires about SICSA and Experimental Architecture programs, or articles in this or other issues of *SICSA Outreach* , should be sent to Professor Larry Bell, Director.

Project Team

Kriss Kennedy (standing) and Peter Davis

The ***Variable-G Life Science Facility (VGLSF)*** project is being undertaken as a graduate research and design study within the UH Experimental Architecture program. Technical and financial support is afforded through a research contract with ***NASA-Johnson Space Center's Space and Life Sciences Division.***

The VGLSF concept presented in this report is one of several simulated gravity facilities under study by SICSA. A scale model and graphic panels are currently on display at the ***Houston Museum of Natural Sciences.***

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