GEOSTATIONARY PLATFORM STRUCTURAL SYSTEM

S. J. DENTON

MARSHALL SPACE FLIGHT CENTER

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BRIEFING TOPICS

STRUCTURAL CONFIGURATION AND DESIGN CONCEPT

THERMAL CHARACTERISTICS

FLIGHT LOAD CONSIDERATIONS

ASSEMBLY APPROACHES

STRUCTURAL CONFIGURATION (Figure 1)

The Geostationary Platform configuration under consideration is shown in the following chart. A tetrahedron structural geometry was selected to provide inherent structural efficiency, all rigid members, and a compact arrangement of node points to which the antennae are mounted. RCS propulsion modules are located on out-riggers at each of the four corners of the structural platform, and solar arrays are located at either end. The largest antenna, 30 meters in diameter, is centrally located to maintain symetry in weight distribution.

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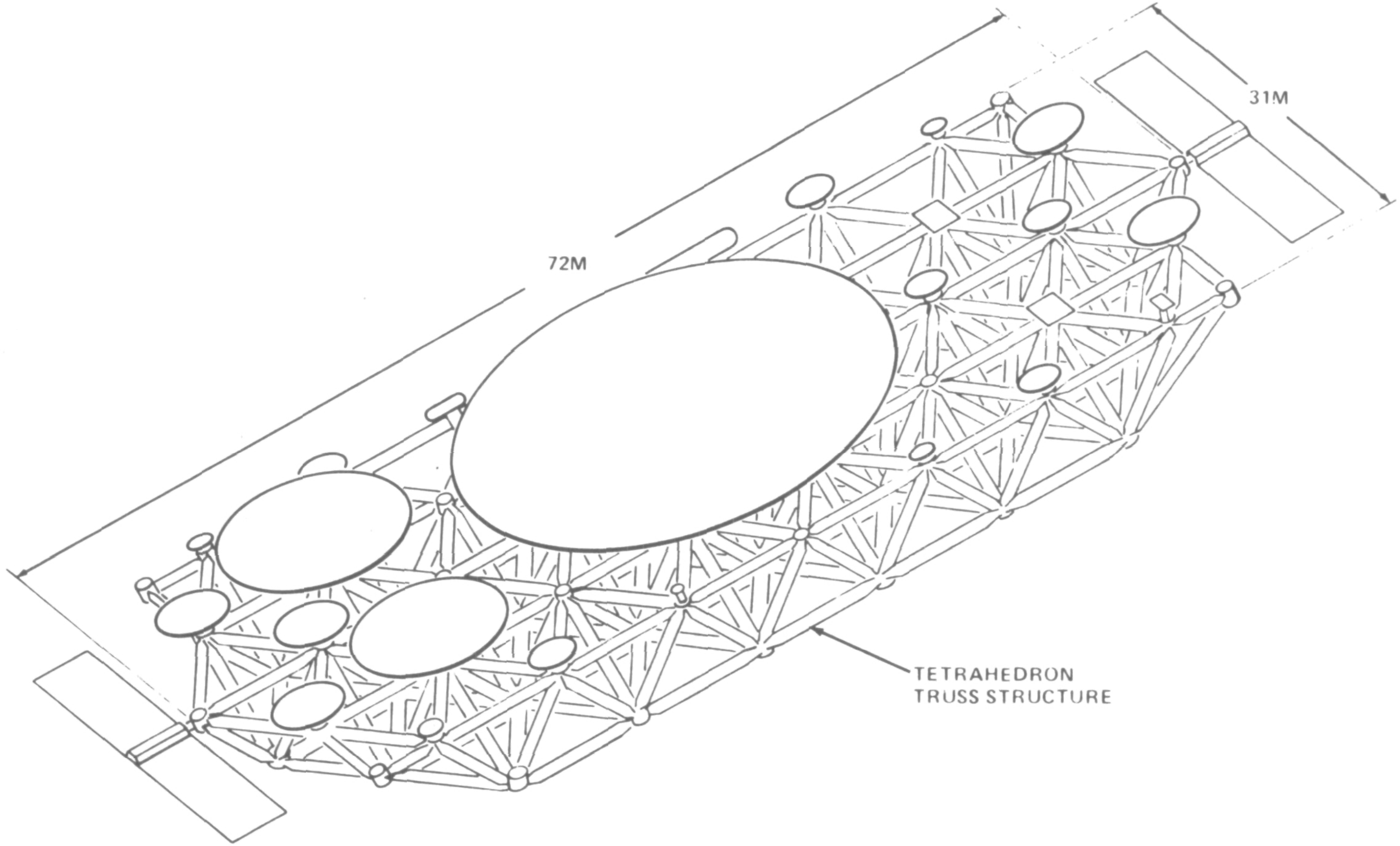

Figure 1

STRUCTURAL SYSTEM DESIGN OPTIONS (Figure 2)

An erectable structure design approach is currently preferred to a deployable system to minimize the number of STS launches required. Although a deployable structure would minimize the assembly tasks required, design concepts with competitive packaging densities and adequate member sizes are not currently available. A structural design approach, which utilizes the best features of both space fabricated and prefabricated structural members in an erectable system, is currently being evaluated.

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OPTIONS TO STRUCTURAL SYSTEM DESIGN APPROACH

ERECTABLE STRUCTURE

SPACE FABRICATED STRUCTURAL MEMBERS

- PROVIDES CAPABILITY TO PRODUCE LONG CONTINUOUS MEMBERS SIMPLIFYING ASSEMBLY

PREFABRICATED STRUCTURAL MEMBERS

- PROVIDES CAPABILITY TO TAILOR MEMBER SIZE AND MATERIAL TO SYSTEM REQUIREMENTS

STRUCTURAL DESIGN APPROACH CAN UTILIZE BEST FEATURES OF BOTH

DEPLOYABLE STRUCTURE

- MAJOR PORTION OF ASSEMBLY TASK ELIMINATED
- DEVELOPMENT OF CONCEPTS WHICH CAN BE PACKAGED IN CARGO BAY IS NEEDED

Figure 2

STRUCTURAL SYSTEM DESIGN CONCEPT (Figure 3, Figure 4)

The current structural system design approach for the Geostationary Platform is shown in the following two charts. Aluminum space fabricated beams, with a 1 meter cross-sectional depth, are utilized for the continuous longitudinal members. Graphite/epoxy prefabricated members, of the nested tapered tube type, are used for the interconnecting lateral and diagonal members. A node point spacing of 9 meters was selected to provide adequate separation of the various antennae mounted on the platform. In order to provide load paths aligned with the triangular cross section of the space-fabricated beams, the tetrahedron geometry deviates from an equilateral tetrahedron to one which is offset, having one member 7.8 meters in length.

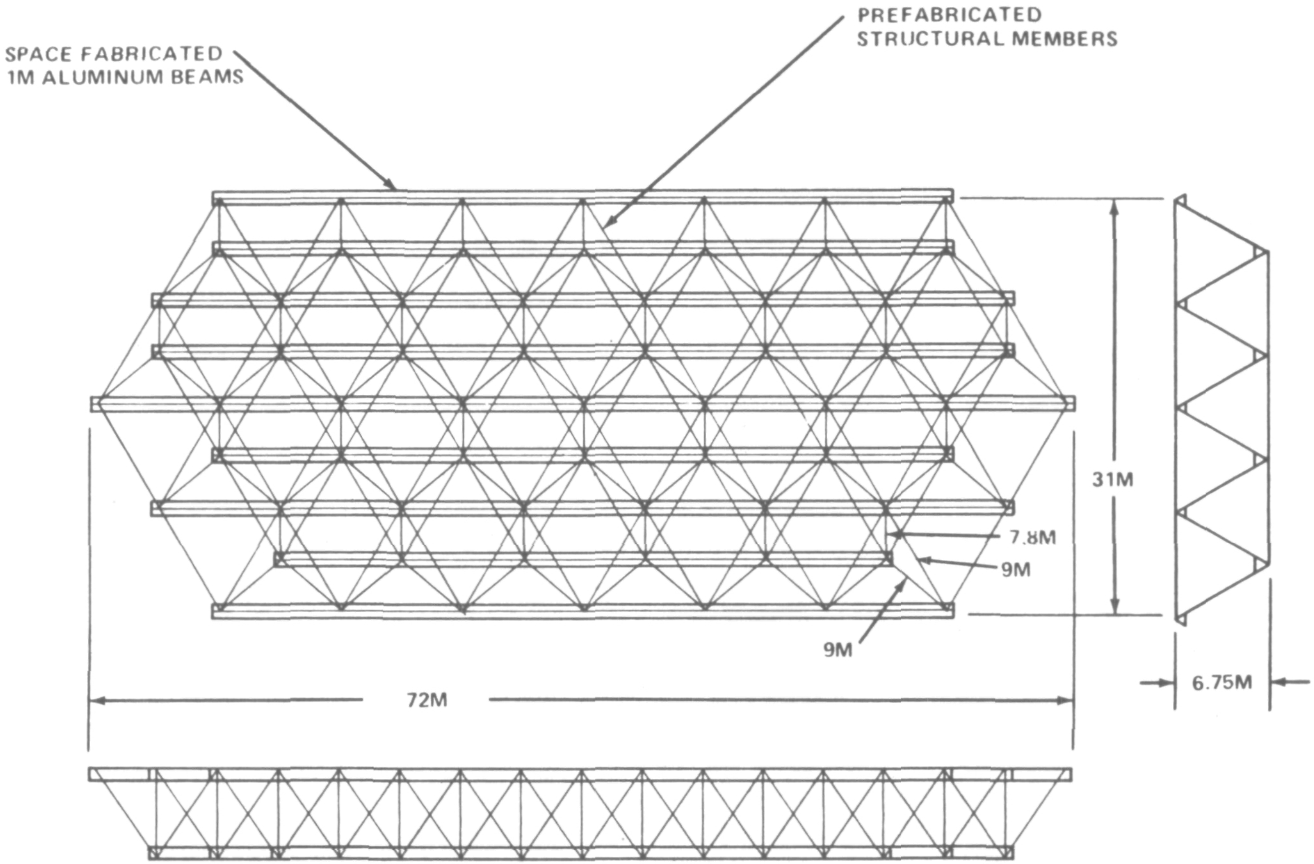
SPACE FABRICATED
1M ALUMINUM BEAMS
PREFABRICATED
STRUCTURAL MEMBERS
31M
7.8M
9M
9M
72M
6.75M

Figure 3

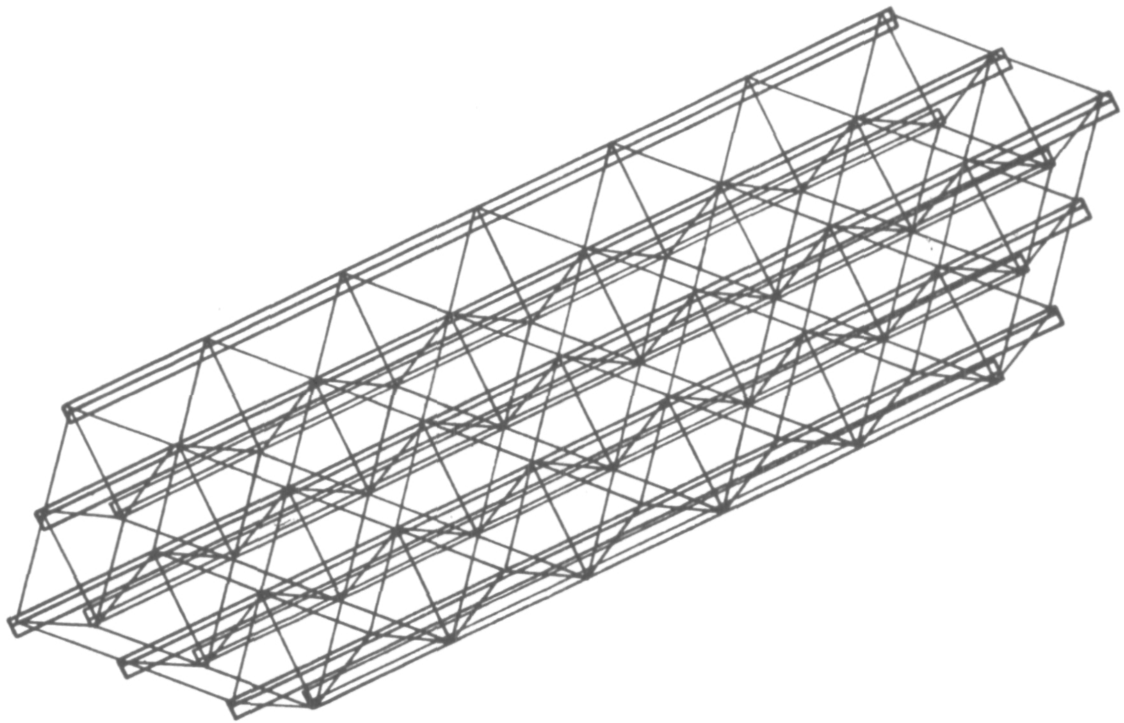

Figure 4

SPACE-FABRICATED BEAM DESIGN (Figure 5)

The design characteristics of the space fabricated beams utilized in the platform are shown. This design is taken from the Space Fabrication Demonstration System contract, currently in progress at Grumman Aerospace Corporation, which will produce a ground prototype metallic beam builder. The terminating tripod end fitting as shown would not be used for this platform structural concept.

PD22	ONE-METER BEAM DESIGN	S. DENTON
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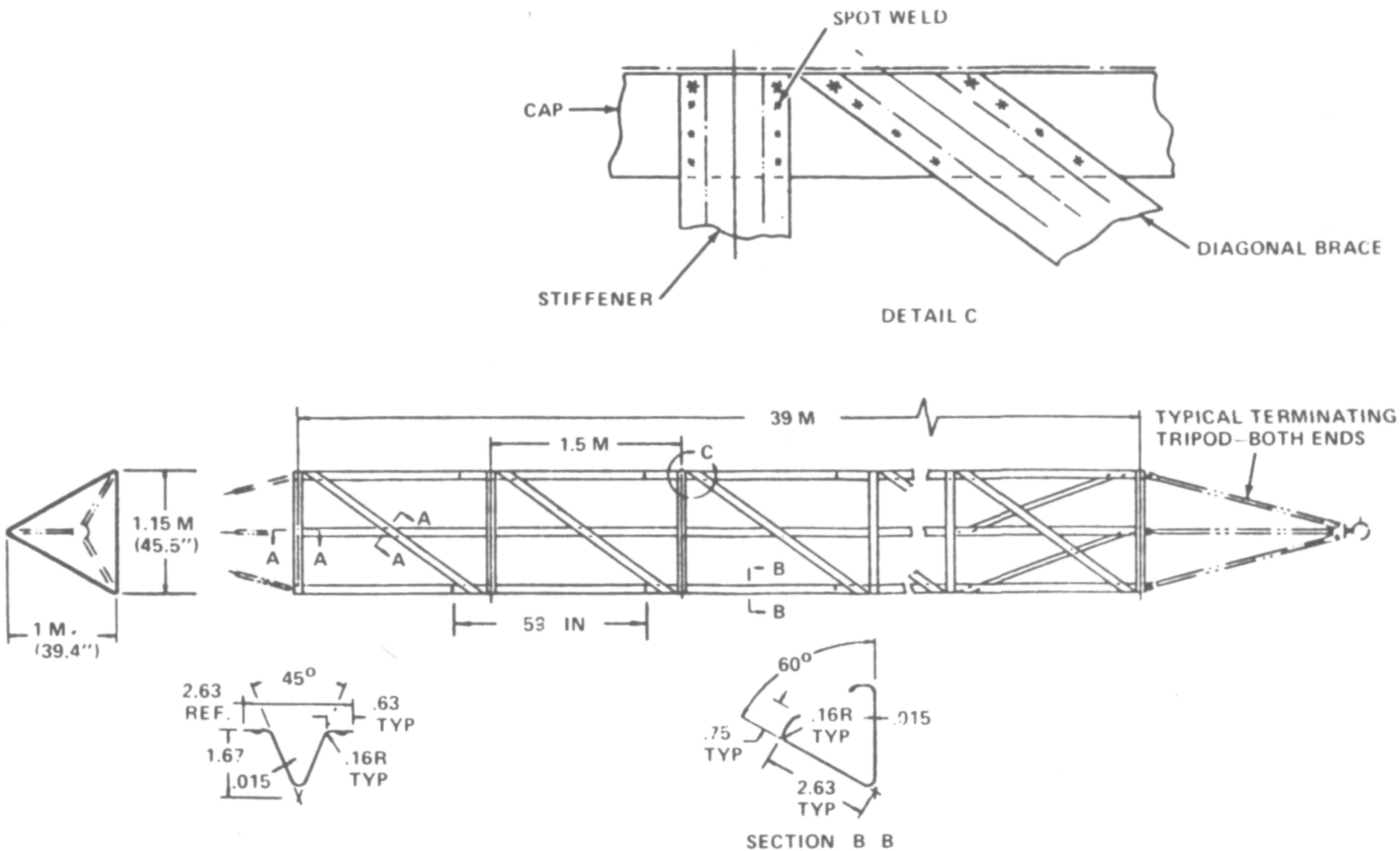

Figure 5

SPACE FABRICATED BEAM JOINT CONCEPT (Figure 6)

Since the space fabricated beams used in the platform structure are continuous in length, a joint concept is required to interconnect the lateral and diagonal members at each 9 meters of beam span. The saddle clamp joint concept shown on the following chart is a design approach to provide strut connections external to the 1 meter beam and to minimize the required volume of the joint. The joint indexes with the V-hat section of the beam lateral members and is installed in one piece. The joint also provides an interface for installation of an appropriate antenna support adapter. As a compromise to reduce the joint size, strut loads are introduced into the beam eccentric to the beam neutral axis. To introduce loads at the neutral axis, either an internal joint concept would be required, or one of excessive size.

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SADDLE CLAMP JOINT CONCEPT

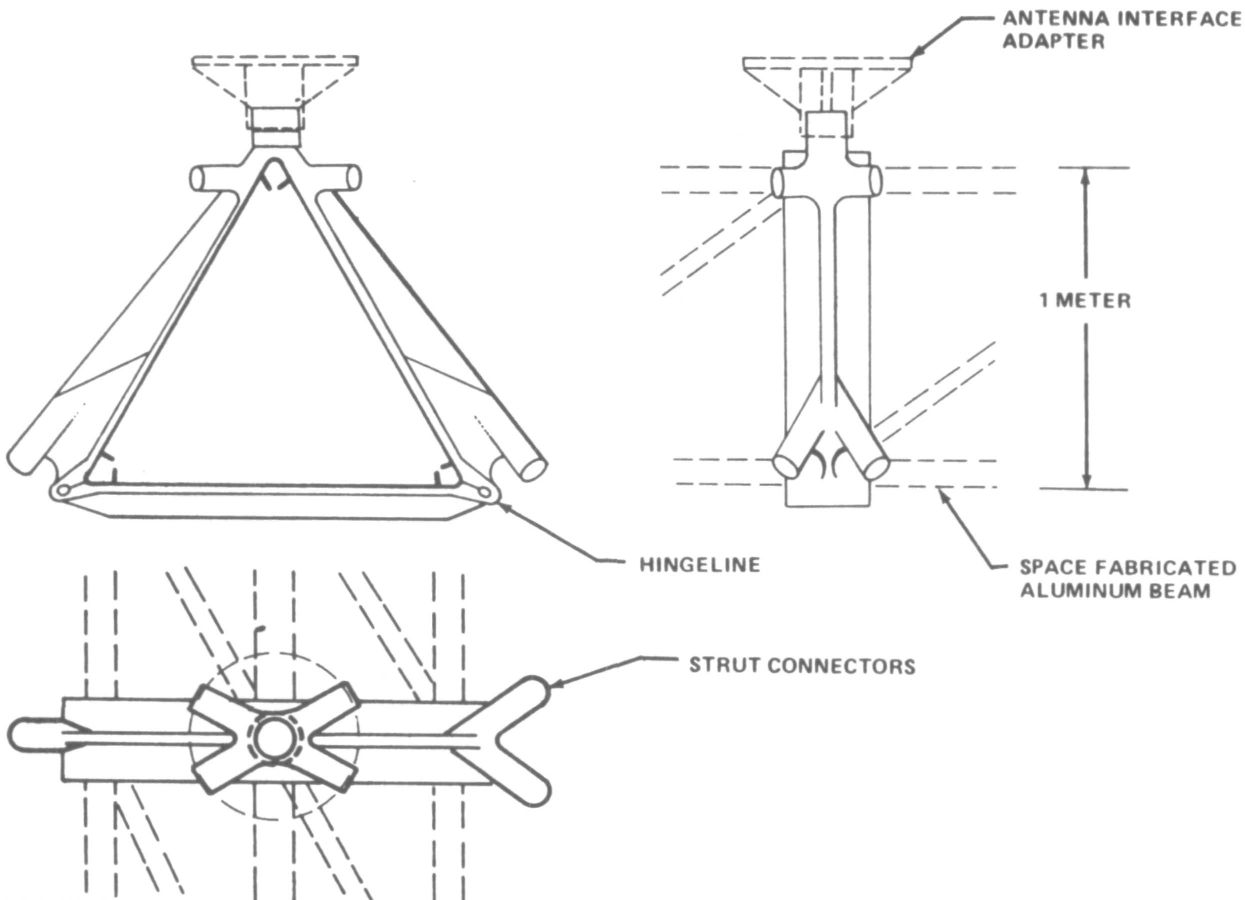

Figure 6

BEAM CAP MEMBER THERMAL CHARACTERISTICS (Figure 7)

The Geostationary Platform is oriented toward the Earth with its longitudinal axis perpendicular to the orbit plane, and since the space fabricated beams are parallel to this axis, they have similar thermal environments. The following chart indicates the temperature history of the cap members of the beams of the lower surface of the platform. The upper surface beams have a similar temperature history, but with a 4-hour phase shift due to a 30° difference in orientation to the sun. The cyclic change in temperature is due to the change in projected area of the cap member to the sun with change in orbit position. The peak temperature occurs with alignment of the open cavity of the cap member to the sun which has the effect of increasing absorptivity.

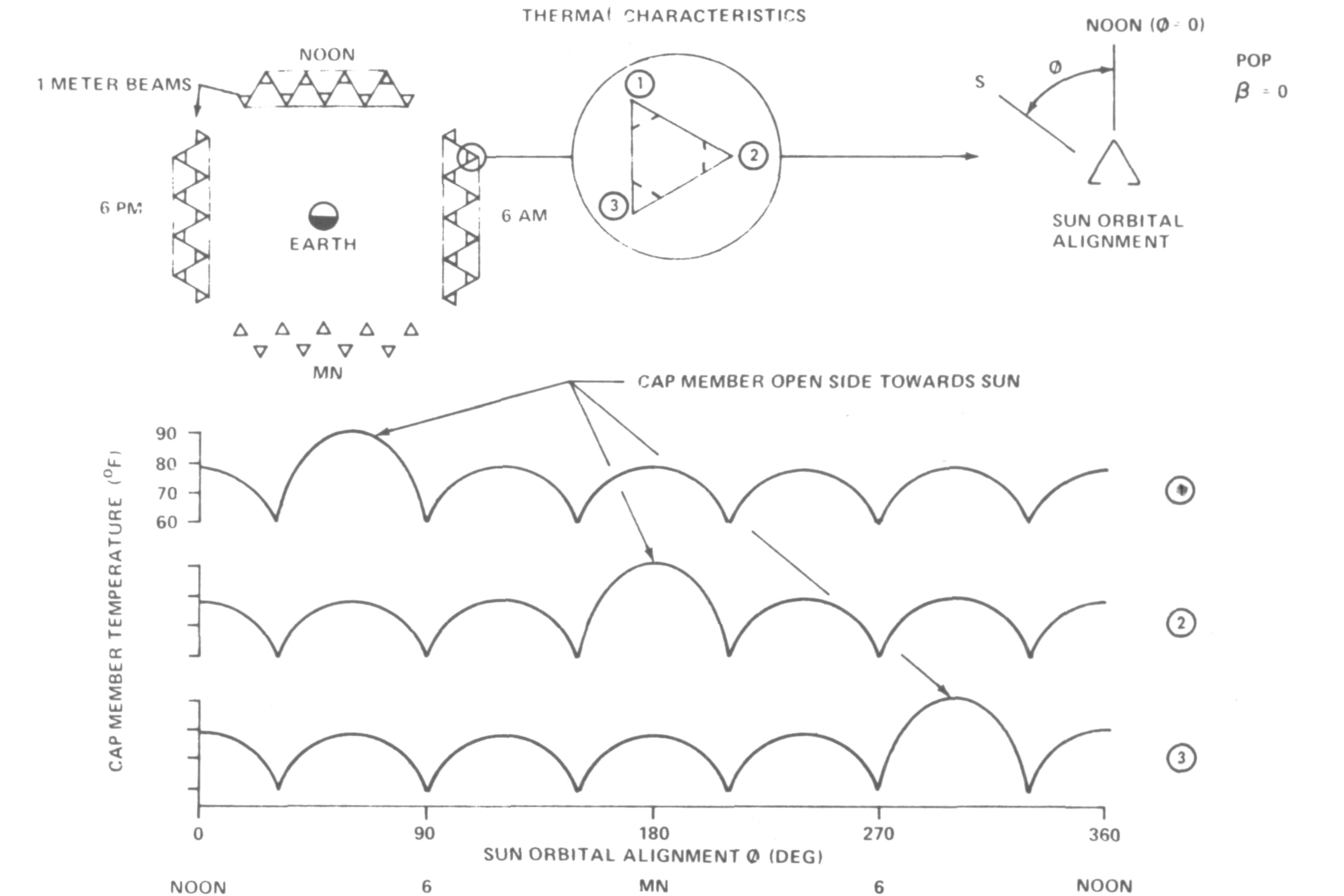
THERMAL CHARACTERISTICS
NOON
1 METER BEAMS
6 PM
EARTH
6 AM
MN
1
2
3
NOON (Ø = 0)
Ø
S
POP
β = 0
SUN ORBITAL
ALIGNMENT
CAP MEMBER OPEN SIDE TOWARDS SUN
CAP MEMBER TEMPERATURE (°F)
90
80
70
60
0
90
180
270
360
SUN ORBITAL ALIGNMENT Ø (DEG)
NOON
6
MN
6
NOON

Figure 7

BEAM CAP MEMBER SHADING EFFECTS (Figure 8)

Shading of the cap members of the space fabricated beam occurs when two members are co-aligned with the sun. This occurs twice per orbit for each cap member with a duration of 24.4 minutes. The following chart indicates the change in solar heat load during the shading period.

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THERMAL CHARACTERISTICS

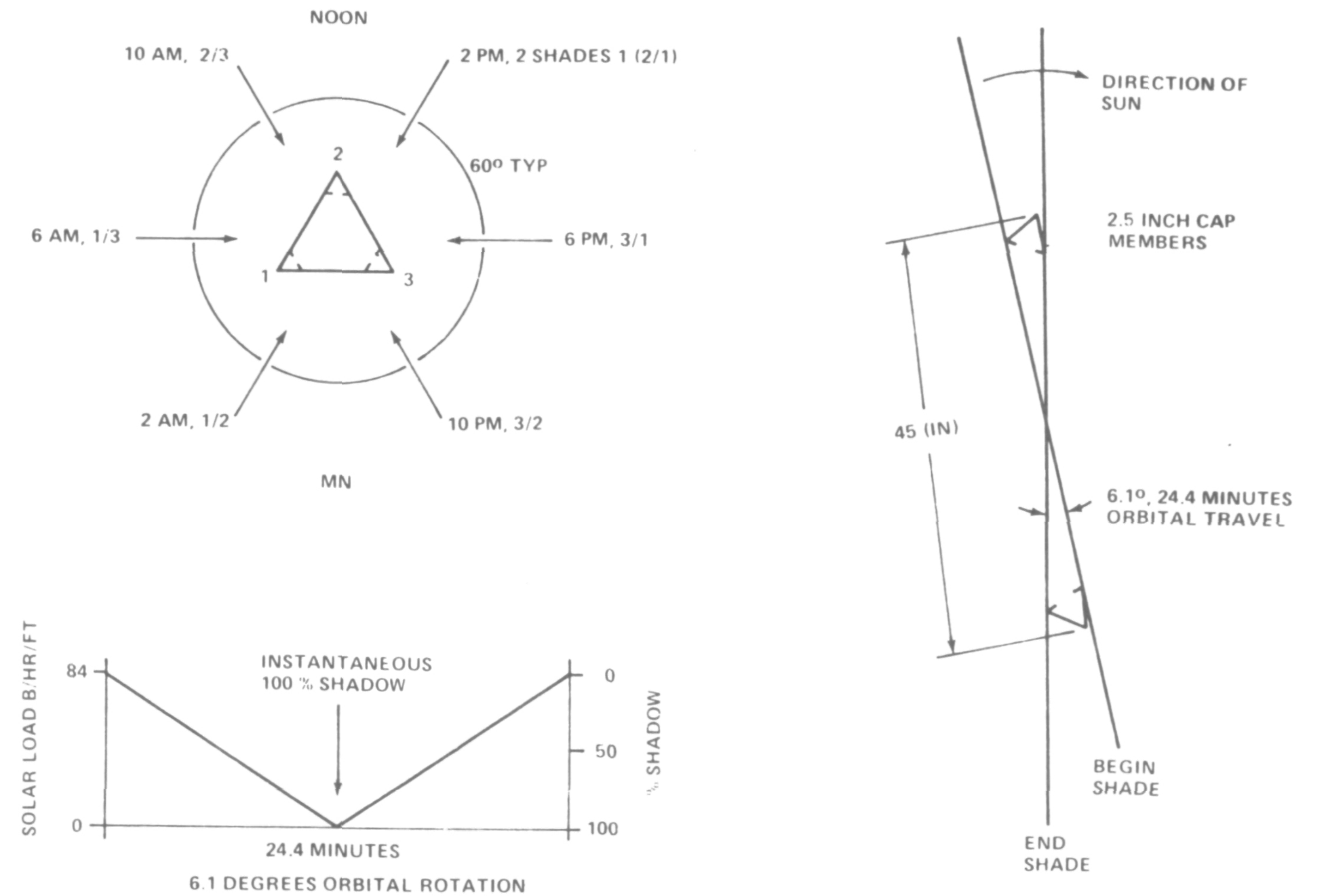

Figure 8

PLATFORM STRUCTURE TEMPERATURE HISTORY (Figure 9)

The following chart indicates the composite temperature history of the space fabricated beams contained in the platform structure. Also shown is the structural temperature change during maximum solar occultation duration, which occurs during the twice yearly equinox periods. These data are to be utilized to evaluate thermal distortion and thermal stress occurring in the structure.

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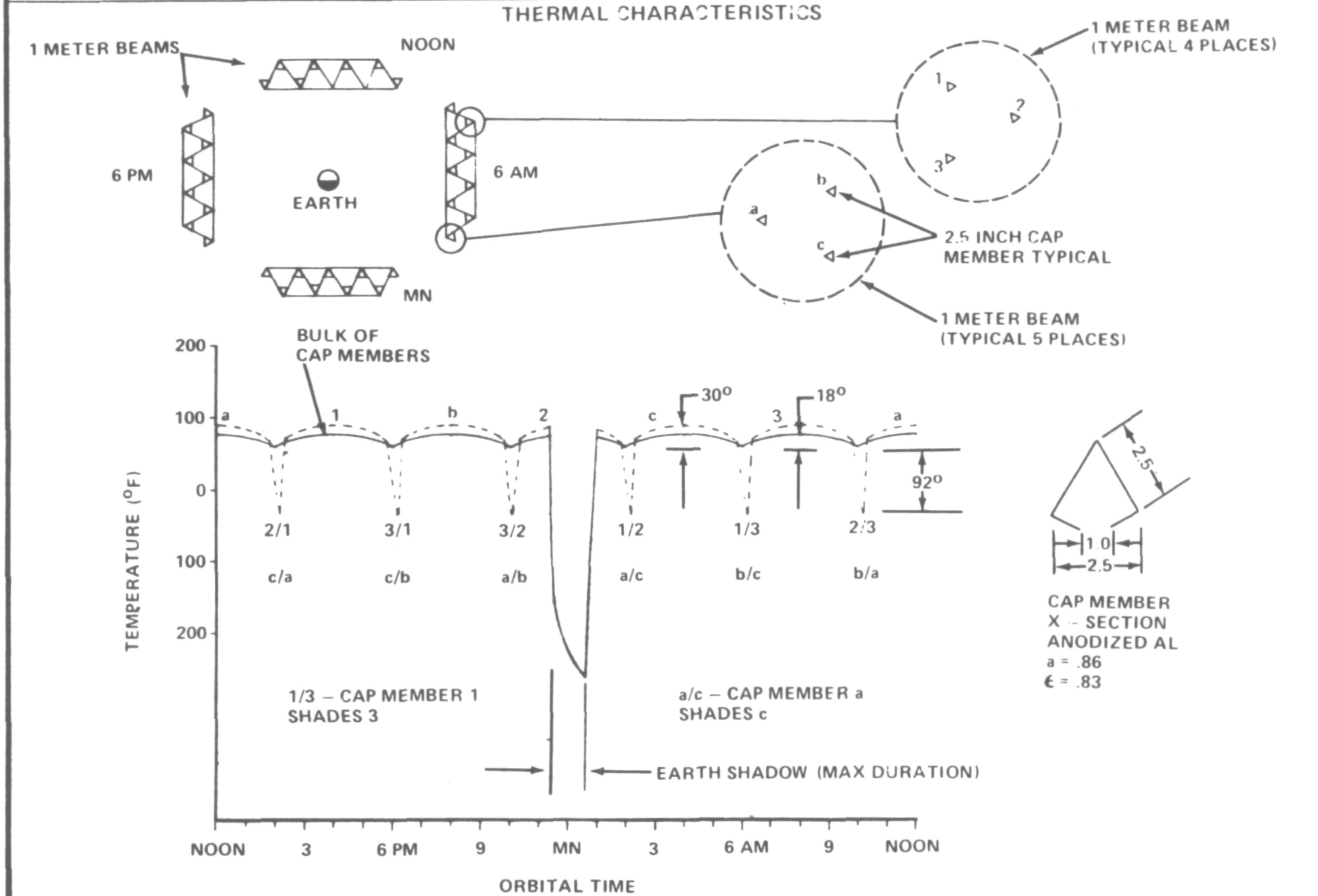

Figure 9

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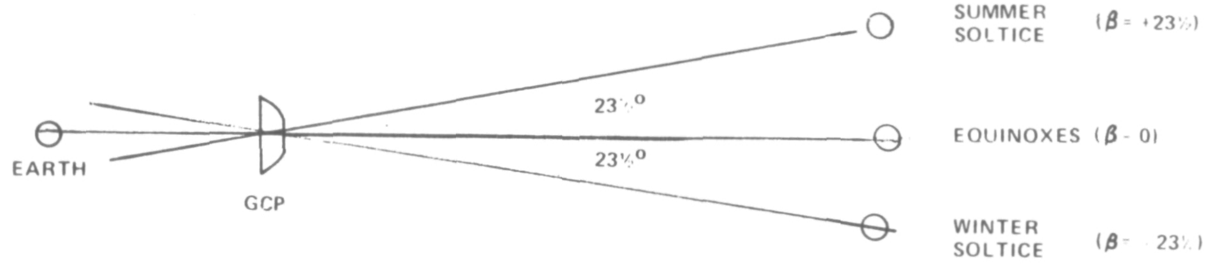
SEASONAL TEMPERATURE VARIATION (Figure 10)

Due to change in angle between the orbit plane and sun line (β) during the year and corresponding change in absorbed solar flux, the structural temperature will vary as indicated in the following chart. This has the effect of raising and lowering the temperature history as shown on the preceding chart.

THERMAL CHARACTERISTICS



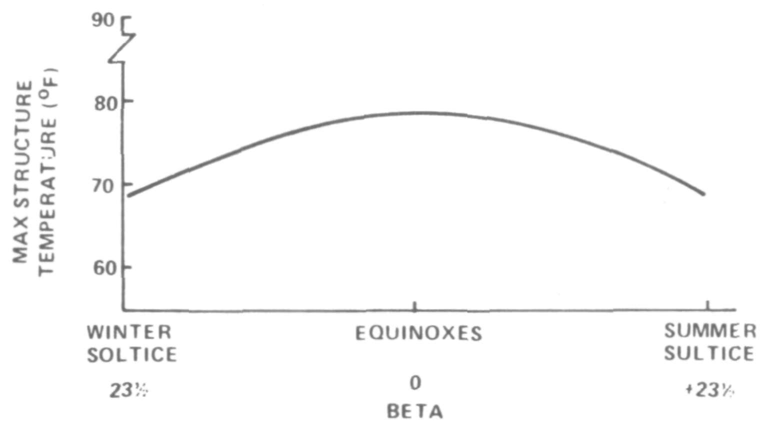


Figure 10

TRANSFER STAGE THRUST LOAD INTRODUCTION (Figure 11)

Options for the introduction of thrust loads into the platform structure are as indicated in the following chart. In each case, components which are not location critical, such as batteries and reaction wheels, are located in a subsystems module to preclude introducing their acceleration load into the platform structure. Although the centrally located thrust introduction point produces somewhat higher structural member loads than the other options, it is currently preferred due to additional design features made possible, such as providing a large rigid interface for the 30-meter-diameter antenna, and use as a support structure for component mounting during Orbiter flight.

OPTIONS FOR INTRODUCTION OF THRUST LOAD

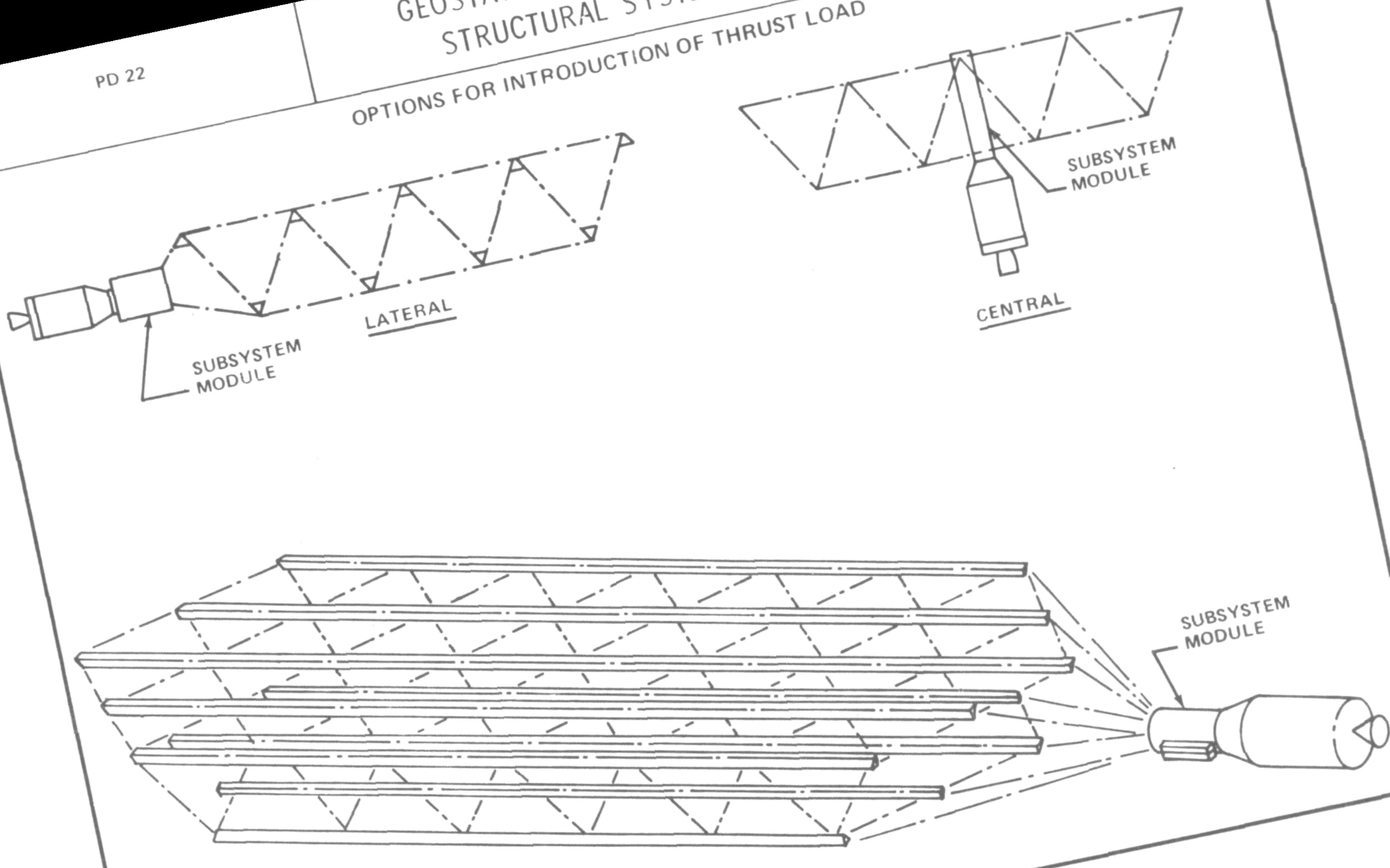


Figure 11

SUBSYSTEM MODULE DESIGN CONCEPT (Figure 12)

A design concept of a subsystem module which provides a docking interface for the OTV propulsion stage is shown. It interfaces with the structural members of the platform as shown, and provides a central location for initiation of structural assembly. As indicated, an interface for the 30-meter-diameter antenna is provided which can also be used for launch support of the antenna in its packaged form. The concept also provides the launch support structure for many of the platform components including prefabricated nested tapered tube structural members, RCS modules, and solar arrays. The internal volume can also potentially be utilized for additional component structural support during launch.

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SUBSYSTEM MODULE CONCEPT

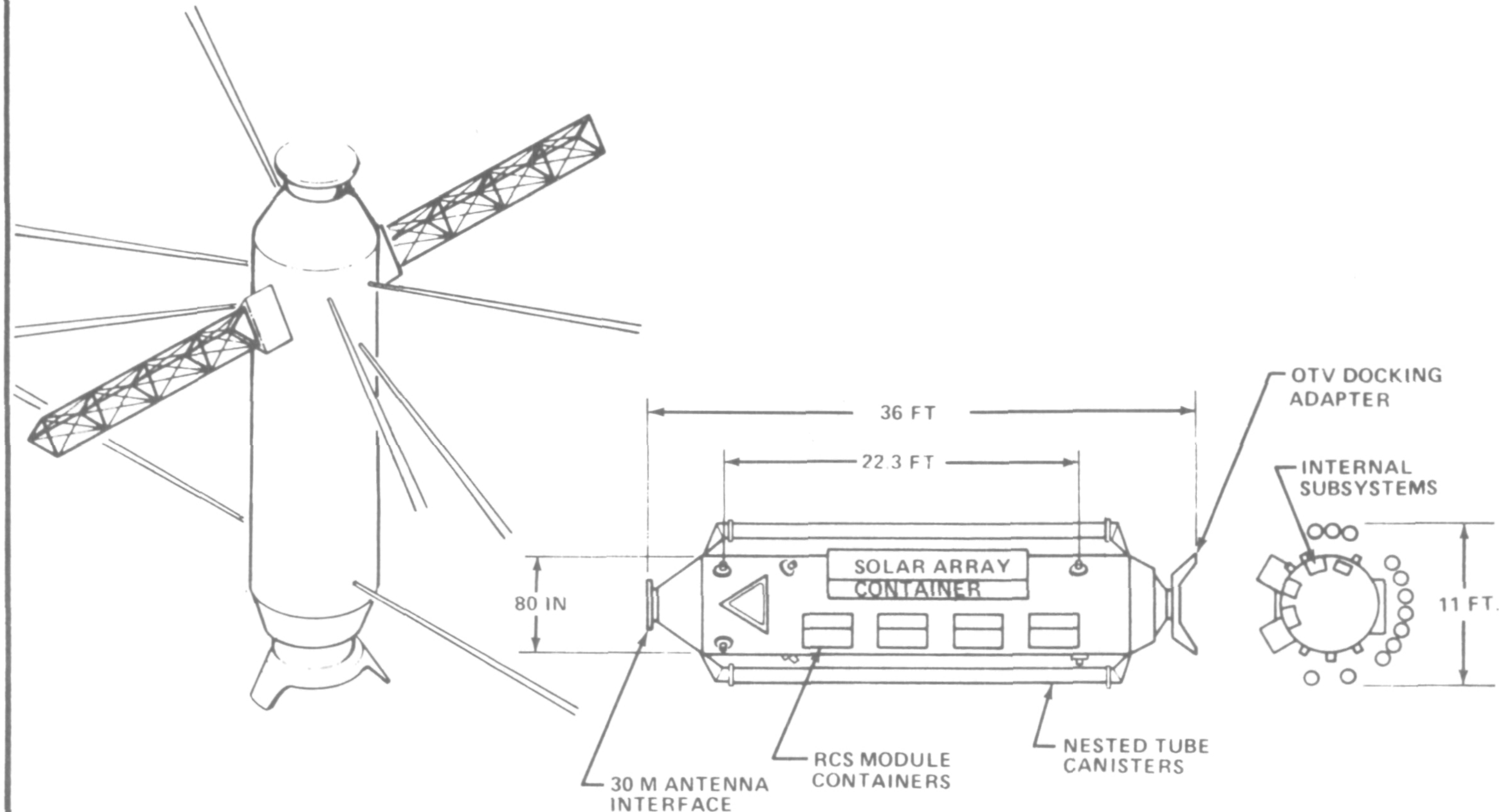

Figure 12

STRUCTURAL MEMBER LOADS DURING ORBIT TRANSFER (Figure 13)

Based upon OTV characteristics as indicated, resulting accelerations and corresponding average loads applied to the space fabricated longitudinal members are shown. Where a 50-percent engine throttle capability is utilized, applied loads exceed the capability of the current member design from the Grumman Aerospace "Space Fabrication Demonstration System" contract, which is used as a baseline.

THRUST EFFECT ON STRUCTURAL MEMBER LOAD

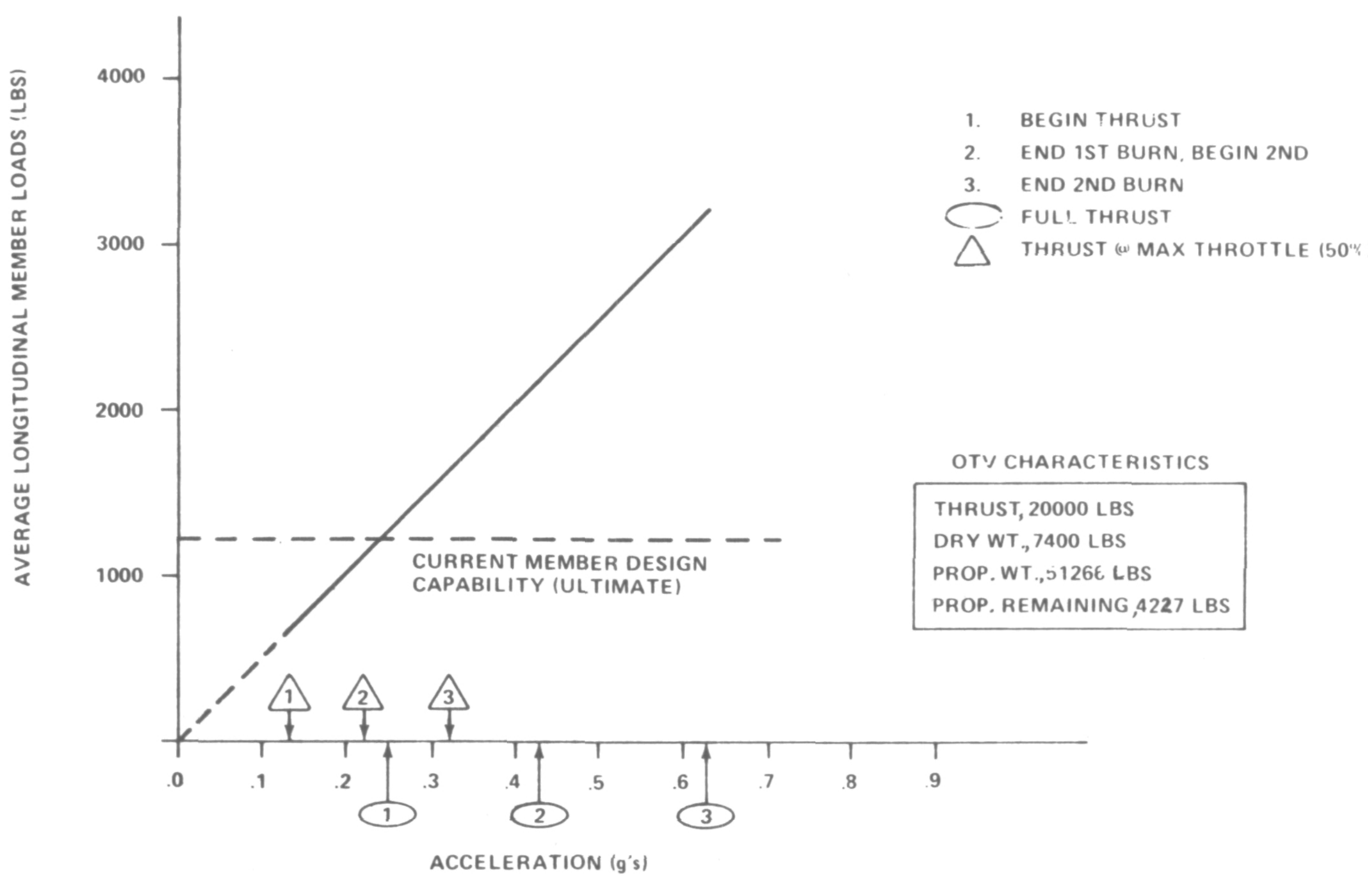

Figure 13

OPTIONS FOR STRUCTURAL LOAD COMPATIBILITY (Figure 14)

Potential options for meeting structural load requirements are as indicated. Unless structural weight becomes highly critical, the more desirable option would be to increase structural member load capability by increasing material thickness.

OPTIONS FOR STRUCTURAL LOAD COMPATIBILITY WITH TRANSFER THRUST

OPTION	IMPACT
• INCREASE SPACE FABRICATED MEMBER LOAD CAPABILITY	• INCREASED STRUCTURAL WEIGHT
• INCREASE STRUCTURAL DEPTH	• INCREASED STRUCTURAL WEIGHT INCREASED ASSEMBLY COMPLEXITY
• LOWER THRUST OTV ENGINE (≈10K) WITH 50% THROTTLING	• DECREASED OTV MISSION FLEXIBILITY PERFORMANCE LOSS DUE TO LOW INITIAL ACCELERATION
• UTILIZE ALL PREFABRICATED MEMBERS SIZED FOR ADEQUATE LOAD CAPABILITY	• INCREASED ASSEMBLY COMPLEXITY

Figure 14

STRUCTURAL SYSTEM MEMBER REQUIREMENTS (Figure 15)

The required structural members of the platform system are summarized as indicated.

STRUCTURAL SYSTEM MEMBER REQUIREMENTS

		NUMBER	LENGTH – m
SPACE FABRICATED MEMBERS		3	63
		4	54
		1	45
		2	35
	TOTAL	10	520
PREFABRICATED MEMBERS		156	9.0
		28	7.8
	TOTAL	184	1622
JOINTS		67	SADDLE CLAMP WITH CONNECTIONS FOR 7 PREFABRICATED MEMBERS

Figure 15

ASSEMBLY-PREPARATION OF SPACE FABRICATED BEAM (Figure 16)

A major feature resulting from use of space fabricated beams is the capability to preassemble many of the system components, such as antennas, cables, and joints, to the beam prior to inclusion of the member into the structural assembly. By means of an erected work platform over the beam builder, a suitable astronaut work site can be provided for installation of these components, and eliminates the need for individual transport to the structural assembly area and any special equipment just for installation.

PREPARATION OF SPACE FABRICATED BEAM PRIOR TO STRUCTURAL ASSEMBLY

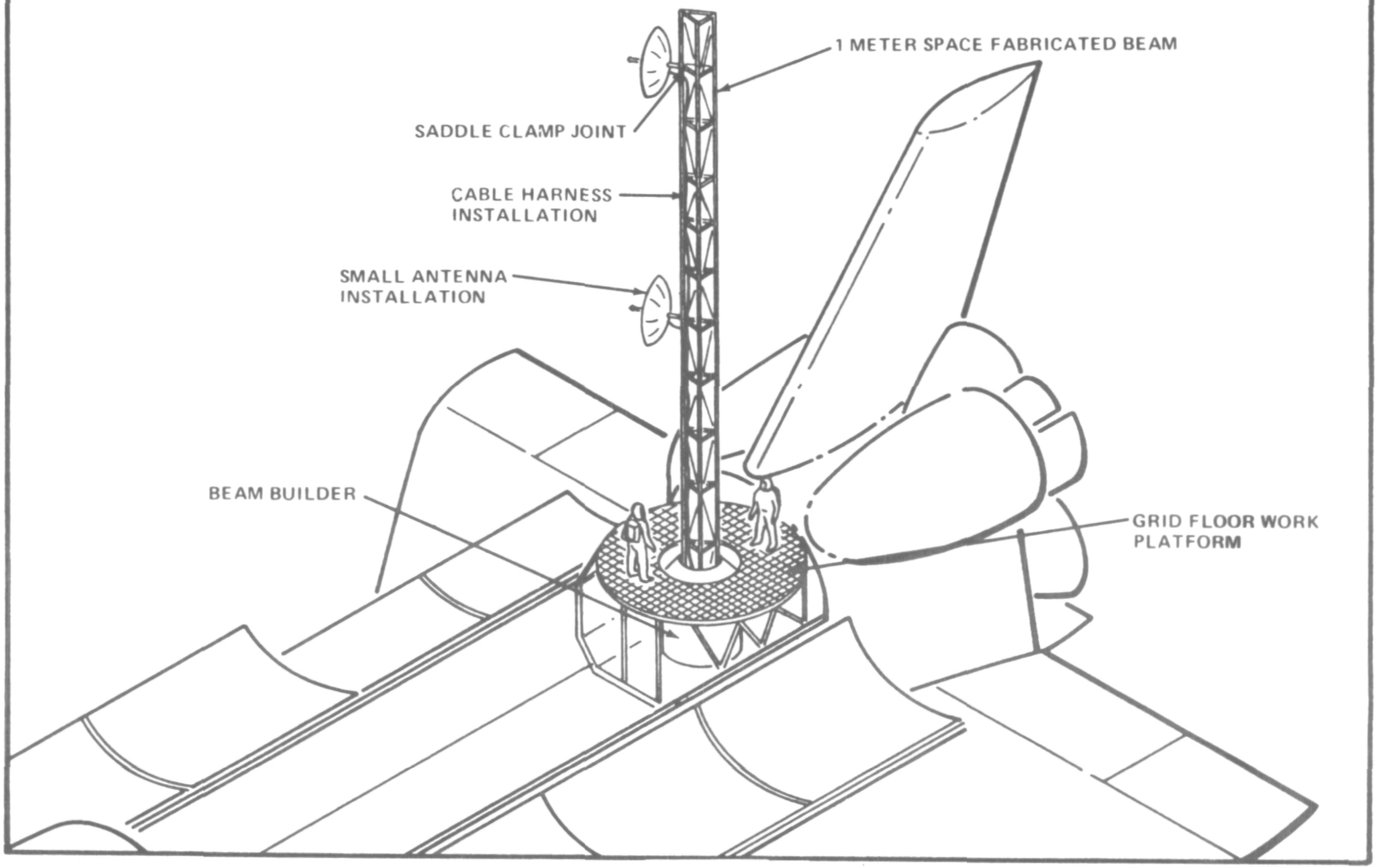

Figure 16

Construction Facility Concept (Figure 17; Figure 18)

The following two charts illustrate a typical concept of a construction facility which can be utilized for assembly of the Geostationary Platform. The concept is based upon a buildup of STS delivered modules and use of expended Shuttle External Tanks as a "strongback" platform. The concept would make major use of large ET mounted manipulator arms as the primary means of transport and positioning of components of the Geostationary Platform during assembly. The 25 kW Power Module is utilized to extend the Orbital stay time of the Orbiter and to provide power to the facility.

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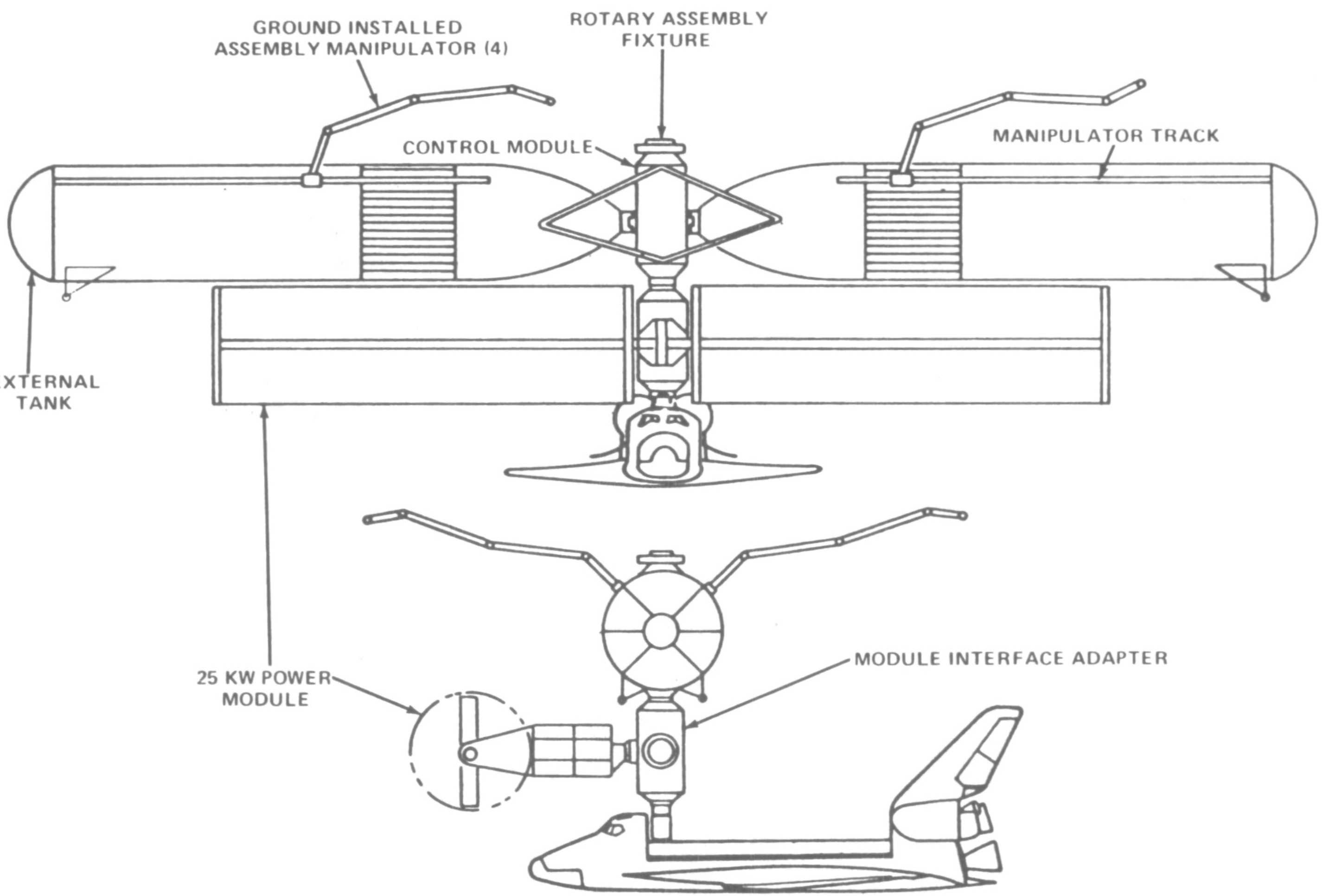

Figure 17

PD22	CONSTRUCTION FACILITY ASSEMBLY ENVELOPE	DATE: JANUARY 1978

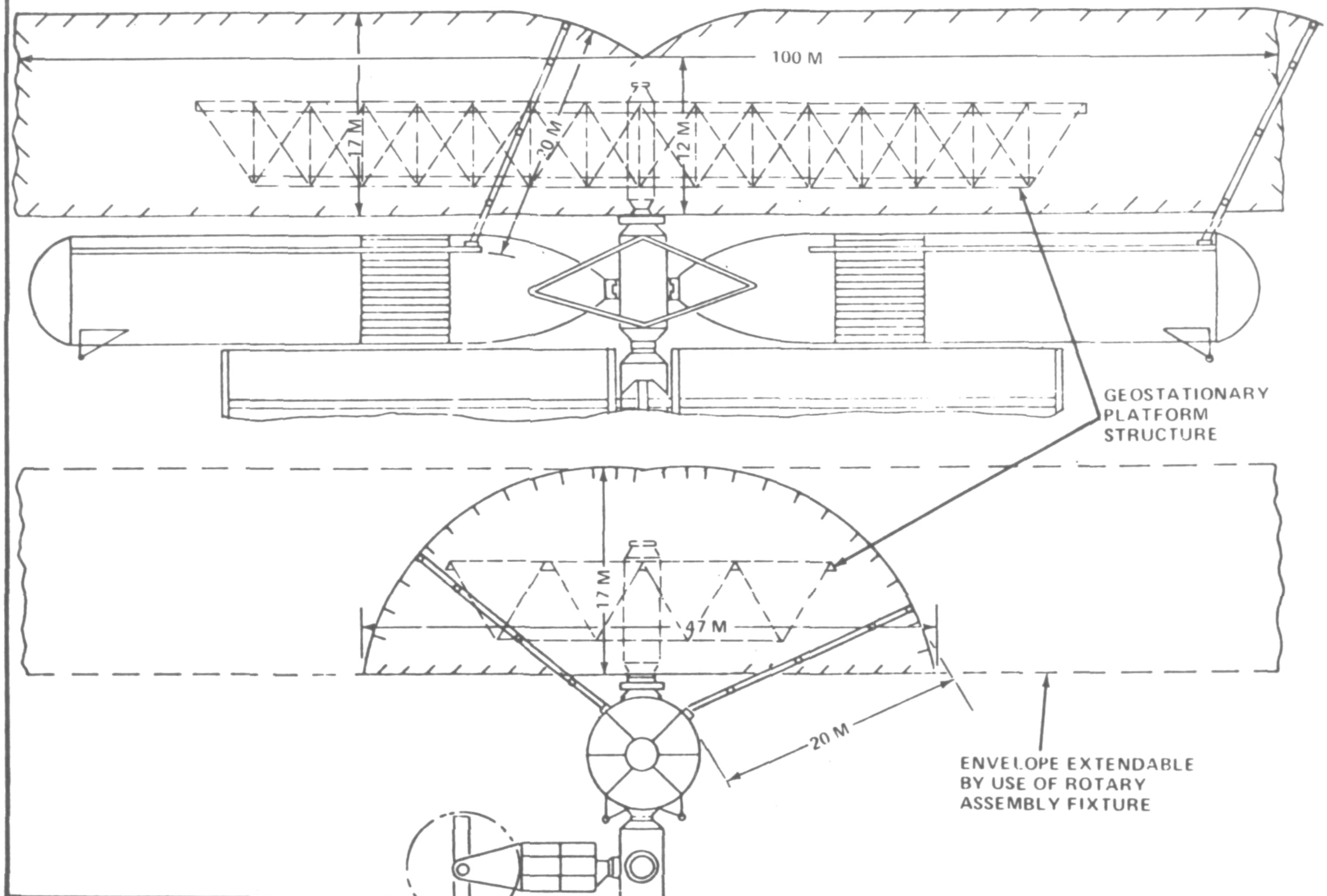

Figure 18

Platform Assembly From Orbiter (Figure 19)

The relatively modest size of the Geostationary Platform leads to the potential of assembly from the Orbiter with a minimum of support equipment. The following chart illustrates the relative size of the Geostationary Platform to the Orbiter and indicates a module that can be utilized to interface the 25 kW Power Module and provide a rotating support fixture for assembly of the platform. Required assembly equipment, needed for transport and positioning of members and components during assembly, are not shown and are subject to results of further studies involving comparative evaluation of capabilities utilizing EVA, teleoperator or manned maneuvering systems, and large manipulator arms.

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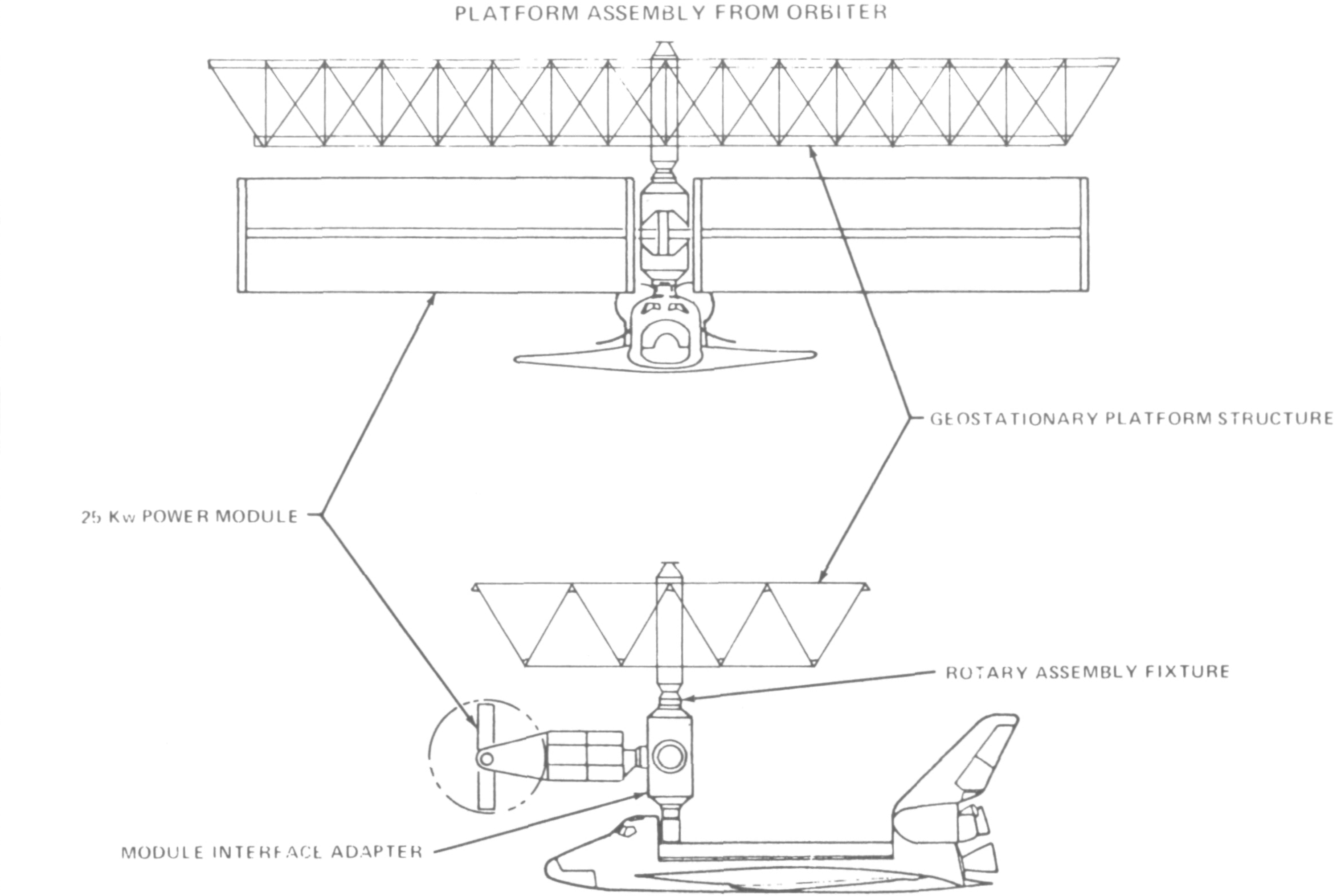
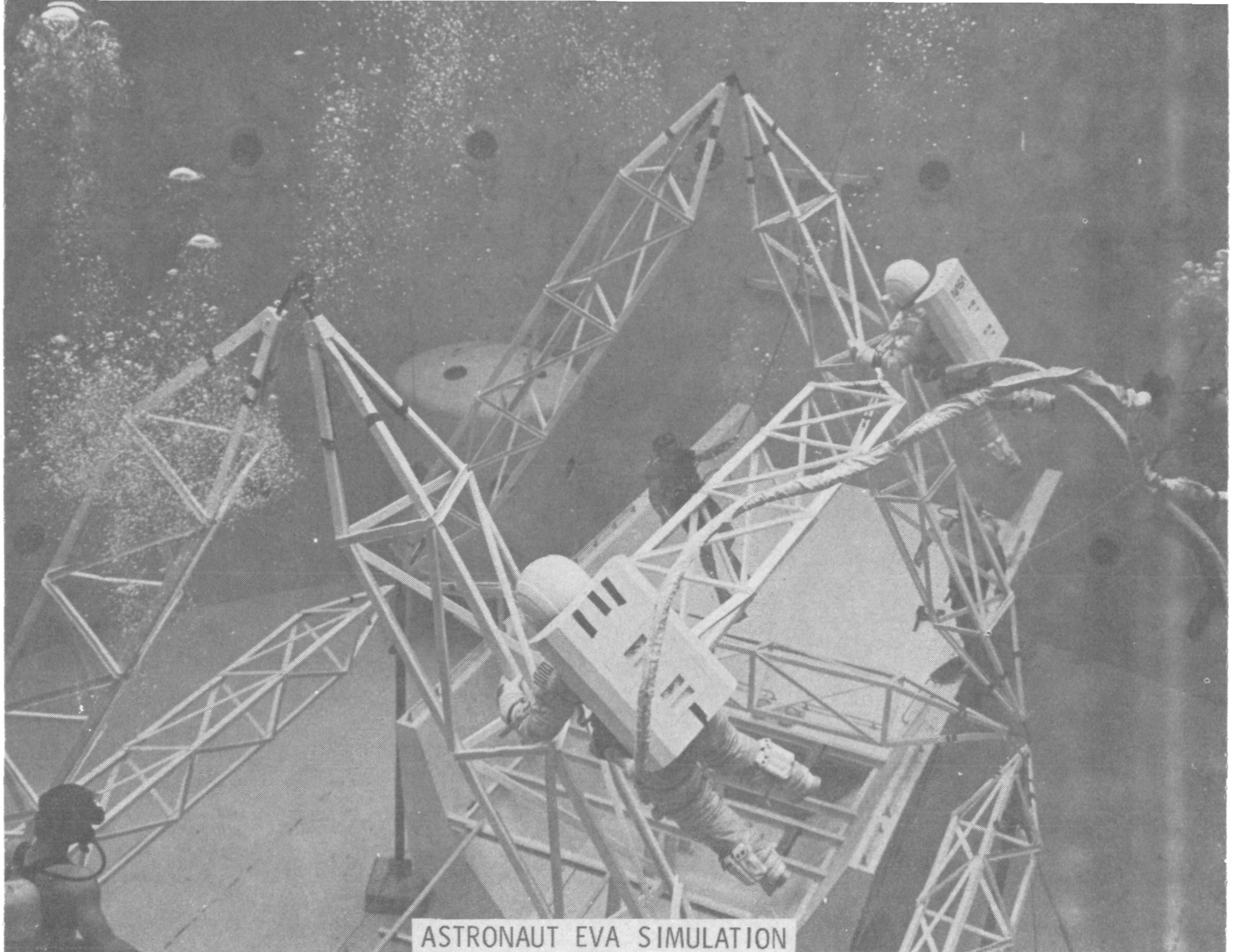


Figure 19

Neutral Buoyancy Tank Simulation of Assembly Tasks
(Figure 20; Figure 21; Figure 22)

MSFC has conducted several advanced studies over the past 3 years which involved the assembly of large space structures. Two questions which were considered high priority are related to transporting structural beams in space and man's ability to connect the beams together. MSFC initiated a test program in its neutral buoyancy tank last spring (1977) to develop answers to these and other fundamental assembly questions. The following three photographs are from tests conducted to evaluate the feasibility of moving beams by man, the Shuttle attached manipulator arm, and by a manned maneuvering system. It is interesting to note that, for the test article indicated, an average of approximately 10 minutes was required to manually transport, position, and attach each beam to another, by using a simple spring-loaded male/female connector.



ASTRONAUT EVA SIMULATION

Figure 20