TABLE 3.4-1

ARTIFICIAL GRAVITY OPERATIONAL CONDITIONS

METHOD	PITCH OR YAW SPINNING	THRUSTER	THRUSTER LEVER ARM (FT.)	ROTATED MOMENT OF INERTIA (SLUG-FT.^{2})	CREW MEMBER'S HIP ROTATING RADIUS (FT.)	CENTRIFUGAL ACCELERATION (g's)	SPIN RATE (RPM)	ONE SPIN (OR DESPIN) PROPELLANT (LB.)	ONE SPIN (OR DESPIN) BURN TIME (SEC.)	CABLE WEIGHT (LB.)
DIRECTLY-CONNECTED GEMINI – STAGE II	EITHER	MS 1–94.5 LB.	8.0	52,100	9.8	1.0 0.5 0.1	17.3 12.2 5.5	46.3 32.8 14.6	125 88 39	0 0 0
DOCKED GEMINI – AGENA VEHICLE	EITHER	MS 1–94.5 LB.	11.3*	62,000	8.0	1.0 0.5 0.1	19.1 13.9 6.1	63.9 45.2 20.2	172 122 55	0 0 0
	EITHER	GACS 2–23 LB.	17.0	62,000	8.0	1.0 0.5 0.1	19.1 13.9 6.1	29.2 20.7 9.2	159 112 50	0 0 0
	YAW	AACS 2–10 LB.	20.4	62,000	8.0	1.0 0.5 0.1	19.1 13.9 6.1	122.0 88.5 27.3	306 221 96	0 0 0
CABLE-CONNECTED GEMINI-AGENA	EITHER	MS 1–94.5 LB.	152	9,580,000	150.	1.0 0.5 0.1	4.4 3.1 1.4	114.3 80.9 36.2	309 218 98	70 35 35

I_{sp} = 50 LB.-SEC./LB. FOR AACS (AGENA ATTITUDE CONTROL SYSTEM)
= 250 LB.-SEC./LB. FOR GACS (GEMINI ATTITUDE CONTROL SYSTEM)
= 255 LB.-SEC./LB. FOR MS (GEMINI MANEUVER SYSTEM)

*EFFECTIVE ROTATIONAL THRUST IS .675 OF ACTUAL THRUST

3.4 (Continued)

system provides a better simulation of artificial gravity and less danger of vertigo because of the larger radius and correspondingly lower angular velocity. More effective head-to-foot gravity forces result from using a parawing bridle to obtain the Gemini orientation shown in Figure 3.4-3.

The reliability of the cable method is lower than for the other methods as a result of the cable attachment and handling facilities required. To minimize the amount of additional equipment required, cable reel-in provisions might be omitted.

The propellant requirements listed in Table 3.4-1 do not include allowances for spinning during extension of the cable; it is assumed spinning is accomplished at the final cable extension. Partial spin-up prior to and during cable extension, which will probably be required to eliminate slack cable conditions, might double the amounts of propellant needed.

Since rendezvous is not required with Stage II of the GLV as the counterweight, equipment such as the rendezvous radar will not be needed. Elimination of this equipment and a reduction of the propellant for the orbit attitude and maneuver system results in adequate weight and space allowance for the cable and its associated equipment. With the Agena as the counterweight, a separate Agena section adjacent to the target docking adapter would be provided for the cable and its associated equipment.

3.5 Simulation of LEM Rendezvous - The Gemini flight test of Apollo LEM-CM rendezvous would evaluate the rendezvous phase of the Apollo mission using actual LEM equipment or modified Gemini hardware. During rendezvous, the rendezvous radar and inertial measuring unit aboard the LEM are used to accumulate range data of the CM relative to the LEM. These data are processed by the LEM guidance computer, where the required velocity change for rendezvous is computed. The LEM propulsion system is then used to change the LEM velocity vector so that a collision course with the Apollo CM is attained.

In the rendezvous test flight, the Gemini spacecraft would have the role of the LEM vehicle with the velocity change computations performed aboard the Gemini and the Gemini propulsion system used to execute the velocity change maneuvers. The Apollo CM would be simulated by either a Gemini Agena Target launched into orbit prior to the Gemini, or by a smaller target launched with the Gemini and separated from the Gemini while in orbit.

With Apollo hardware available for the flight, the LEM computer, IMU, and radar would be used aboard the Gemini to compute the velocity change maneuvers. Also, an Apollo CM transponder would be installed on the rendezvous target vehicle. Should Apollo equipment not be ready for the test flight, Gemini equipment, including a modified Gemini computer, would be used to perform the same operations as the LEM hardware. If only some of the Apollo hardware could be used for the test flight, e.g., the radar, then modified Gemini equipment could be substituted and the flight performed using a combination of Gemini and Apollo equipment.

A preliminary estimate of the added weight of the Apollo equipment is 223 lbs. This includes the computer, power supply, IMU, radar, and Gemini structural changes. This weight addition is within the launch weight capabilities for a two day Gemini rendezvous mission. For example, several spacecraft have experiments with weights

3.5 (Continued)

in excess of the Apollo equipment weights. Therefore, this equipment can be incorporated into future spacecraft without affecting mission capability. If modified Gemini equipment without any Apollo hardware is used, the weight increase would be a 25 lb. auxiliary tape memory for the Gemini computer.

3.6 Structural Assembly in Orbit - The antenna to be erected in orbit is shown in Figure 3.6-1. The manual erection of this type of structure by EVA will be most valuable in the performance of assembly, maintenance, inspection, and alignment of such items as:

Radiators

Sensors

Solar arrays

Gimbal mounts

Fuel lines, valves, and connections

Antennas

Propulsion systems

Docking ports

3.6.1 Types of In-Space Operations - Man's role, as applied to the various types of in-space assembly separations, is discussed in the following paragraphs.

A. Fluid or Gas Transfer Connections and Large Electrical Connections - Manual connection and manual activation are preferred for simplification of these operations. However, automatic connections may be desirable for safety reasons. Visual inspection of the connection will be important.

B. Assembly of Heavy Structures

1. For Space Station build-up or assembly, manual operations are desirable in order to omit complex hinges, locks, and automatic or motor driven fasteners. However, built-in positioning and holding devices will be needed because of the inability to position and hold large masses by hand.

2. Large Telescopes - Manual alignment and calibration is desirable.

ANTENNA ERECTION AND ASSEMBLY IN ORBIT

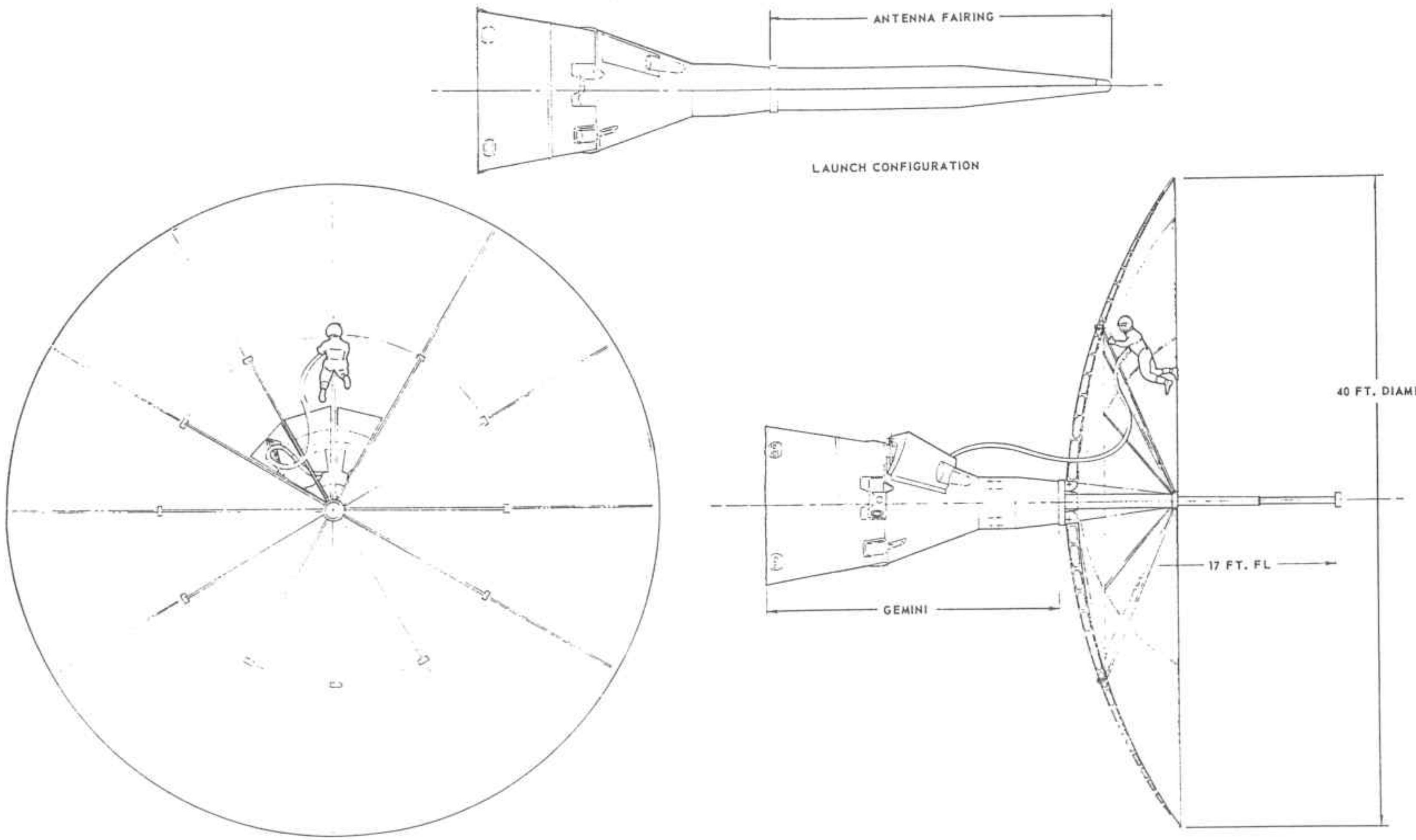


FIGURE 3.6-1

ANTENNA ERECTION AND ASSEMBLY IN ORBIT

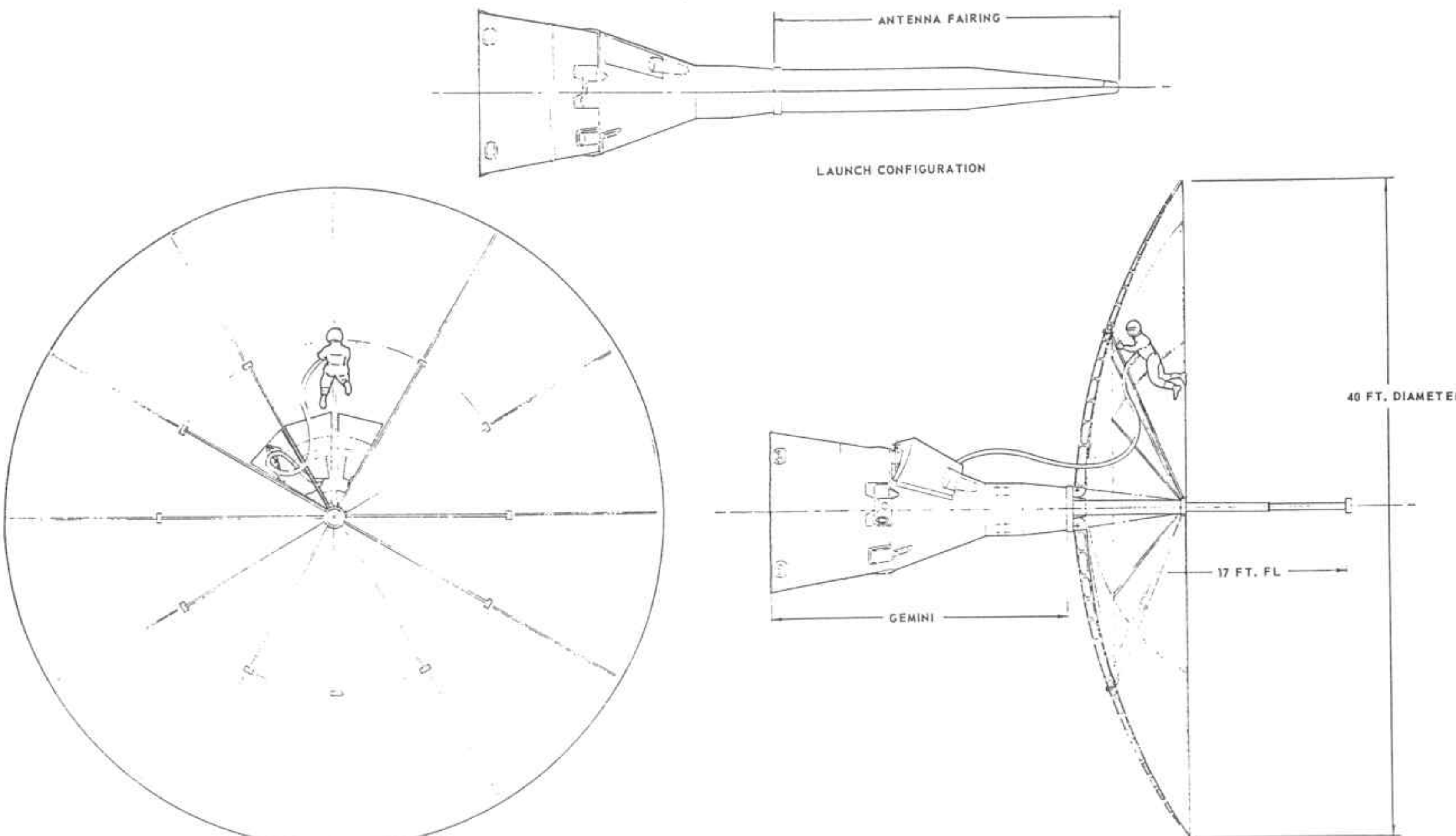


FIGURE 3.6-1

3.6.1 (Continued)

C. Assembly of Large, Low Density Structures

1. Antennas, solar arrays and radiators - Very little actuator power is required to mechanize erection because of weightlessness. However, man is required as backup to this operation as well as to provide final lock-up, alignment, and inspection.

2. Pressurized Transfer Tunnels - Man can more effectively perform sealing operations and also perform seal inspection and seal maintenance.

D. Return of Gemini Thrust Chamber Assembly - Rocketdyne has accomplished a breakthrough on thruster life capability for the Gemini spacecraft. Although the Gemini TCA's have an appreciable margin of safety for the Gemini missions, the precise margin has not been determined due to the face that endurance testing of rocket motors at orbit pressure altitude has not been accomplished to date on ablative-type motors. Information of this type is of particular interest because of the speculation of shorter life capability in space than that estimated from tests conducted at altitudes intended to be representative of orbital altitudes, but which do not duplicate actual operating conditions. It is especially important to obtain endurance results from a pulsing mode of operation.

3.6.2 Erectable Antenna Weight Estimates - The preliminary weight estimate is given in Table 3.6-1.

TABLE 3.6-1

STRUCTURAL ASSEMBLY IN ORBIT

	WEIGHT – LB.
WEIGHT REMOVED	(–817)
SPACECRAFT 12 EXPERIMENTS	–279
RADAR	–87
DOCKING SYSTEM	–18
OAMS TANKS	–44
OAMS PROPELLANT	–288
WEIGHT ADDED	(818)
ANTENNA	685
STRUCTURE	103
ECS LINES	30
NET WEIGHT INCREASE – LB.	1

3.7 Propellant Transfer

3.7.1 Orbiting Vehicle Configuration - The orbiting vehicles utilized to accomplish this task are a rendezvous configuration Gemini and Gemini Agena Target (G.A.T.). The basic configuration of the Gemini is altered to incorporate two propellant tanks, one pressurant tank, and transfer plumbing in the adapter equipment section. The G.A.T. is altered to accommodate two propellant tanks and a pressurant tank externally accessible.

3.7.2 System Configuration - The transfer system schematic is shown in Figure 3.7.1. The Gemini equipment includes liquid/vapor separators in the propellant tanks, propellant quantity gauging devices externally mounted, in-line flow meters, pressure transducers, thermocouples, and latching solenoids. The latter are used to control the transfer, purge the system, regulate the receiving tank pressure, and pressure check the system prior to transfer. The G.A.T. equipment is similar, except the propellant tanks contain collectors, the pressurant tank utilizes a heater blanket to provide maximum transfer, and the pressurant switch is regulated. The propellant quantity gauge is used on these tanks for complete transfer monitoring, but flow meters which would be redundant, are felt not to be necessary.

3.7.3 Typical Transfer Procedure - The following is a typical mission sequence for storable propellant transfer:

A. Gemini rendezvous with Agena (nose dock)

B. Latch up vehicles (rigid)

C. Connect propellant and pressurant lines (EVA)

D. Secure and check connection (EVA)

E. Pressurize transfer lines and turn off pressurizing source

F. Pressure-check lines by monitoring transfer line pressure to verify good connection

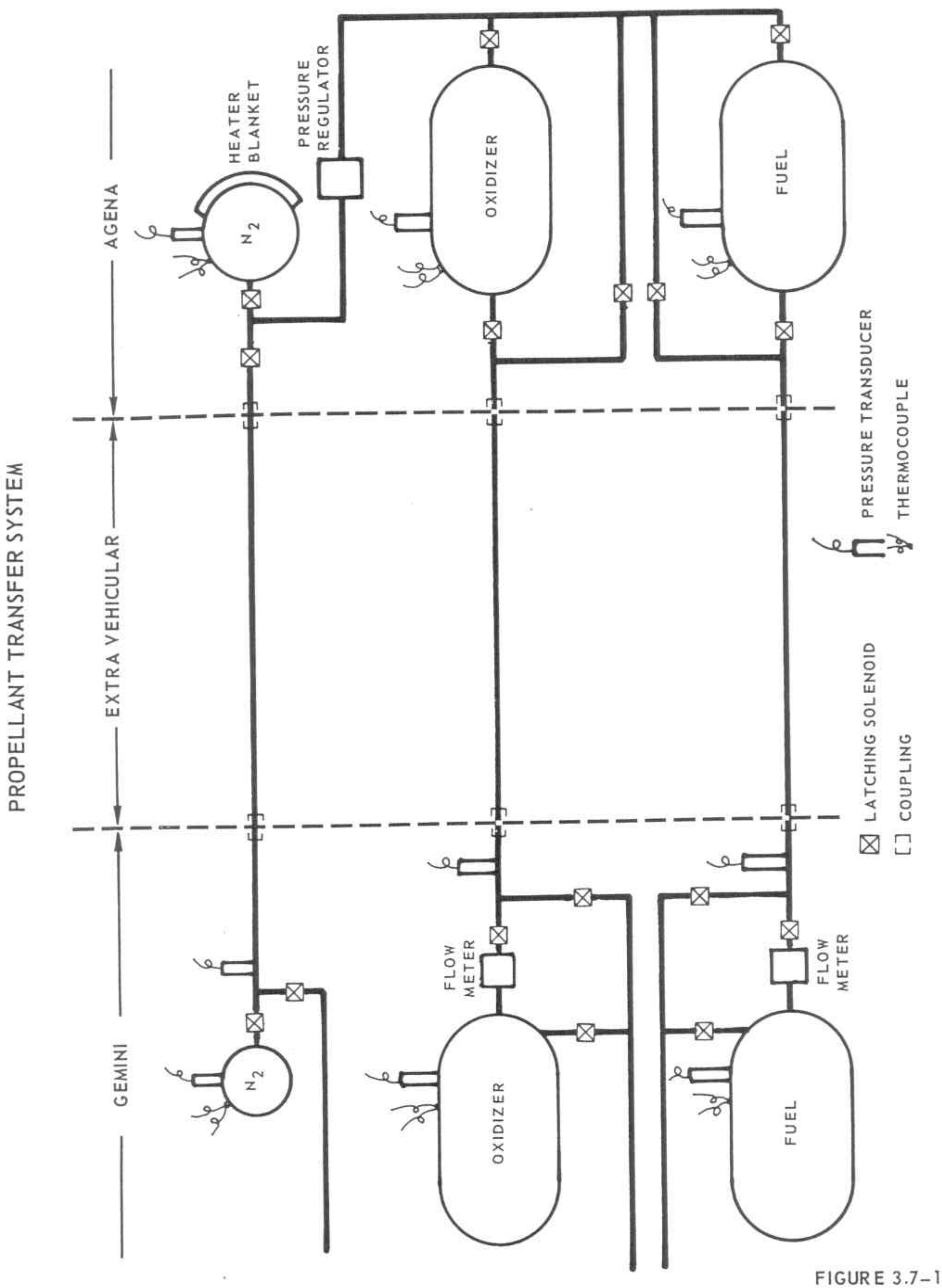

PROPELLANT TRANSFER SYSTEM
AGENA
EXTRA VEHICULAR
GEMINI
HEATER BLANKET
PRESSURE REGULATOR
N_2
OXIDIZER
FUEL
FLOW METER
PRESSURE TRANSDUCER
THERMOCOUPLE
LATCHING SOLENOID
COUPLING

FIGURE 3.7-1

3.7.3 (Continued)

G. Release transfer line pressure and close dump valve

H. Pressurize oxidizer (N_2O_4) receiving tank to 90 PSIA

I. Check oxidizer tank temperature (not to exceed 150°F)

J. "Zero" oxidizer transfer integrating flow meter

K. Commence oxidizer transfer

  (1) Introduce regulated pressure to oxidizer tank (300 PSIA)

  (2) Open oxidizer tank isolation valves (2)

  (3) Monitor integrating flow meter

  (4) Bleed receiving tank to maintain 70 PSIA

L. Halt transfer when complete

  (1) Shutdown regulated pressure to supply tank

  (2) Shutdown receiving tank bleed valve

  (3) Shutdown isolation valves

M. Purge transfer line

  (1) Open dump valve

  (2) Open regulated pressurant to transfer line

N. Halt purge

O. Close dump valve

P. Pressurize fuel (MMH) minimum 10 PSIA

Q. Repeat steps I to N inclusive

R. Open pressurant receiving tank isolation valve

S. Open pressurant storage tank isolation valve

T. Open and control pressurant transfer valve until tank pressures are equal

U. Turn on tank heater

V. Close down pressurant isolation valves

3.7.3 (Continued)

W. Turn off pressurant tank heater

X. Open oxidizer transfer line dump valve

Y. Disconnect transfer lines

3.7.4 Weight Summary - The weight added to Gemini is summarized in Table 3.7-1.

TABLE 3.7-1
WEIGHT SUMMARY
PROPELLANT TRANSFER

	WEIGHT – LB.
WEIGHT ADDED TO GEMINI (LEM EQUIPMENT)	(80)
FUEL TANK	12
OXIDIZER TANK	12
FUEL DETECTOR	2
OXIDIZER DETECTOR	2
CONTROL UNIT	7
PRESSURIZATION TANK AND GAS	25
MOUNTING AND CIRCUITRY	20

3.8 Long Duration Mission - The in-orbit configuration of the long duration orbital spacecraft is shown in Figure 3.8-1. The mission section to be added to the Agena is 165 inches long and is mounted between the Forward Auxiliary Rack and Forward Rack. The inflatable tunnel is stored in a fairing attached to the mission section. The fuel cells, reactants, and breathing oxygen are housed in an unpressurized section. Food, water, emergency oxygen, and personal needs are contained in a pressurized section.

The combination access tunnel/living quarters is shown after EV erection, which can be accomplished manually by one man. The tunnel provides easy access to the mission section. It is a structural assembly with a volume of approximately 230 cubic feet. The tunnel selected is based on a Goodyear design which was developed under Air Force contract.

A weight summary of the tunnel and associated end attachments to the Gemini is given in Figure 3.8-2. The weights were taken from a Gemini B study of the same type inflatable tunnel and are directly applicable to this case.

A meteoroid penetration evaluation of the tunnel and Gemini Re-entry Module, for a period of 30 days, is given in Figures 3.8-3 and 3.8-4. The evaluation was based on Aerospace meteoroid penetration environment and penetration criterion (Ref. 3.8-1).

A summary and extrapolation of both Gemini and Apollo fuel cell weights for supplying electrical power for the duration of the mission are given in Figure 3.8-5. The electrical power design point is based on previous estimates including an allowance of 1.6 KW, peak, for experiments and operation of the Agena mounted items which would be carried in either the pressurized or unpressurized sections, as appropriate. Based on analyses conducted during the Gemini B study and Gemini Ferry study (Ref. 3.8-2), the Gemini systems, including the re-entry batteries, should operate properly after the orbital storage period. Power will be supplied

LONG DURATION MISSION CONFIGURATION
45 DAYS

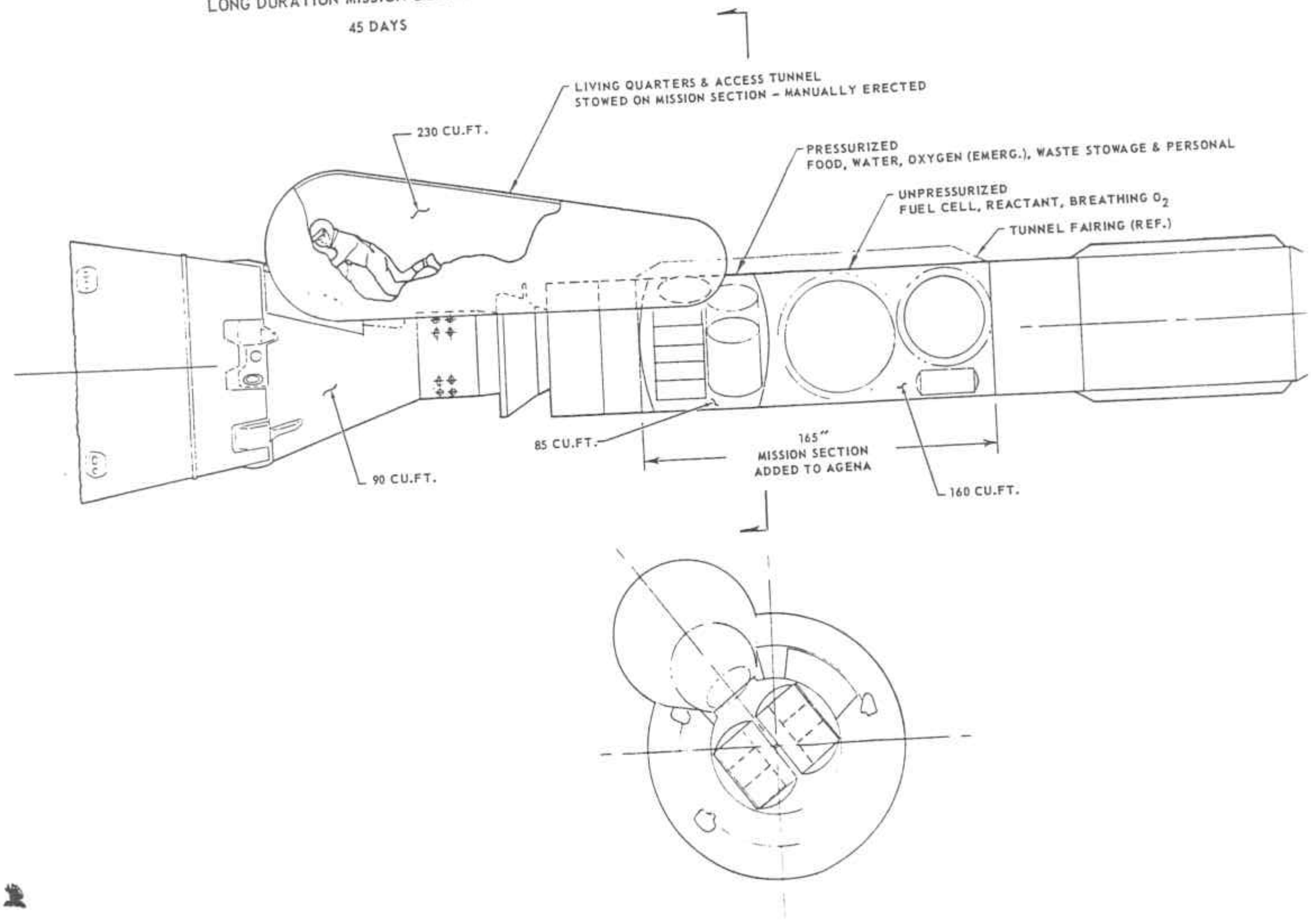


FIGURE 3.8-1

LONG DURATION MISSION CONFIGURATION
45 DAYS

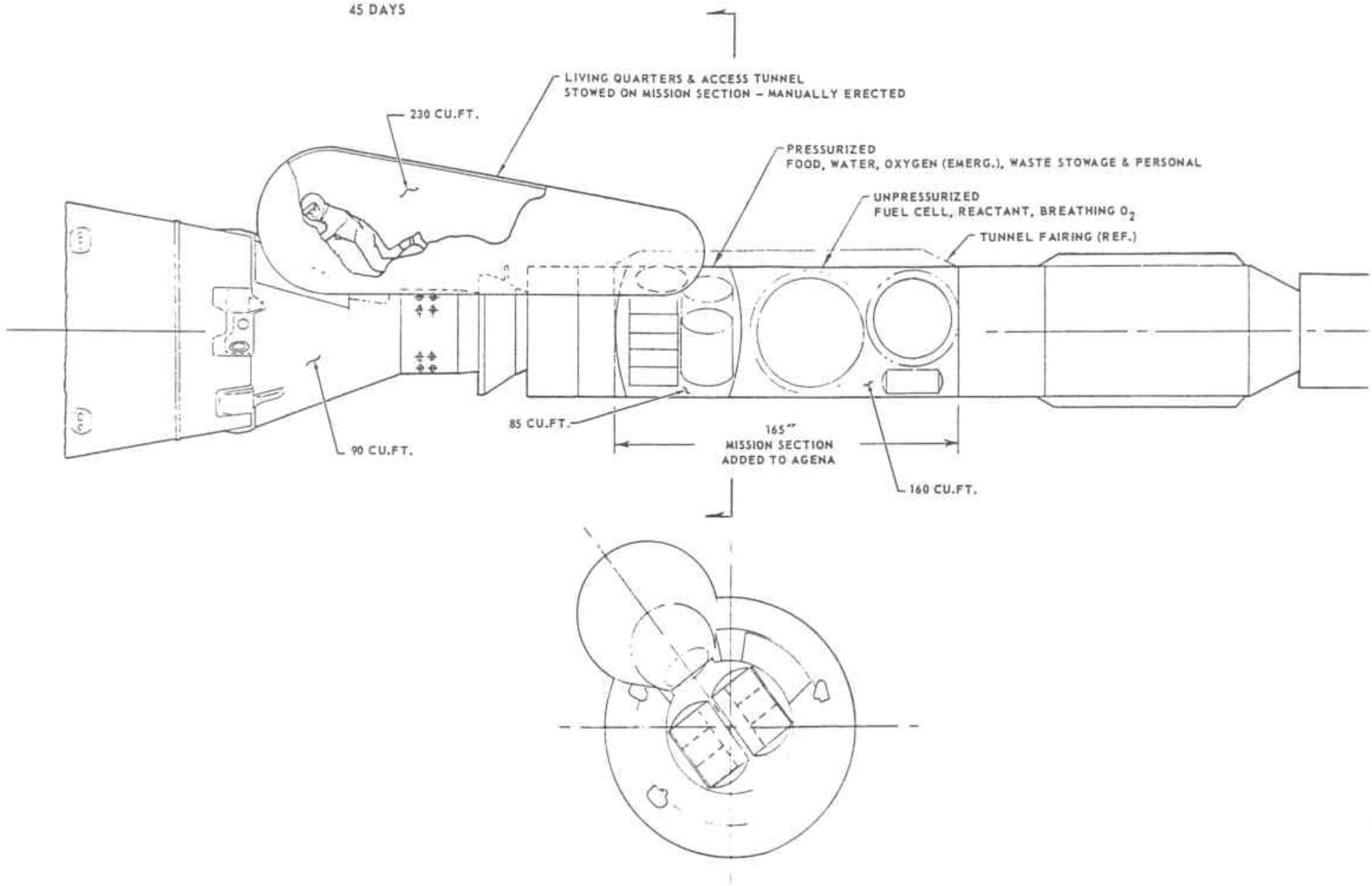


FIGURE 3.8-1

IFIGURATION

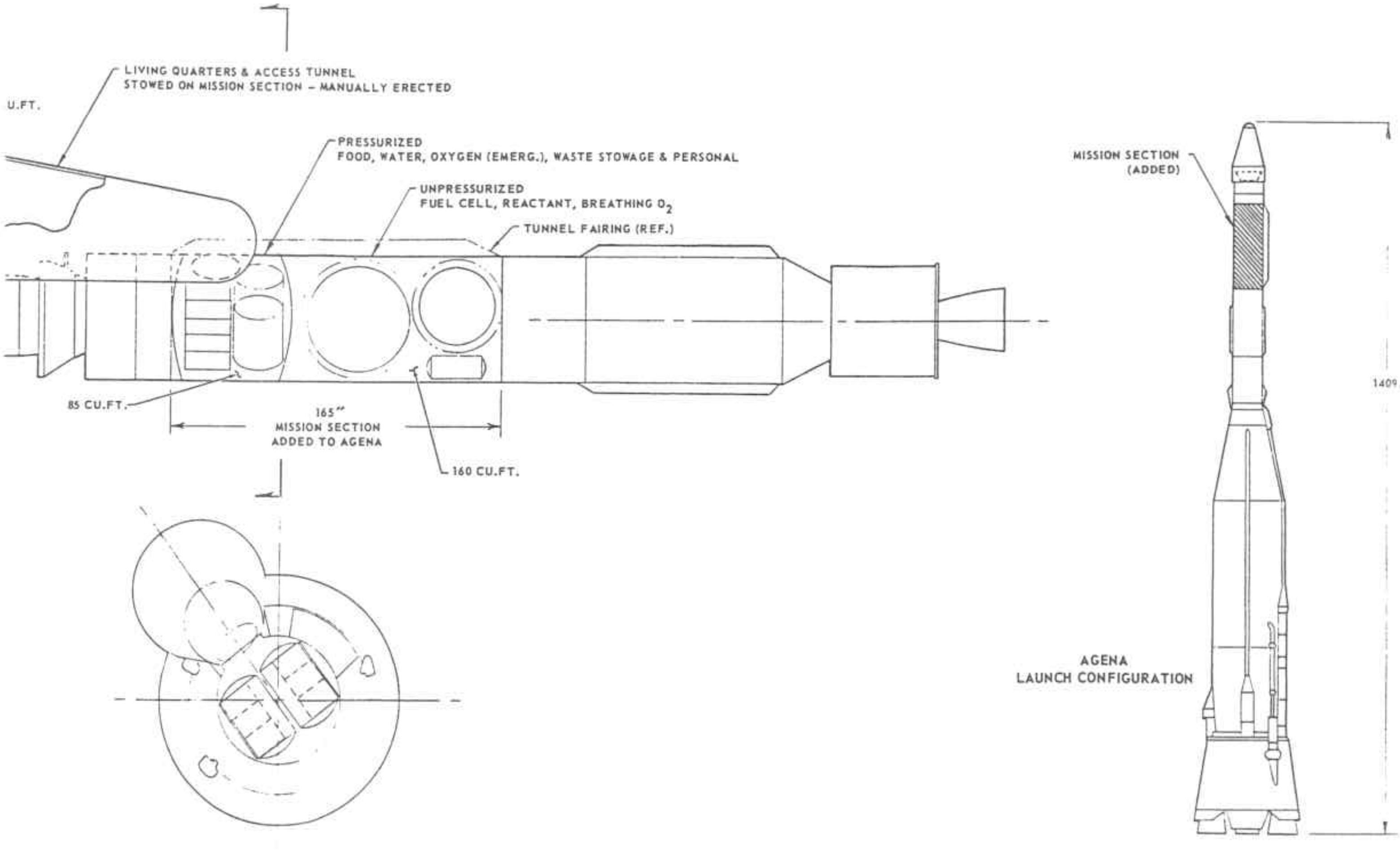
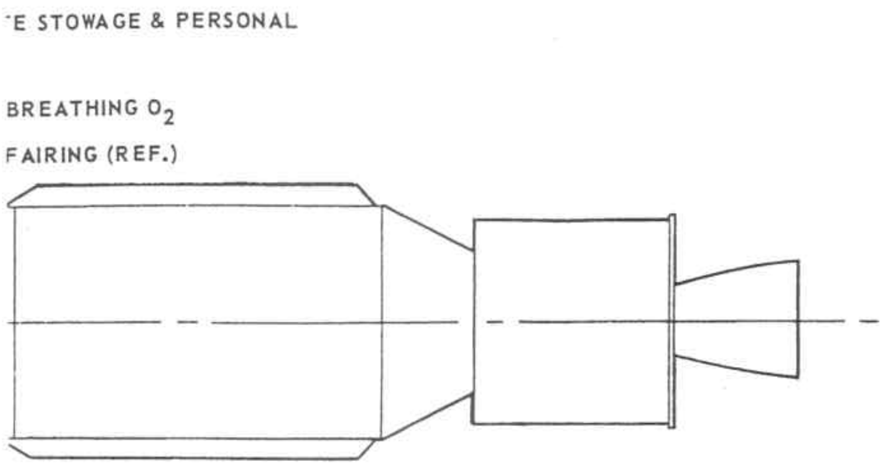
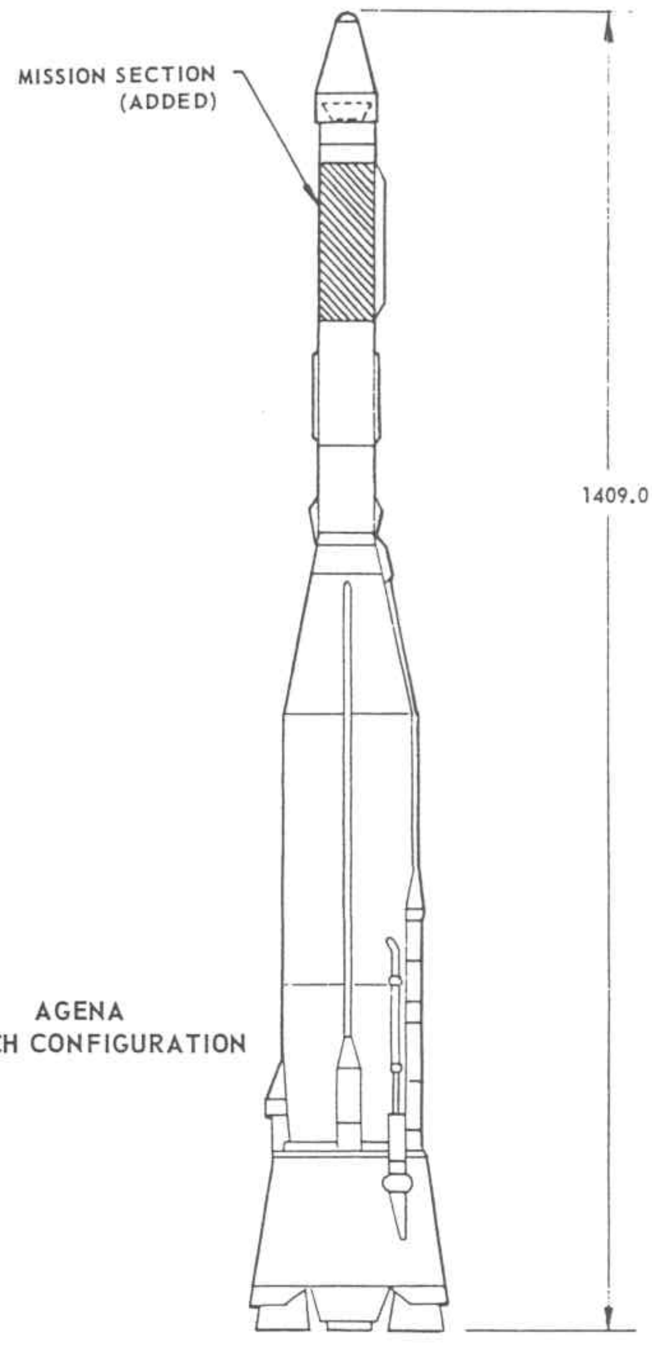


FIGURE 3.8-1





AGENA
LAUNCH CONFIGURATION

WEIGHT STATEMENT
INFLATABLE TUNNEL

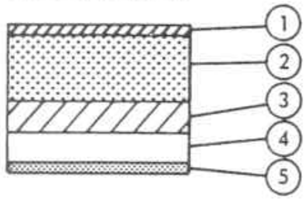
ITEM	DETAILED CALCULATION		WEIGHT (LB.)
TUNNEL/ LIVING QUARTERS	CROSS SECTION		(226)
	 (1) .020 IN. DACRON 52	.75 LB./SQ.FT.	
	(2) 1.25 IN. POLYURETHANE	×	226
	(3) .038 IN. DACRON 52	252 SQ. FT. × 1.20%	
	(4) .060 IN. VINYL FOAM		
	(5) .020 IN. DACRON 52		
FAIRING			(185)
	SKIN – .025 TITANIUM		45
	.025 RENE LEADING EDGE		2
	FRAMES – TITANIUM		29
	STRINGERS – TITANIUM		11
	PADDING – RF300		3
	INSULATION – RF300		25
	FLEXIBLE LINEAR SHAPED CHARGE		30
	ATTACHMENT – TITANIUM		40
HATCH-IN HATCH			(34.0)
	HATCH-IN-HATCH		
	EDGE RING – TITANIUM AT .51 SQ.IN. + RUBBER SEAL		7.8
	STRUCTURE – SHINGLES, SKIN, STIFFENERS,		6.5
	WINDOW AND FRAME		11.5
	MODIFICATION TO PRESENT HATCH		
	REMOVE WINDOW		–13.3
	STRUCTURAL CUT-OUT		–4.2
	ADD HATCH SILL TITANIUM AT .45 SQ.IN.		5.5
	HATCH BEEF-UP		12.3
	LATCHING MECHANISM		2.8
	TUNNEL SILL		5.1
COMMUNI-CATIONS AND LIGHTS			(10.0)
ENVIRON-MENTAL CONTROL SYSTEM	LONG UMBILICAL, 2 – 25 FT. AT 0.3 LB. FT.		(15.0)

FIGURE 3.8–2

INFLATABLE TUNNEL PENETRATION EVALUATION

30 DAY MISSION
EARTH SHIELDING FACTOR = 0.7

NOTES:
1. A_p = 75 SQ. FT. (MAXIMUM)
2. A_S = 150 SQ. FT.
3. FOAM DENSITY = 1.2 LB./CU.FT.

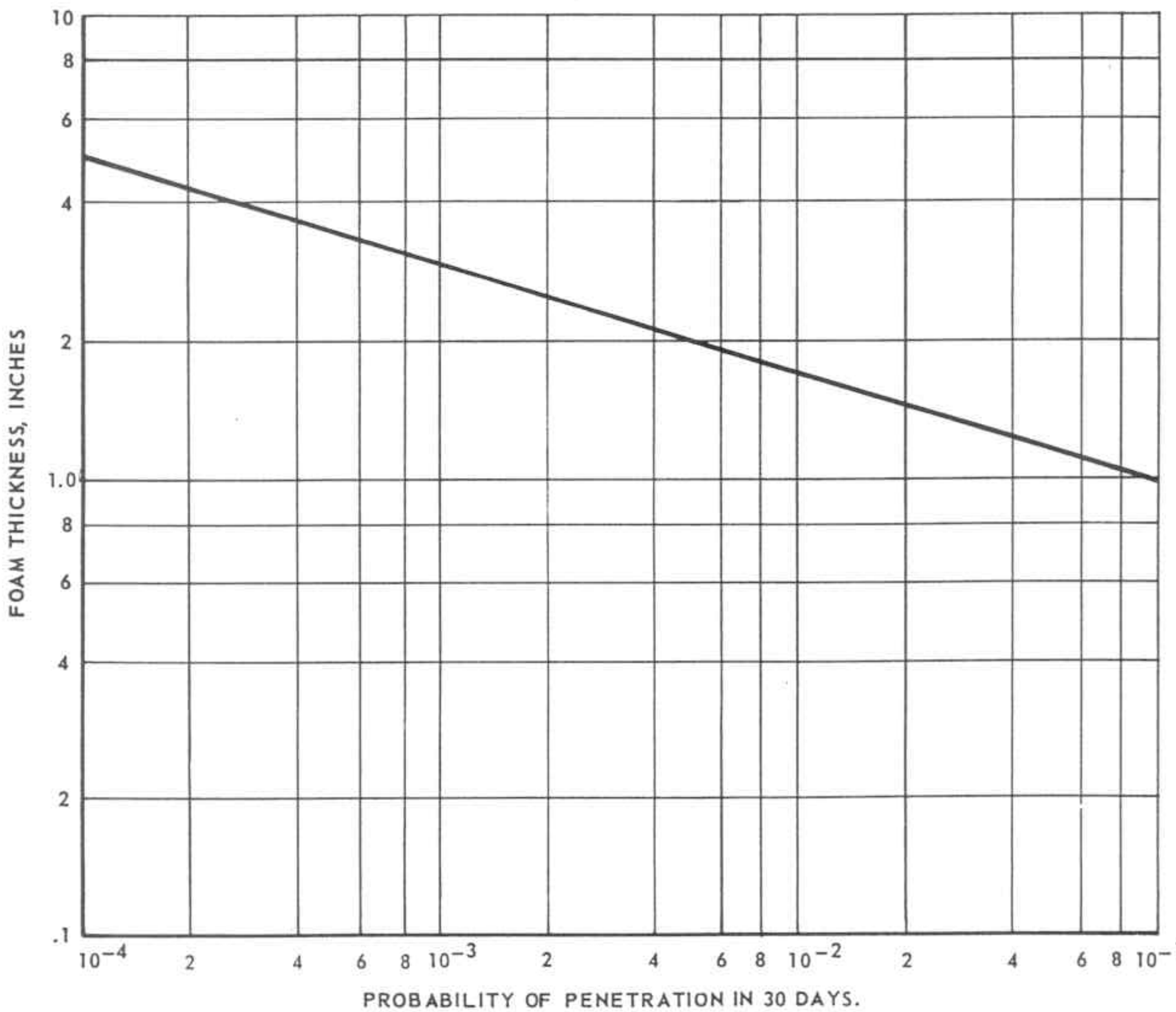


FIGURE 3.8-3

METEOROID HAZARD EVALUATION

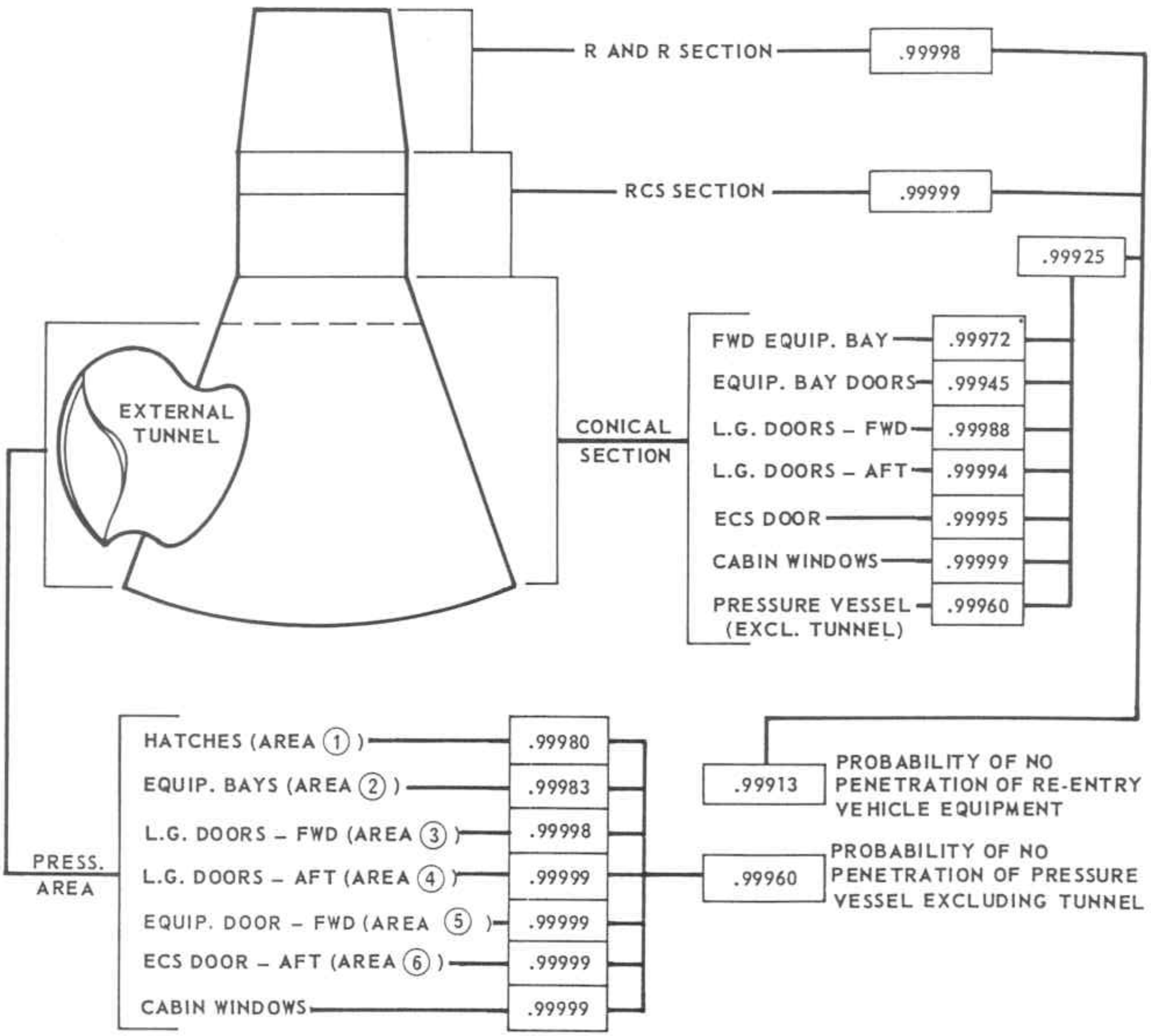


FIGURE 3.8-4

ELECTRICAL POWER SUMMARY

1. FUEL CELLS APPEAR TO BE THE MOST APPLICABLE POWER SOURCE TO BE USED IN THE CAN, ATTACHED TO THE AGENA, FOR ORBITAL OPERATIONS.
2. POWER TO OPERATE GEMINI ORBITAL STORAGE LOADS (RCS HEATERS, WARMANT LOOP, TELEMETRY) SUPPLIED FROM CAN TO THE GEMINI THROUGH THE DOCKING ADAPTER UMBILICAL CONNECTOR.

ITEMS	GEMINI	APOLLO
FIXED HARDWARE	414 LB.	508 LB.
REACTANTS (1,000 KWH)	1,342 LB.	1,212 LB.
TANKAGE	610 LB.	542 LB.
TOTAL (30 DAYS)	2,366 LB.	2,262 LB.
TOTAL (45 DAYS)	3,342 LB.	

ASSUMPTIONS: AVERAGE LOAD – 1,400 WATTS
PEAK LOAD – 2,000 WATTS
INITIAL CAPACITY INSTALLED – 4,000 WATTS

FIGURE 3.8-5

3.8 (Continued)

to the appropriate Gemini systems through the Gemini target docking adapter umbilical.

A preliminary weight breakdown of the mission section and associated equipment, to be launched on the Atlas-Agena, is given in Table 3.8-1.

Habitability aspects of a spacecraft have a direct relationship to mission duration and crew performance. One of these aspects is the free space, which is defined as the pressurized cabin space less that occupied by the man himself, instruments, and other equipment (a pressure suited crewman will normally require 5 cubic feet). In contrast to other provisions, such as life support, the requirement for free space cannot be precisely defined. The design goal is to provide a spacecraft volume which is just adequate, particularly when increased volume might add substantially to cost or delay the achievement of operational flight capability.

To put the requirement of free space in better perspective, 37 studies reporting the behavioral aspects of confinement were reviewed (Ref. 3.8-3). These were studies judged to be relevant to spacecraft design and involved the use of experimental chambers, simulated vehicles, and operational vehicles. The results of the analysis, which integrated mission duration, volume per man and performance, and physicological factors are depicted in Figure 3.8-6, taken from Reference 3.8-3. Relating this analysis to the 30-45 day Gemini mission, the following extrapolations are pertinent:

A. Volumes per man of less than approximately 40 cubic feet can result in severe degradation in performance and physiological functioning.

B. For missions up to thirty days, volumes per man between 100-200 cubic feet appear to be satisfactory.

C. For missions longer than thirty days, additional volume allocations beyond 200 cubic feet per man becomes relatively less important as a determinant of habitability.

TABLE 3.8-1

WEIGHT SUMMARY
LAND DURATION MISSION

WEIGHT ADDED TO AGENA	POUNDS	
SECTION ADDED TO AGENA		327
STRUCTURE	304	
HATCH	23	
DOCKING ADAPTER		360
INFLATABLE TUNNEL		276
TUNNEL	226	
RINGS AND PORT HOLE	50	
FAIRING		185
COMMUNICATIONS AND LIGHTS		10
ENVIRONMENTAL CONTROL SYSTEM		1,210
FOOD AND CONTAINERS	190	
DRINKING WATER	585	
TANK AND MOUNTING	104	
BREATHING OXYGEN	180	
TANK, MOUNTS AND VALVES	76	
HOSES	15	
EMERGENCY OXYGEN AND TANK	60	
ELECTRICAL POWER SYSTEM		3,482
FUEL CELLS AND HARDWARE	414	
REACTANTS	2,013	
TANKAGE, MOUNTS AND VALVES	1,055	
TOTAL WEIGHT ADDED TO AGENA		5,850 (1)
WEIGHT ADDED TO GEMINI		
HATCH IN HATCH		34

(1) ATLAS – AGENA B CAPABILITY AT 150 NA.MI. (-3σ) = 6200 LB. (REF. 3.8-6)