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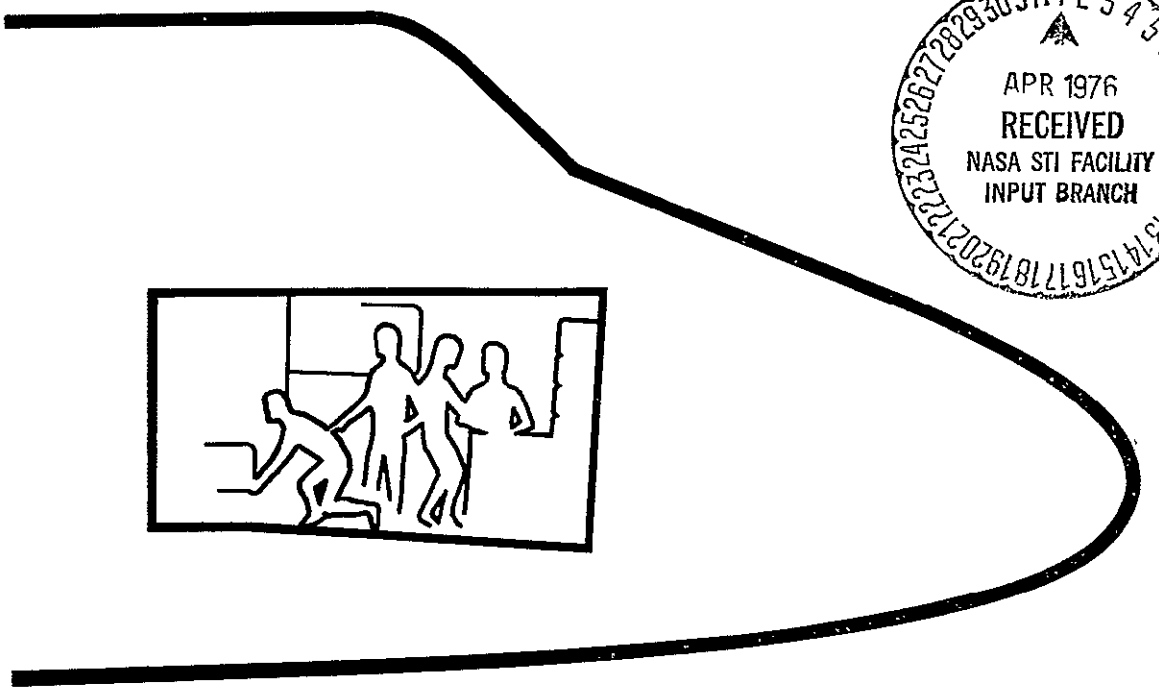
CONCEPT DESIGN AND ALTERNATE ARRANGEMENTS OF ORBITER MID-DECK HABITABILITY FEATURES.



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CONCEPT DESIGN
AND
ALTERNATE ARRANGEMENTS
OF
ORBITER MID-DECK HABITABILITY FEATURES

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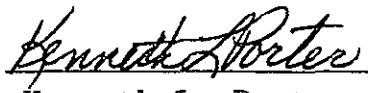

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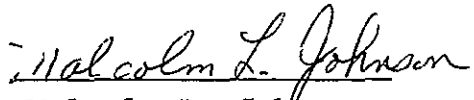

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FOREWORD

This report provides a summary of the industrial and engineering conceptual design program conducted to evaluate the Shuttle Orbiter Mid-Deck habitability features considering mission operational procedures, crew compliments, crew activities, female and male crew member anthropometry, baselined structural arrangements and design concepts, and Skylab experience, when applicable. The program effort covered the following areas:

Airlock Forward Hatch Stowage
Sleep Stations
Eating/Work Table
Personal Hygiene Station
Waste Management Compartment
Airlock Out Flight Configuration
Mobility/Stability Aids
Sleep Restraint
Wet Trash Management
Color Schemes.

The evaluation method included the generation of dimensional layouts and illustrations of baseline and alternate features. The recommended features were selected after comparing advantages and disadvantages of each concept. A 1/10-scale model of the Mid-Deck area was constructed and utilized as a visual aid to demonstrate the advantages of recommended concepts over the existing baseline features, when applicable. The NASA-JSC full-scale Mid-Deck mockup was also utilized to demonstrate the recommended features. A photographic record was maintained of the modeling and mockup activities. Design requirements and illustrations of recommended concepts are provided.

This document was prepared by Nelson and Johnson Engineering, Inc. and is submitted as a Type I document in accordance with the requirements of Attachment 1 to Exhibit A, Statement of Work, Data Requirements List (DRL) No. T-1093 of Contract NAS 9-14686, Line Item No. 3.

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1.0 INTRODUCTION

1.1 Purpose - This final report documents and summarizes the results of the program to provide evaluations and recommendations for habitability features in the Space Shuttle Orbiter Mid-Deck.

1.2 Scope - This final report covers the entire program effort conducted in accordance with the NASA approved program plan as directed by the Technical Monitor.

1.3 Summary - The Orbiter mission plans, the Mid-Deck dimensions and baseline arrangements along with crew compliments and typical activities were initially defined to establish the basis for the study program. Female and male anthropometric data based on zero-g operations were also defined. Evaluations of baseline and alternate feasible concepts provided the following recommendations:

- With the airlock installed in the Mid-Deck, it is recommended that the airlock forward hatch be opened by removing the hatch and stowing it above the access opening to minimize impact on Mid-Deck space.

- Sleep stations of the 3 horizontal/1 vertical baseline arrangement should be retained but it is recommended that the lower horizontal station face down and the vertical station face forward. The width of the horizontal stations should be increased to an inboard plane defined by the original baseline floor trace to be able to accommodate 95th percentile male sizes. The sleep station closeout should be of rigid material providing a modular appearance with bi-fold access doors. The closeout should be made in sections to facilitate reconfiguration and provide access to stowage areas. A lightweight cross-member structure concept is recommended to provide support attachment for the horizontally installed sleep restraint frames with rigid sound-attenuating material incorporated in the design.

- An eating/work table having individual surfaces retained in a tilted position and having height adjustment capability is recommended to accommodate 95th percentile to 5th percentile male and female crew member sizes in a zero-g posture and minimize space requirements. A retractable bungee concept integral with each table surface

is recommended for restraint of food tray, small items, or paper work. A full-scale mockup of the four position table concept was provided for use in the full-scale Mid-Deck mockup at JSC.

- A tilted seat in the waste management compartment (WMC) is recommended to accommodate zero-g posture. Handrails and lap strap facilitates use of the equipment.

- The personal hygiene washer location requirements on the aft side of the galley are provided and a handrail located beneath the washer should be included to facilitate washer use.

- It is recommended that the upper portion of the waste management compartment door slope outboard of the primary interdeck access opening to provide privacy and minimize obstruction to the primary access opening when the door is in its opened position. A sliding door extension completes the privacy closeout of the personal hygiene station (PHS) area and provides additional width at the washer area for body/arm movement.

- Use of the window in the side hatch as a photographic experiment station will preclude access to the personal hygiene station and the waste management compartment. It is recommended that an alternate camera station be utilized to allow access to and use of the hand washer and the waste collection equipment.

- A deployable tray concept is recommended for the stowage of damp towels and washcloths for up to seven crew members.

- The airflow controls for the PHS/WMC should be located at the WMC opening so that they are accessible to a crew member in the PHS.

- When the airlock is not installed in the Mid-Deck, it is recommended that the space on the aft bulkhead be utilized as the location for stowage lockers to provide easier access to the vertical sleep station. A pedestal supported table can also be utilized to provide free access to all of the forward tier lockers.

- Handrails are recommended in the Mid-Deck area to facilitate zero-g mobility and control of body stability.

- A modified Skylab sleep restraint with full length liner zippers and standard size restraint frame are recommended based on sleep station compartment size and 95th percentile male crew member size. Restraint strap adjustments accommodate smaller size crew members down to 5th percentile females. The concept includes a movable belt to which two sleep liners are attached. By moving the belt, the alternate liner can be moved into the use position and enable dual use of the compartment when larger crew compliments operate on a split-shift schedule. A full-scale mockup of this concept was constructed for use in the full-scale Mid-Deck mockup at JSC.

- The open spaces between side wall frames in the sleep station areas are recommended to be used as the temporary stowage areas for clothing and other personal provisions. A bungee spring concept can be utilized to restrain loose items. This recommendation also applies to the side wall area in the PHS/WMC area.

- The lower side wall spaces between frames in the area of PHS are recommended to remain open so that the floor surface out to the side wall can be used for comfortable placement of the feet when using the suction cup shoes.

- A trash compactor is recommended to handle all wet trash items that can be crushed to reduce the volume of the generated wet trash in order to be compatible with the useful stowage volume of the wet trash floor compartment. A nonfunctional full-scale mockup of the trash compactor and trash bag was constructed for use in the full-scale Mid-Deck mockup at JSC.

- An alternate color scheme is recommended to provide white as the basic color for major surfaces with accent colors such as yellow, brown, and orange for the main activity area, light and dark blue colors within the sleep stations, and an all white surface area in the personal hygiene/waste management compartment area.

A 1/10-scale model of the Mid-Deck and scale model representations of baseline and recommended features were constructed and utilized to demonstrate the advantages of recommended features. The NASA-JSC full-scale mockup of the

Mid-Deck was utilized to demonstrate the recommended features. Full-scale mockup activity also included construction of concepts for the eating/work table, the sleep restraint, and the trash compactor. These mockups along with other recommended features of the Mid-Deck were installed and demonstrated in the Mid-Deck mockup at JSC. A photographic record of the model and mockup activity was provided.

All measurements and calculations were made in English units which have been converted to the International System (SI) units for this final report. All dimensions on illustrations are given in centimeters with the inch value in parenthesis.

2.0 DISCUSSION

2.1 Skylab Experience - The following paragraphs briefly highlight some of the pertinent results reported by Skylab crew members in regards to habitability aspects of that mission.

2.1.1 Sleep Compartments - As described in References 1, 2, and 3, the private sleeping quarters provided for each crewman were considered by the crewmen to be of adequate size. The smallest of the sleep areas was 0.7 by 0.96 by 1.98 meters (29 by 38 by 78 inches). The largest was 0.73 by 1.22 by 1.98 meters (29 by 48 by 78 inches). The vertical body orientation type of compartment arrangement with respect to the floor and ceiling was considered adequate by the crews. Only one crewman reversed the sleep restraint orientation such that his head was toward the floor to avoid air blowing into his face/nasal area since the air outlet was in the floor and air flowed from floor to ceiling. This particular arrangement also made it easier for him to adjust the airflow without getting out of the sleep restraint. The crews generally expressed satisfaction with the communication box and light locations which were accessible to them while in the normally oriented sleep restraint (head toward ceiling). The lockers provided within each compartment were considered sufficient for the permanent stowage of new clothing as well as other mission items. The crews felt, however, there was a lack of temporary stowage provisions for doffed clothing and personal pocket items. The crews had to improvise in this latter case, such as stowing clothes behind the communication box or securing them outside the compartment. A tissue dispenser and trash storage locker were also provided to each crewman.

The primary complaint about the Skylab sleeping stations was that concerning noise. The background noise of the workshop was relatively quiet and changes in noise level from either equipment or movements from one of the crewman would disturb their sleep. A loose sleep restraint support assembly on SL-IV, generated noise that disturbed the other two crewmen. The privacy curtain along with a light baffle covering the ceiling open grid were considered adequate for insulating each compartment from the rest of the workshop lighting. The fabric light baffle, on occasion, would close and block ventilation airflow. One crewman would leave the privacy curtain partially open to ensure adequate ventilation.

2.1.2 Eating/Work Table - Three food trays attached to a wardroom floor mounted column were provided. Each tray could be covered with a tray lid for conversion to a work

surface. Foot and thigh restraint provisions were at each eating station. The main problem turned out to be associated with the incompatibility of the foot restraint provisions with the triangular shoe restraint. However, once the restraint plate was removed to expose the normal floor grid, the foot restraint situation improved. Very little commentary was made about the use of the thigh restraint. Apparently only a few crewmen found it useful. Other crewmen appeared to float while holding onto the tray edge or use only one foot restraint. The Science Pilot (SPT) position was located such that he had to move around the other crewmen or fly over the table for access to the galley area. This situation did not appear to present any real problem as there was enough space for movement about the wardroom between the window side and back of the Pilot eating station. Although some of the crewmen initially indicated the tray height was adequate, the consensus of opinion appears to be that a closer surface-to-mouth position would have been better.

When the tray top was used for a desk or work surface, the main problem was found to be with the lack of restraints for holding paper sheets or a book onto the surface. Bungee springs were stretched across the top and worked satisfactorily.

2.1.3 Personal Hygiene/Waste Management Stations - The waste management compartment on Skylab contained the handwasher and the urine/fecal collection equipment. The handwasher was located just inside the access hatch for the WMC. The urine/fecal collection was located outboard of the washer with the seat oriented on the wall such that the crewman use position was facing toward the compartment floor. Light duty foot restraints were attached to the floor in front of the washer and a handrail was provided at the lower edge of the washer opening. Light duty foot restraints were also provided in front of the urine/fecal collection equipment to provide restraint during independent use of the urine collection equipment. Handholds were provided on either side of the fecal collector seat along with a lap strap. The lap strap was adjustable in length with velcro pile for the fastening feature. A handrail was provided at the ceiling in front of the wall containing the washer and fecal collector. Stowage of personal hygiene provisions was in the lockers adjacent to the washer location. A washcloth/towel drying station utilizing slit retention cups was located on the wall opposite the washer location near the WMC access hatch.

Crew commentary on the WMC features are summarized in the following paragraphs based on the crew subjective evaluation for Experiment M487, References 3 and 4.

One of the main problems reported by the crew members with the WMC concerned the light duty foot restraints. The adjustable velcro pile type straps were too small for use with the triangle shoe restraint and apparently too large for barefoot use. As a result, crew members had to improvise body restraint by wedging themselves against the backwall or just float in front of the washer to allow use of both hands. Otherwise, they held on to something with one hand. The washer handrail received a good rating by most of the crew members, probably for this reason.

The fecal collector lap strap was reported by a majority of the crew members as being necessary but should have a positive locking buckle that would allow tightening adjustment rather than the velcro pile fastening feature. The two handholds on either side of the seat were also reported as being needed with a few crewmen commenting that they only used the handholds. Without adequate foot restraints, crewmen reported problems of clean up after equipment use as they had to float about the compartment while performing this hygiene chore.

The overhead ceiling handrail was not used by many of the crewmen, in fact, some reported that they did not even know it was there.

Only two of the crew members felt that the stowage provisions for personal hygiene items should have been on a personal locker basis, otherwise, little was mentioned other than being acceptable. The washcloth/towel drying station provision was also acceptable except at least two of the crew members felt the restraint cups should be spread apart. The towels tended to float out when only restrained on one end. Other temporary restraint provisions were reported as being deficient and that more of them, such as the bungee type, should be provided.

A few of the crew members felt that simultaneous use of the personal hygiene washer and the urine/fecal collector by two people would have been advantageous. When one person was at the washer, it blocked access to the other equipment located outboard of the washer.

2.1.4 Mobility/Stability Aids - Reference 5 provides a summary of the types and use of the personnel mobility aids provided within the Skylab compartments. In general, preinstalled handrails were used frequently as both mobility and stability aids. The handrails were not used for hand-over-hand translation but were used as grab bars to control body orientation, to change motion direction, or to stop

translation. The crews recommended that handrails be installed around hatches and along main traffic routes within future spacecraft. A few areas within Skylab were reported to be deficient in handrails or stability aids such as at the film vault and the food lockers. Also there was a deficiency of handrails in the Multiple Docking Adapter and all three crews commented on the difficulty of moving around in this smaller diameter portion of Skylab even though there were many equipment protrusions which were used as handholds. Translation about the experiment compartment and crew quarters, which were one-g oriented as to a floor/ceiling arrangement, presented little difficulty even though few handrails were provided. The open grid of the floor and ceiling which were only 198 centimeters (78 inches) apart, provided handhold openings and the various pieces of equipment and stowage boxes provided edges and surfaces to grab or push against. Handrails were necessary for stabilization while crew members were restraining themselves with the foot restraints but were not needed to perform a task once properly restrained.

Translation modes used by the Skylab crews are summarized in Reference 6. The general mode used within the crew quarters area was to assume an erect but slightly crouched position with legs pulled up to shorten their overall length. They would thrust themselves toward their destination and upon arrival, grab onto anything close at hand to stop their motion. Sometimes, they would push off with their toes against the grid and utilize their shoe toes in the grid for mid-course corrections.

2.1.5 Sleep Restraint - Reference 7 summarizes the results of the use of the Skylab sleep restraint. Although the Skylab sleep restraint was basically satisfactory, several shortcomings were noted. These were as follows:

a. Ingress/egress through the neck ring was cumbersome particularly because of the close quarters and proximity of the neck ring location to the ceiling.

b. Excess volume, particularly in the leg/foot area, created localized thermal problems in that area.

c. Various pieces of the assembly were poorly labeled (causing confusion during changeout) and were too complex in design for the simple purpose they served.

d. The method to support the sleep restraint frame permitted the frame to swing when the crew member moved causing the frame, on some occasions, to hit the wall and create noise disturbance.

Favorable characteristics of the Skylab sleep restraint were found to be as follows:

a. Adjustable, flexible restraint straps

b. Arm slits

c. Adjustable/removable pillows

d. Adjustable thermal protection.

2.1.6 Trash Management - Skylab trash management consisted of placing trash items in general purpose trash bags which were then ejected into the large waste tank through the trash disposal airlock. Large plenum bags were also used for strictly dry type trash. These latter trash bags were placed in the plenum trash storage area below the crew quarters flooring. The messiest trash generation area was in the wardroom from meals. A can crusher was provided that could crush the food cans individually but residual food presented a messy handling problem.

2.2 Anthropometric Requirements - All anthropometric requirements are based on 95th percentile male and 5th percentile female data. For zero-g operation, a weightless posture has been assumed as the normal position of a crew member when at an activity location for any length of time. Figures 1, 2, and 3 present views of this posture for the various size crew members based on Skylab experience, Reference 8. Additional anthropometric dimensional data was obtained from MIL-STD-1472B, Reference 9. A 5.08-centimeter (2-inch) height allowance has been utilized to account for the use of suction cup shoes, when applicable, as this is the foot restraint technique for the Orbiter.

Figures 4, 5, and 6 were generated in order to establish anthropometric requirements based on various body positions that must be considered for activities within a sleep station (i.e., don/doff clothing and stretch to full stature) and while using a sleep restraint As indicated on these figures, a minimum peripheral envelope about the 95th percentile male body defines the shape for a sleep restraint frame.

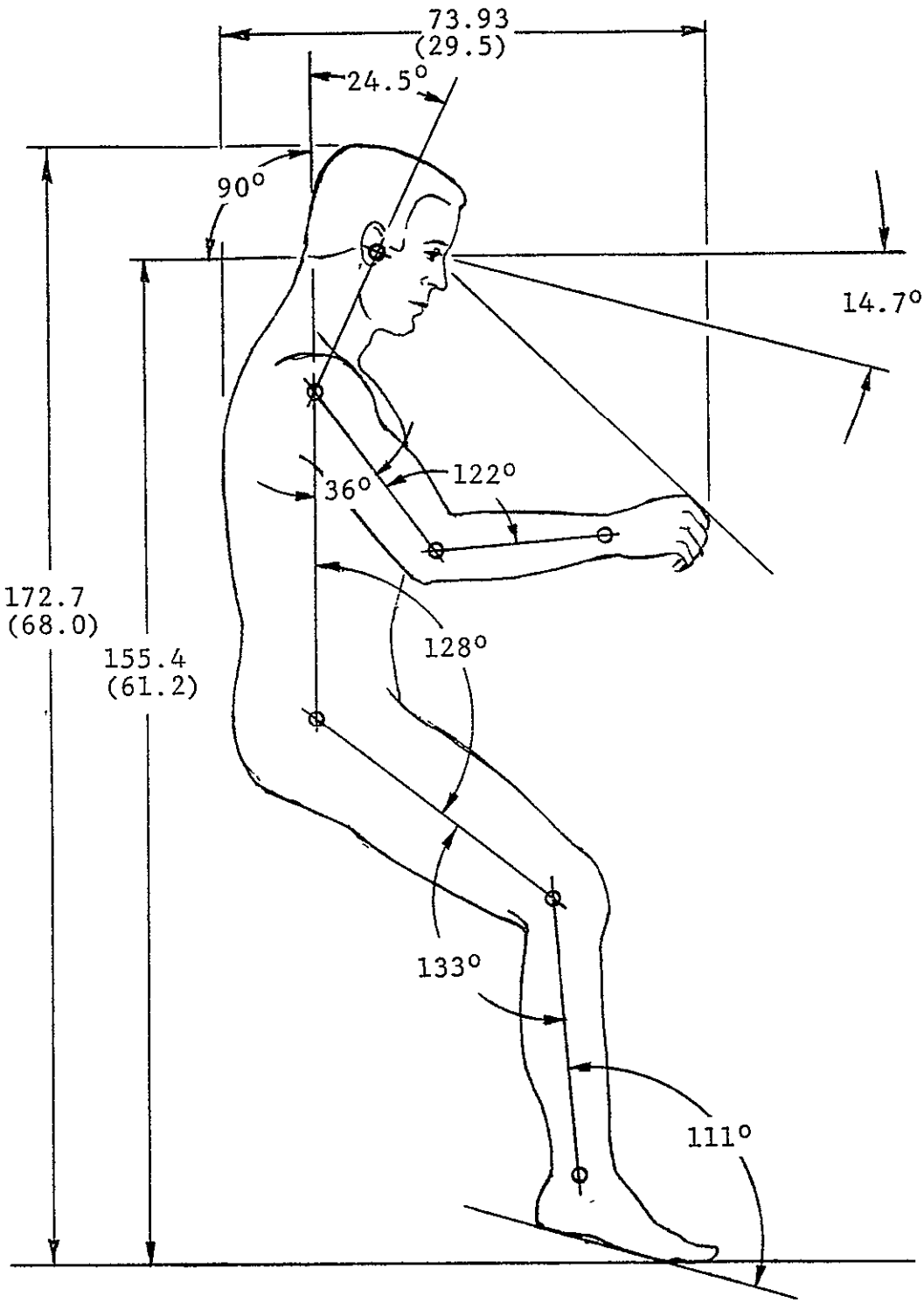


FIGURE 1 95TH PERCENTILE MALE IN WEIGHTLESS NEUTRAL BODY POSITION

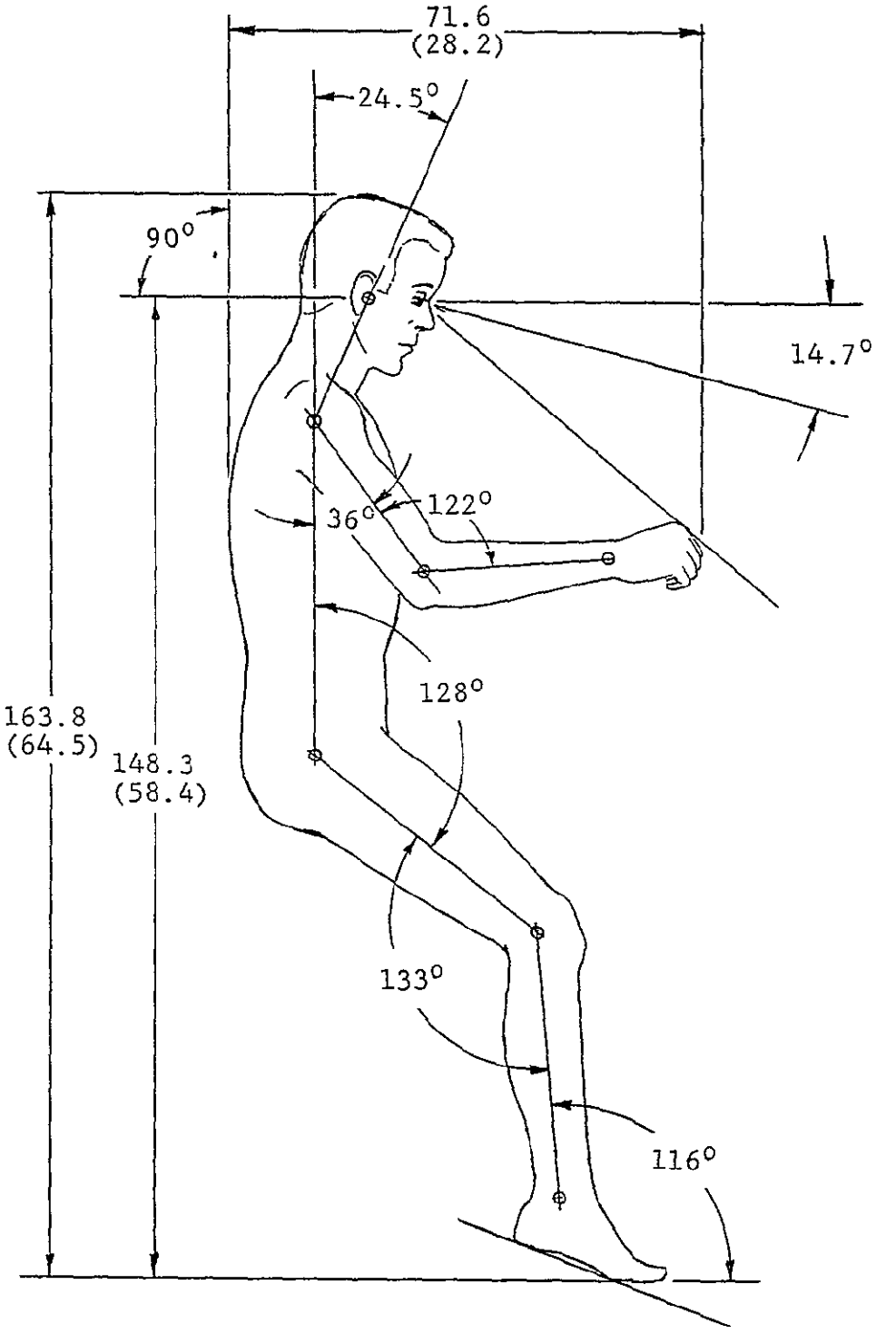


FIGURE 2 . 42ND PERCENTILE MALE IN WEIGHTLESS NEUTRAL BODY POSITION

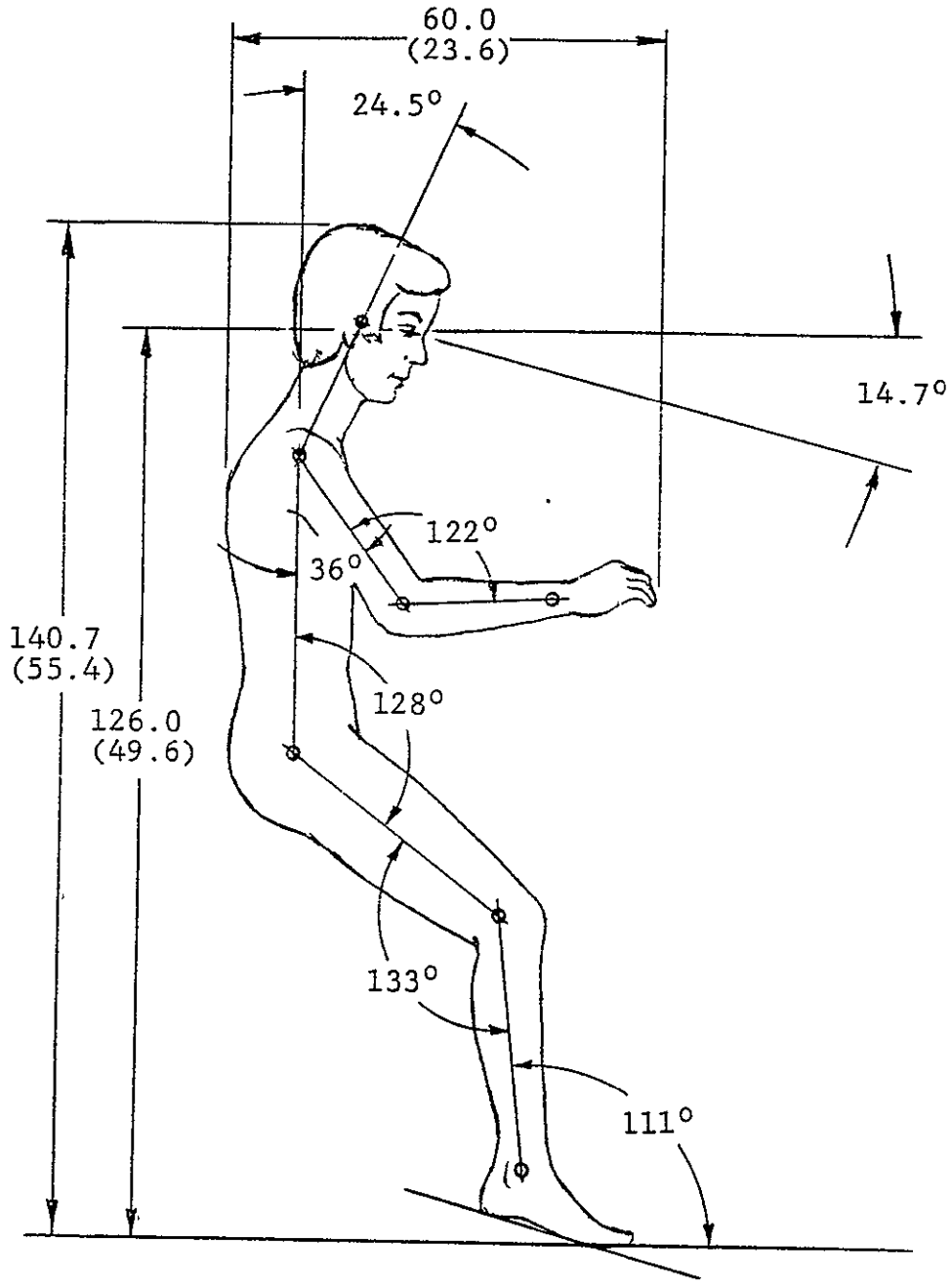


FIGURE 3 5TH PERCENTILE FEMALE IN WEIGHTLESS NEUTRAL BODY POSITION

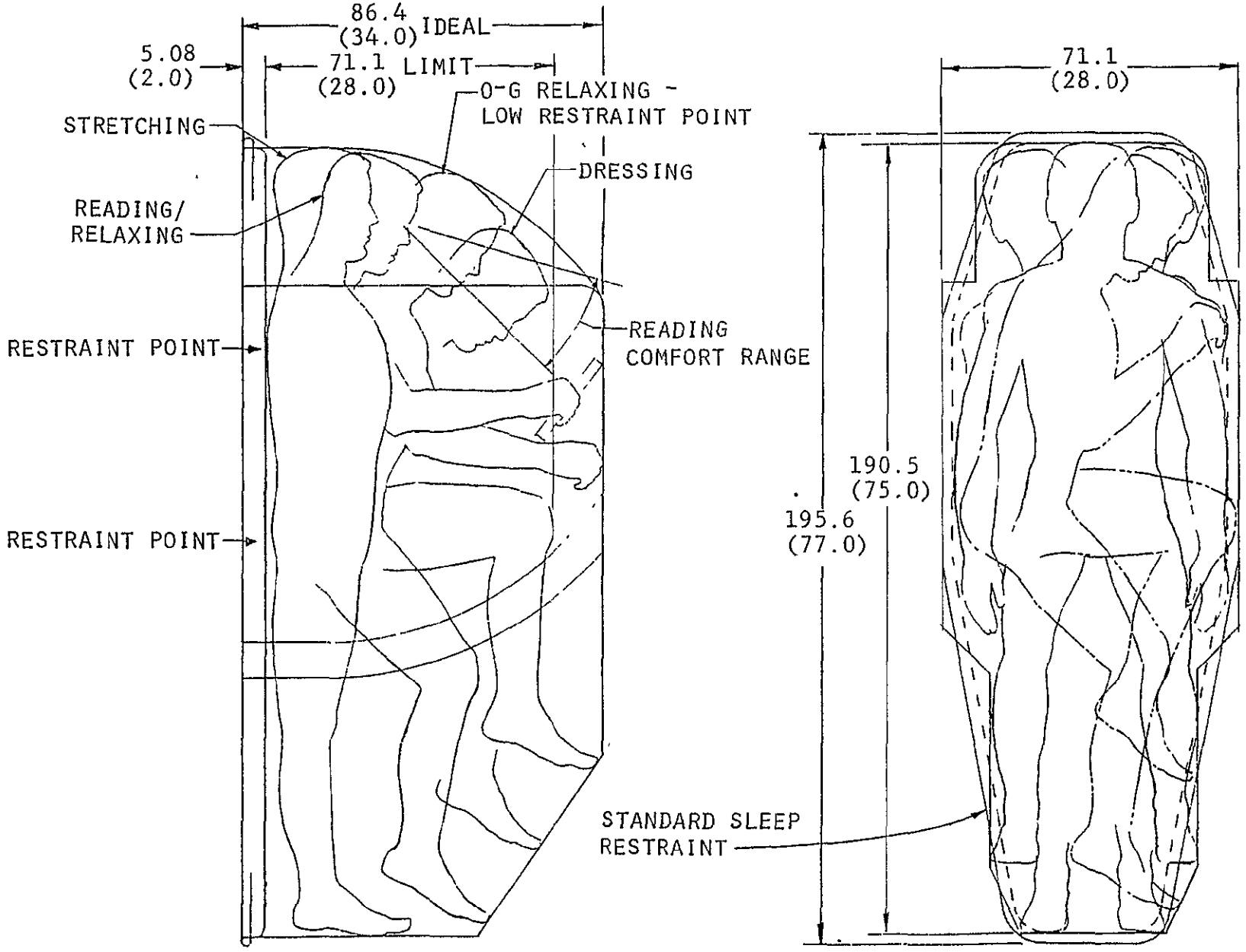


FIGURE 4 SLEEP COMPARTMENT MINIMUM ACTIVITY ENVELOPE FOR 95TH PERCENTILE MALE

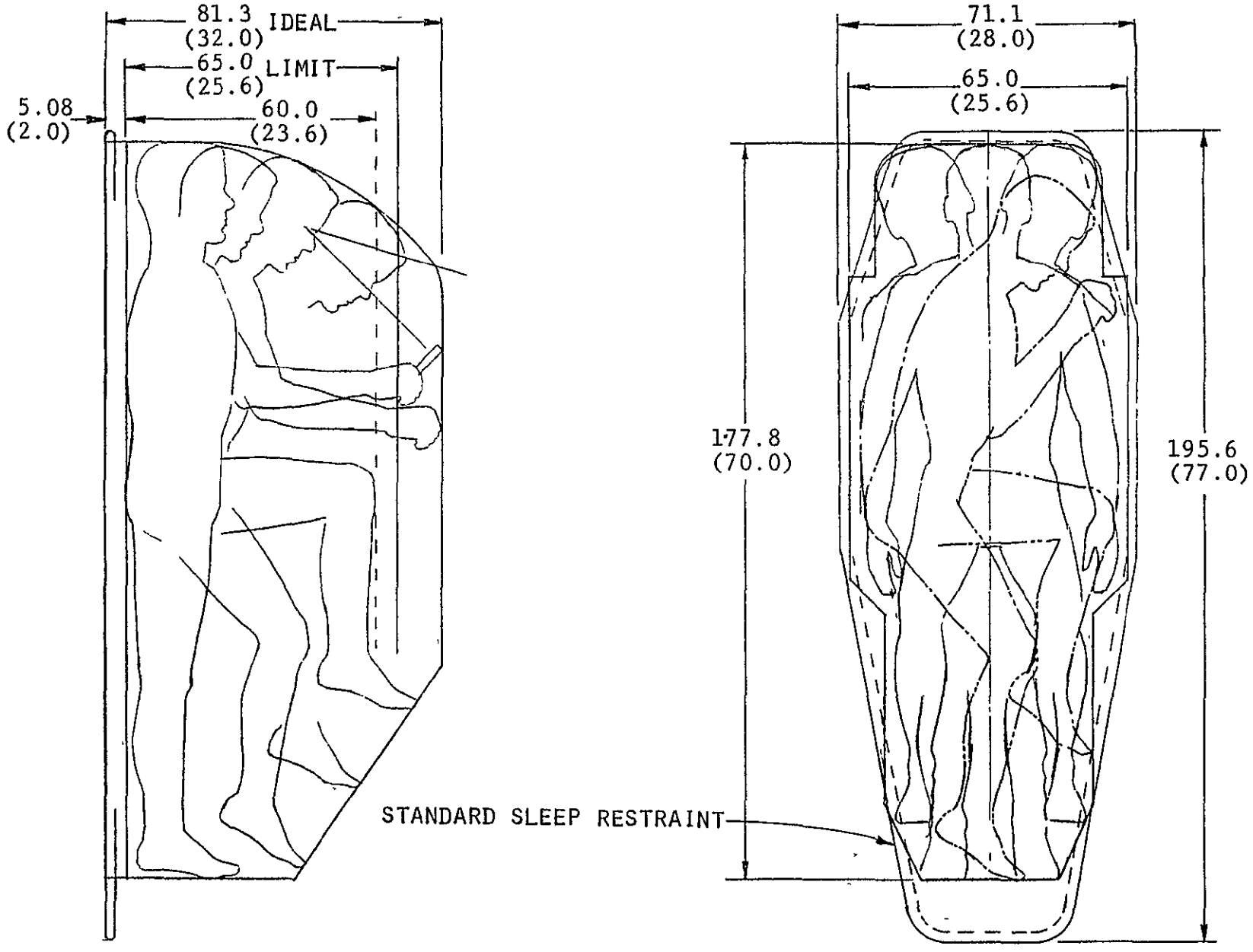


FIGURE 5 SLEEP COMPARTMENT MINIMUM ACTIVITY ENVELOPE FOR 42ND PERCENTILE MALE

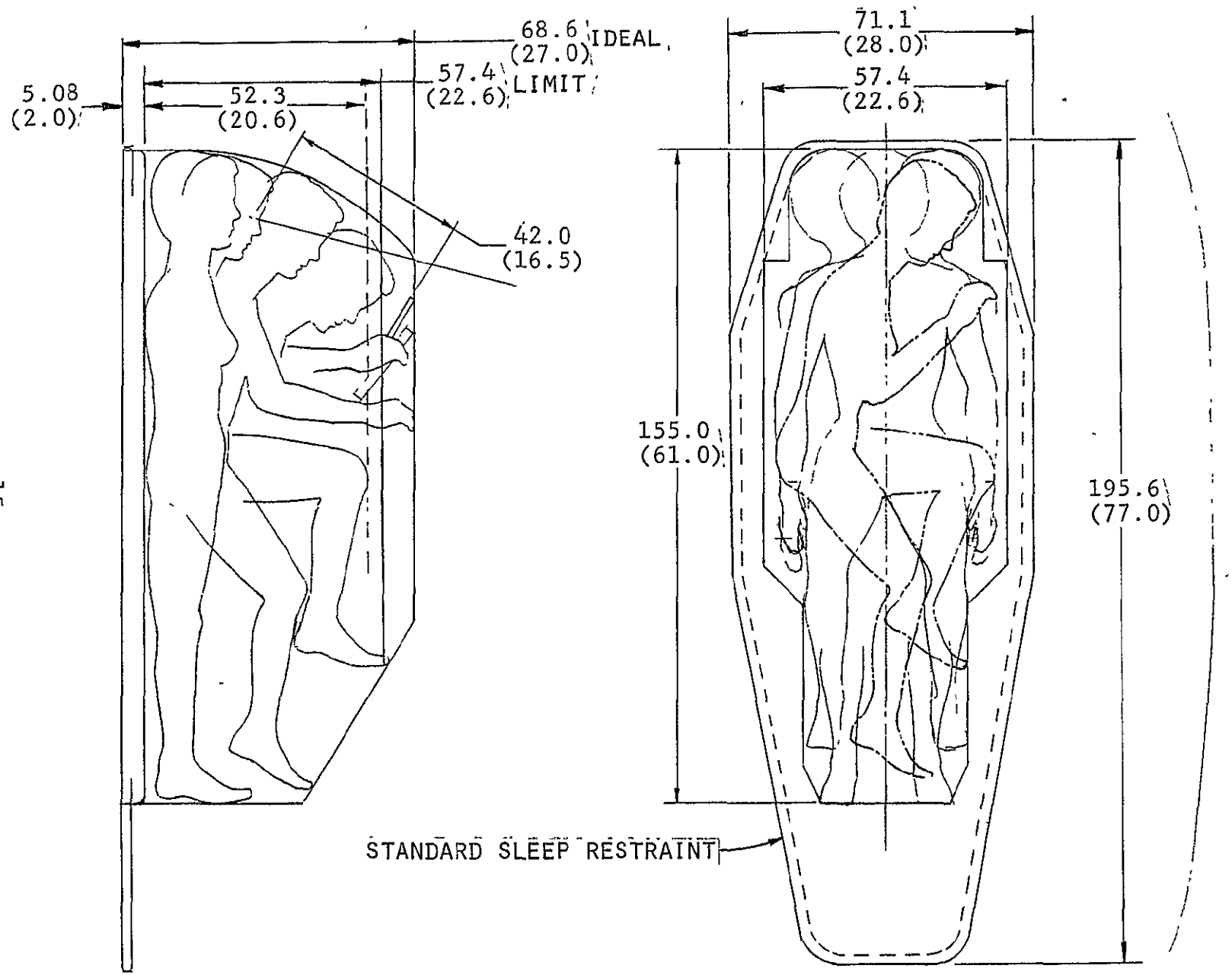


FIGURE 6 SLEEP COMPARTMENT MINIMUM ACTIVITY ENVELOPE FOR 5TH PERCENTILE FEMALE

Utilizing the neutral zero-g body posture for the largest and smallest size crew members, Figures 7 through 10 were generated to define the height and clearance requirements for crew positions at an eating/work table having a conventional horizontal orientation with respect to the floor. Figures 11 and 12 present the table surface location requirements for a tilted orientation.

Figures 13, 14, and 15 for a 95th percentile male and Figures 16 and 17 for a 5th percentile female were developed to determine activity envelope dimensions based on personal hygiene activities as defined in Table I. For waste management compartment use, Figures 18 and 19 provide the envelope dimensions required for a conventional posture on a horizontally oriented commode seat. Figure 20 presents the envelope dimensional aspects of a tilted commode seat. Figures 21 and 22 were included to define the envelope dimensions required for male crew member use of the urinal from standing positions.

Reach envelopes for the 95th percentile male and the 5th percentile female are presented in Figures 23 through 26.

2.3 Orbiter Mission and Crew Compliment - The Shuttle Orbiter is launched into an earth orbit to perform payload delivery/retrieval type missions and revisit/sortie type missions. The Orbiter normal mission duration is 7 days. However, single pass missions can be provided. In addition, mission durations of up to 30 days can be provided by use of mission extension kits. The Orbiter is manned by a normal crew compliment of 4 consisting of a Commander (CDR), a Pilot (PLT), a Mission Specialist (MS), and a Payload Specialist (PS). Total flight personnel can be increased to 7 persons for certain operational missions and to 10 persons for rescue missions. Table II presents a summary of the mission and crew compliment information.

2.4 Mid-Deck Baseline Identification - The Mid-Deck baseline accommodations and architectural arrangement utilized by this study are summarized in Table III. Figures 27 through 31 provide views of the Mid-Deck baseline as interpreted from the data packages provided at the start of the program. The Mid-Deck area serves as the crew living quarters and is located beneath the flight/payload operations compartment, referred to as the Flight Deck, in the forward end of the Orbiter vehicle. The habitable volume of the Mid-Deck is enclosed by the side wall portions of the vehicle forward conic section. A smooth, translucent ceiling and a smooth, metal floor are provided. Two interdeck access hatches are located in the Mid-Deck ceiling. A forward wall separates an avionic equipment compartment from

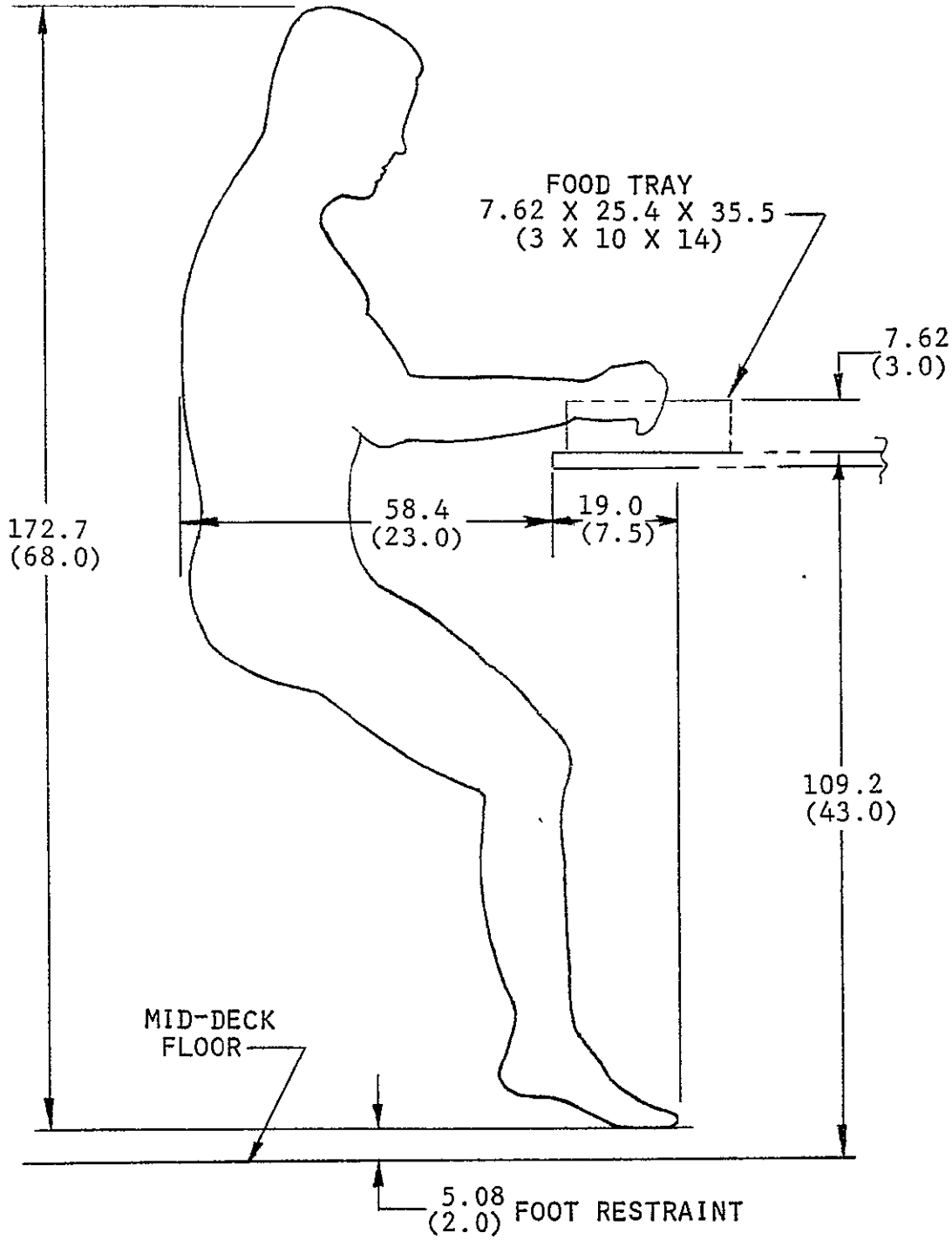


FIGURE 7 95TH PERCENTILE MALE NEUTRAL ZERO-G BODY POSTURE AT HORIZONTAL TABLE -.SIDE VIEW

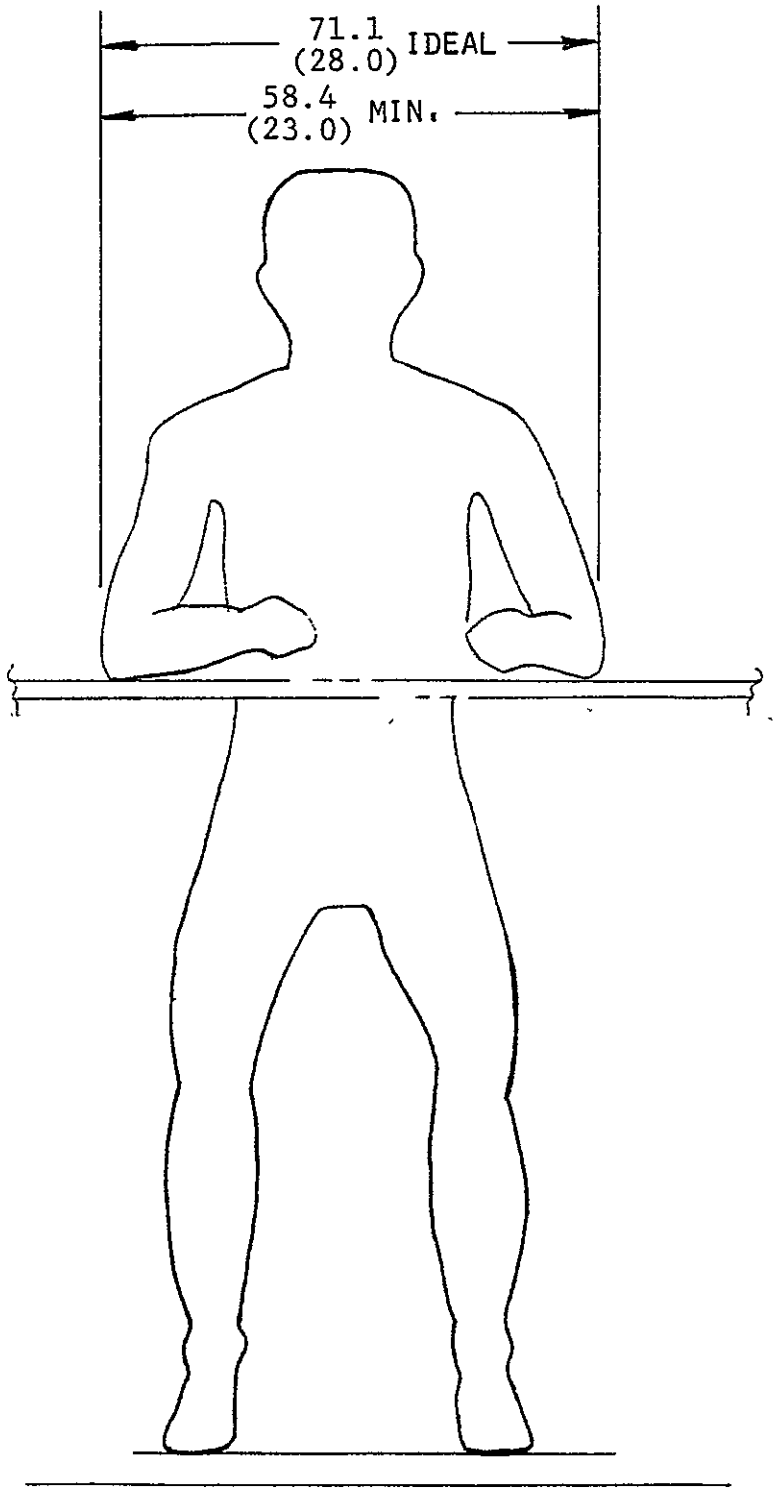


FIGURE 8 95TH PERCENTILE MALE NEUTRAL ZERO-G BODY POSTURE AT HORIZONTAL TABLE - FRONT VIEW

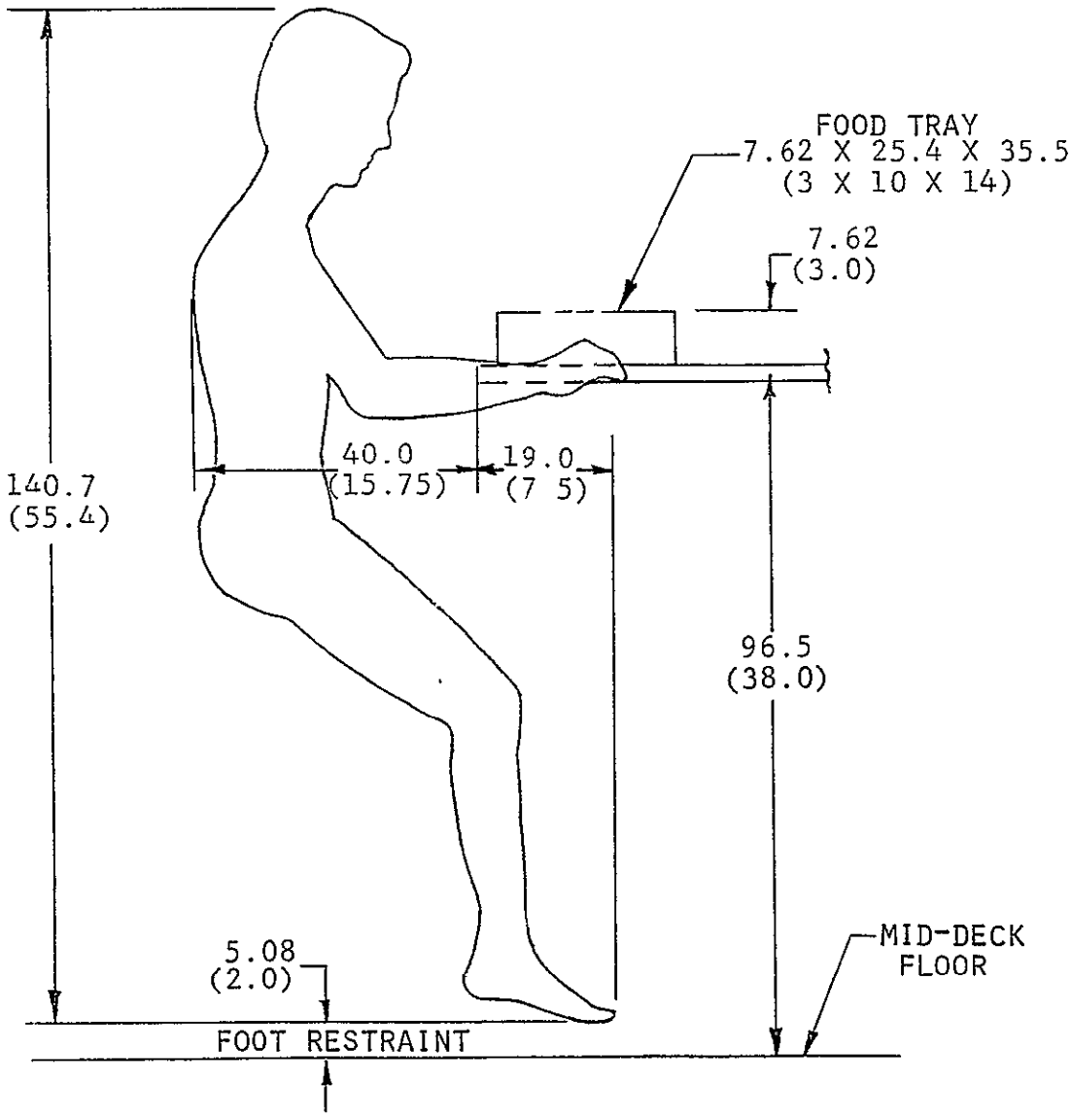


FIGURE 9 5TH PERCENTILE FEMALE NEUTRAL ZERO-G BODY POSTURE AT HORIZONTAL TABLE - SIDE VIEW

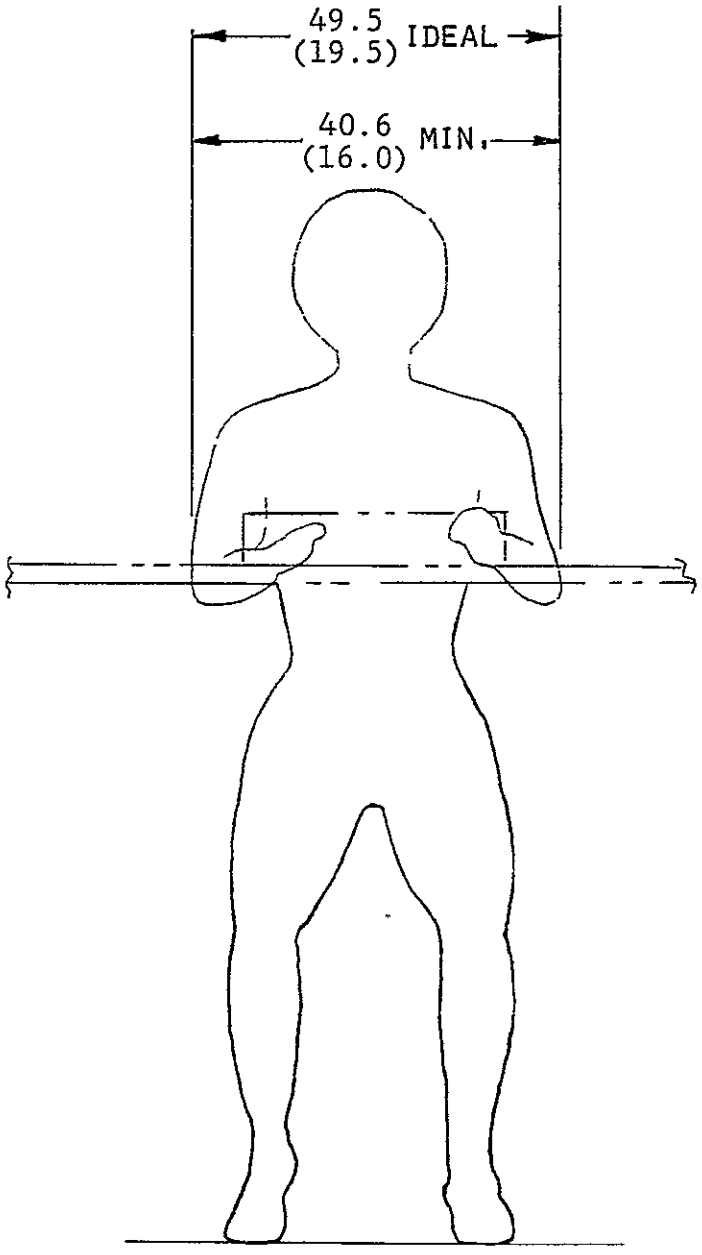


FIGURE 10 5TH PERCENTILE FEMALE NEUTRAL ZERO-G BODY POSTURE AT HORIZONTAL TABLE - FRONT VIEW

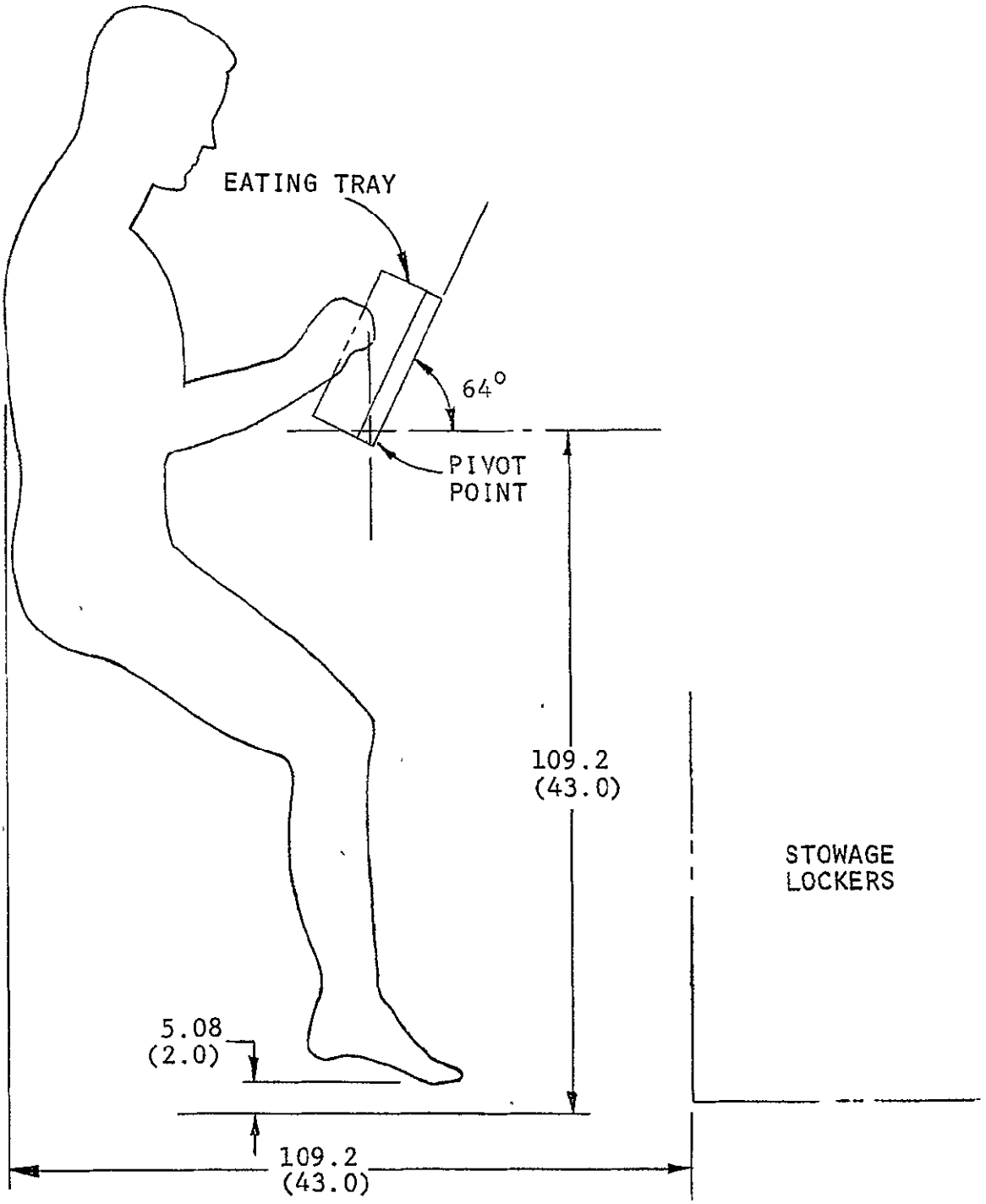


FIGURE 11 95TH PERCENTILE MALE NEUTRAL ZERO-G BODY POSTURE AT TILTED TABLE

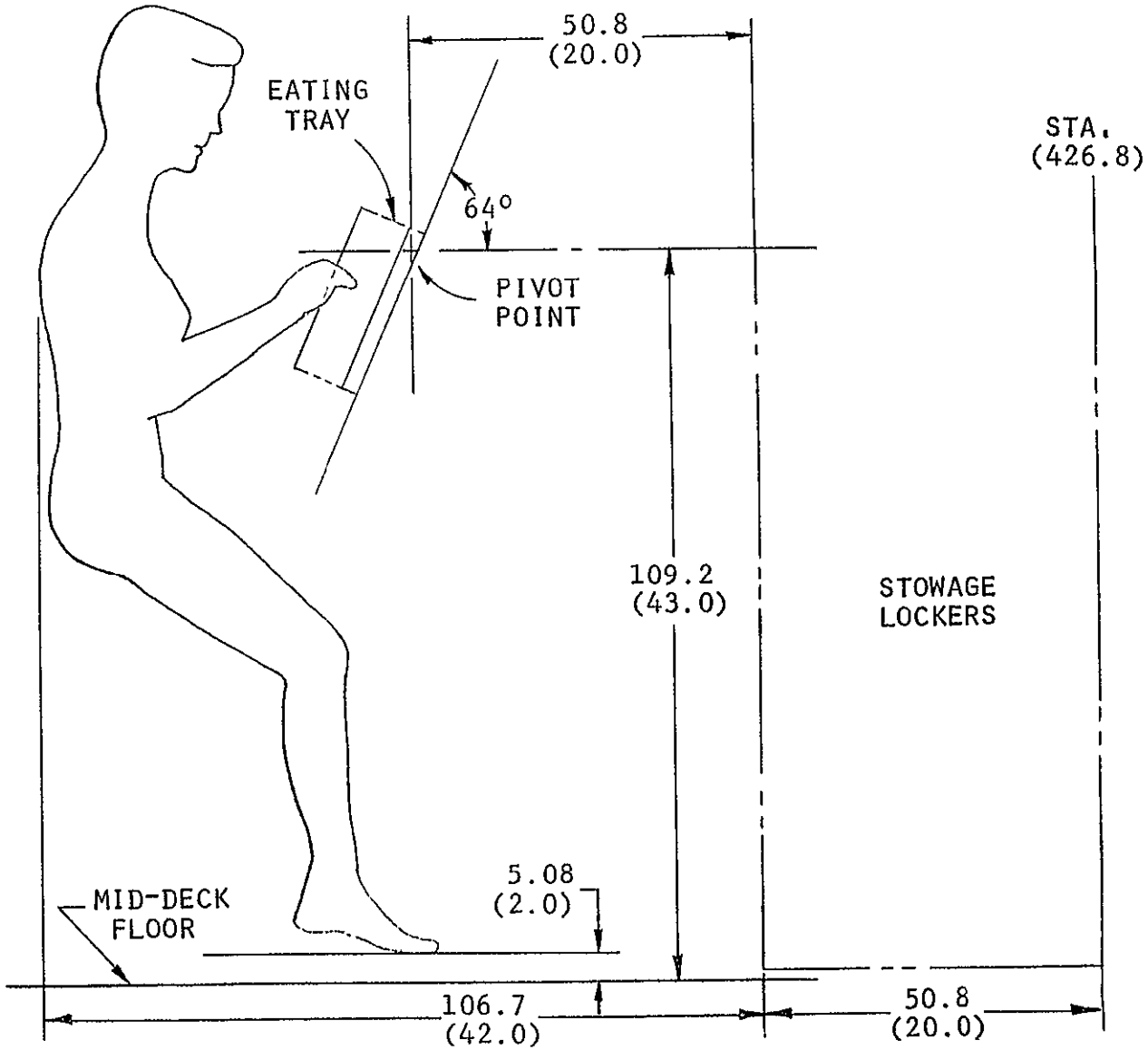


FIGURE 12 5TH PERCENTILE FEMALE NEUTRAL ZERO-G BODY POSTURE AT TILTED TABLE

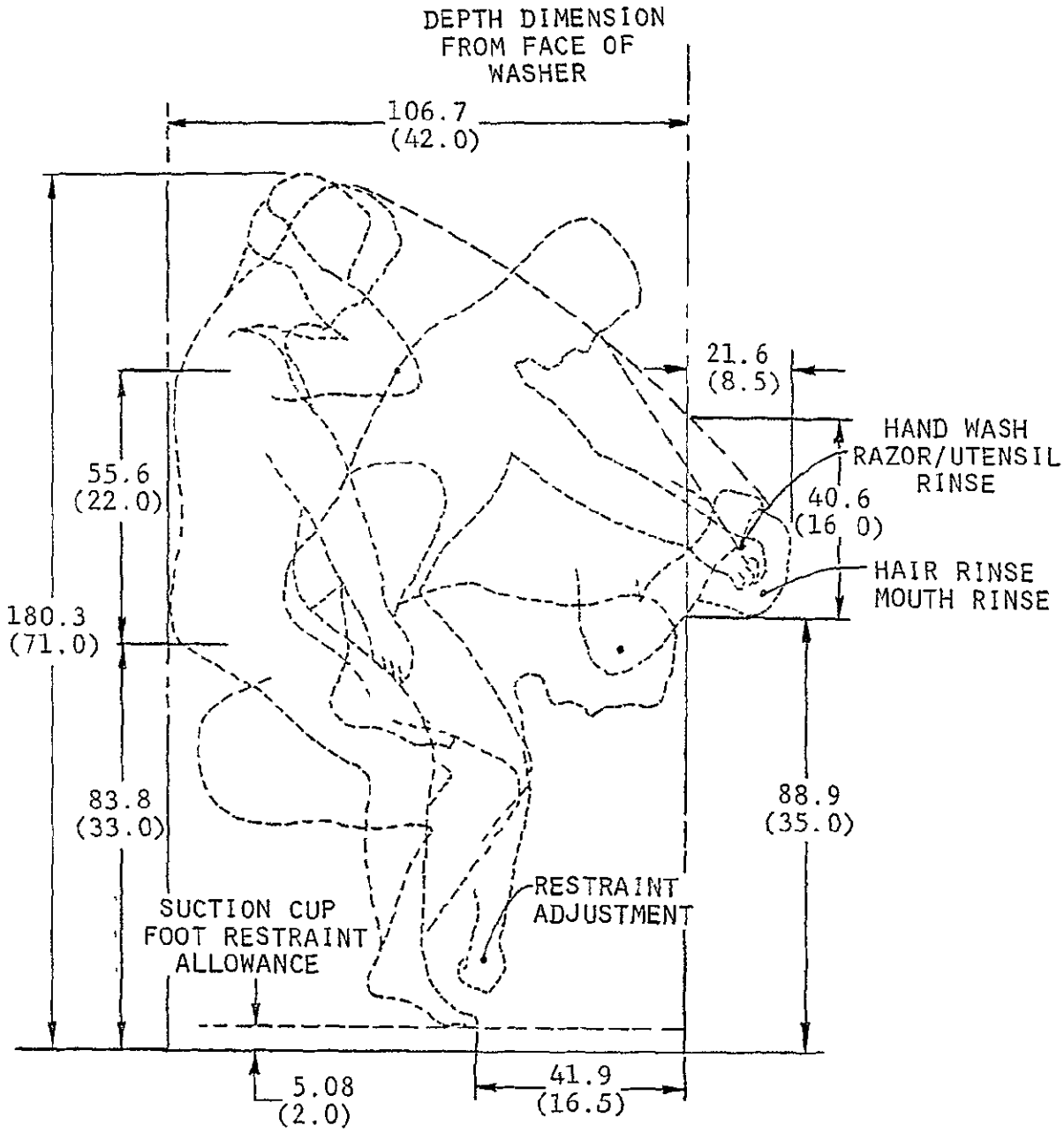


FIGURE 13 95TH PERCENTILE MALE ACTIVITY ENVELOPE FOR PERSONAL HYGIENE (SIDE VIEW)

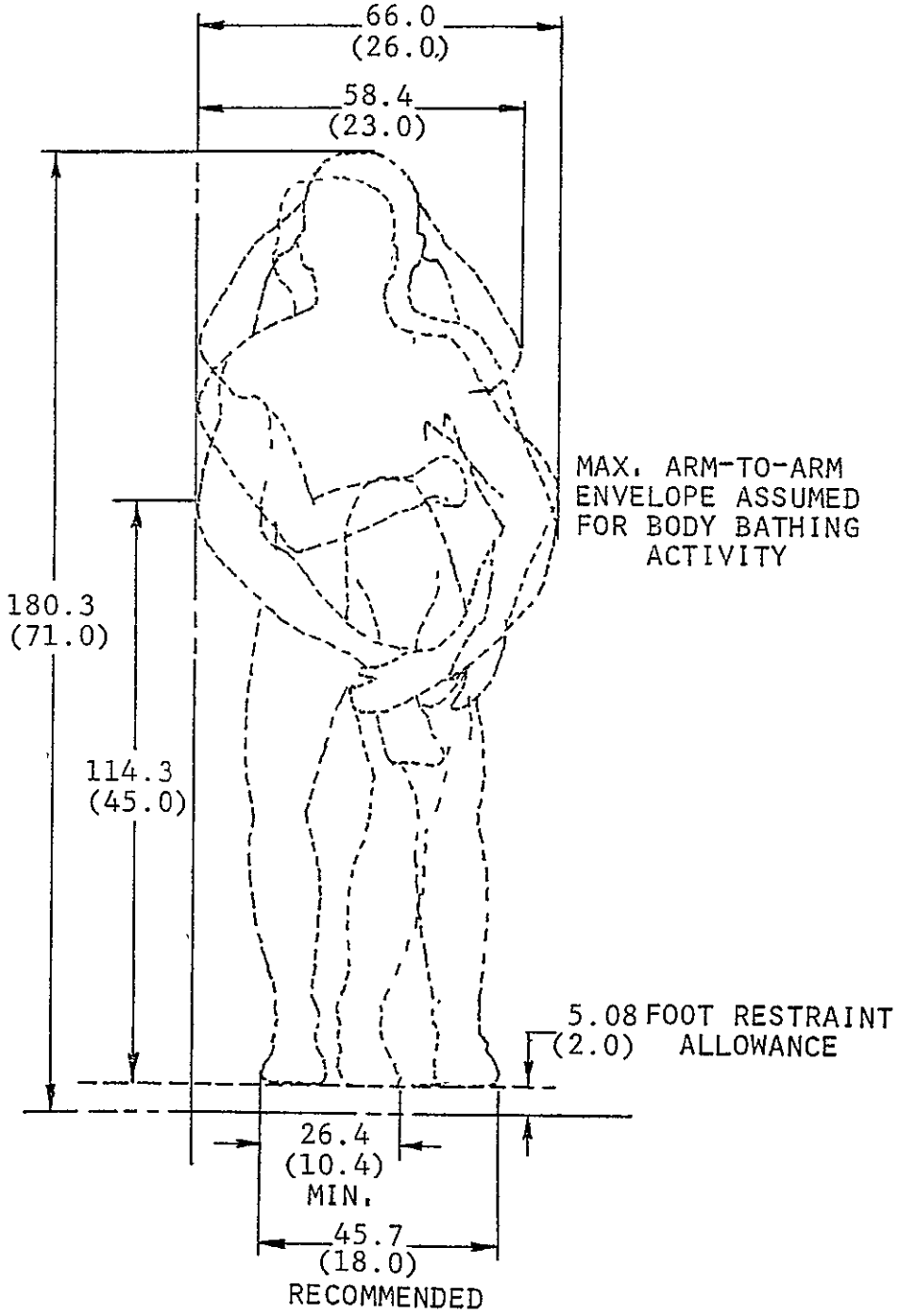


FIGURE 14 95TH PERCENTILE MALE ACTIVITY ENVELOPE FOR PERSONAL HYGIENE (FRONT VIEW)

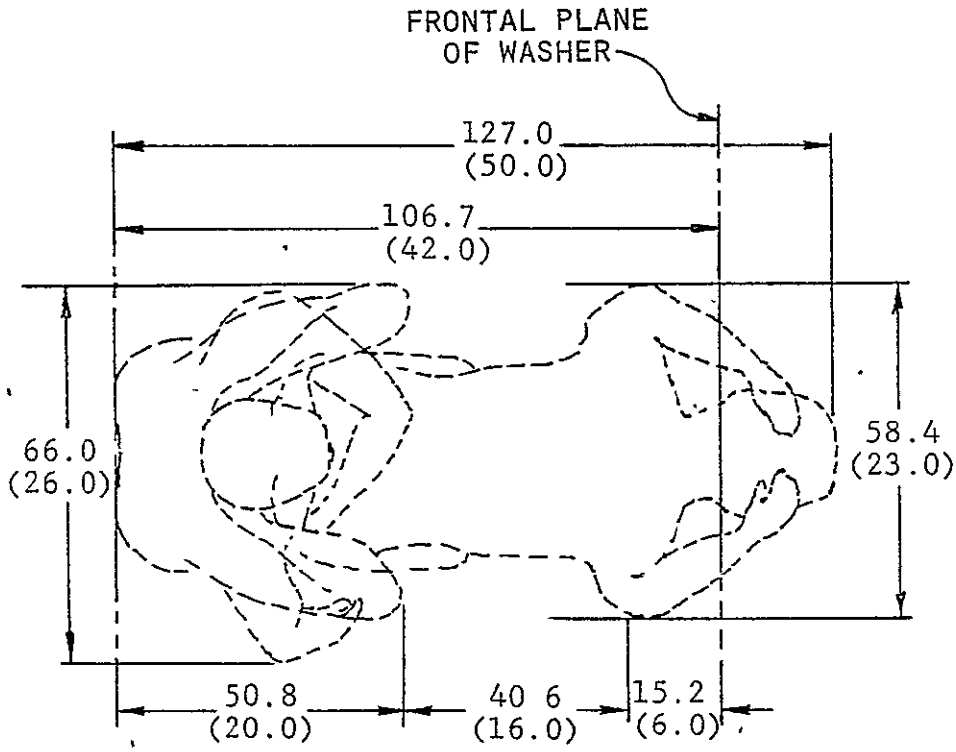


FIGURE 15 95TH PERCENTILE MALE ACTIVITY ENVELOPE FOR PERSONAL HYGIENE (TOP VIEW)

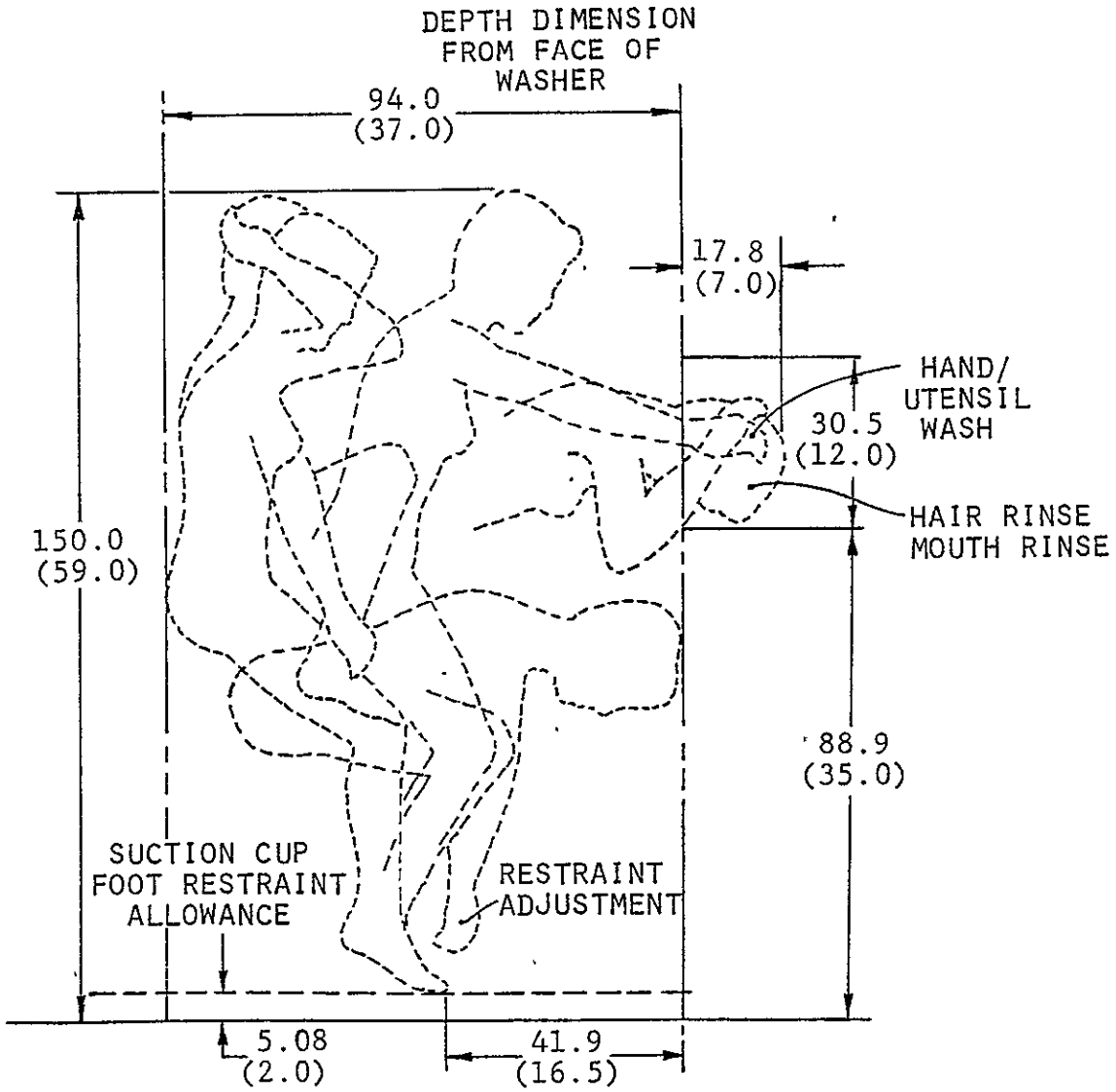


FIGURE 16 5TH PERCENTILE FEMALE ACTIVITY ENVELOPE FOR PERSONAL HYGIENE (SIDE VIEW)

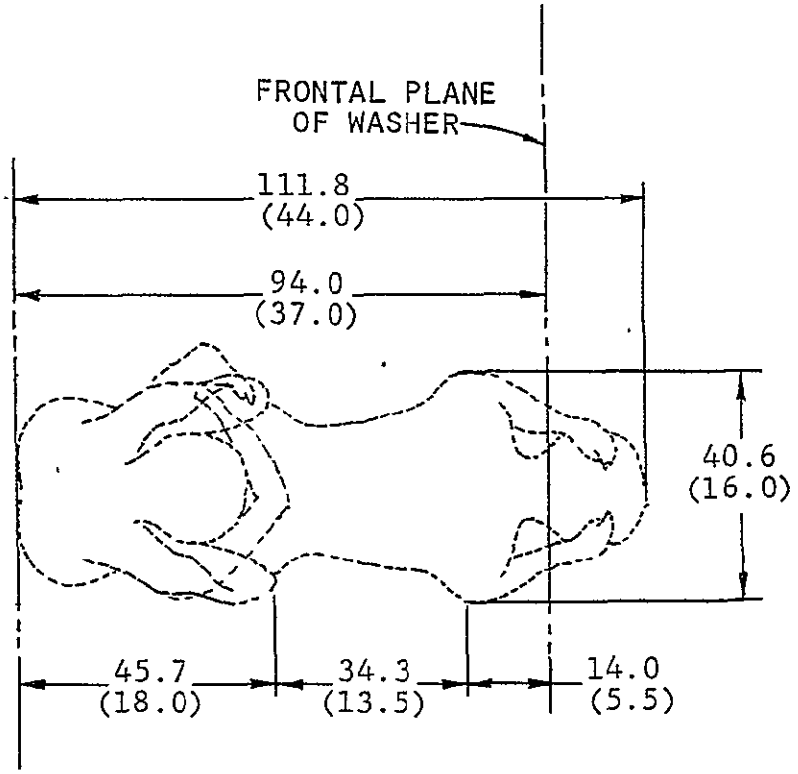


FIGURE 17 5TH PERCENTILE FEMALE ACTIVITY ENVELOPE FOR PERSONAL HYGIENE (TOP VIEW)

TABLE I

PERSONAL HYGIENE STATION ACTIVITY DEFINITIONS

ACTIVITY	DEFINITION
Hand Wash (Also Utensil Wash)	Crew member stands in a weightless neutral body posture wearing suction cup shoes while using washer on aft side of galley.
Body Wash	Crew member enters area, doffs clothes and shoes. Positions self in front of washer on aft side of galley. Places bare foot or feet in or under a foot restraint (light duty type but not like Skylab). Washes various parts of body which requires raising one arm at a time, raising one leg at a time, spreading one leg at a time, bending down, full stature, weightless neutral body posture (in other words body movements to allow washing all over with a washcloth in a confined area).
Shaving and Razor Cleaning	Crew member position in front of washer using either suction cup foot restraint or barefoot restraint. Looks in mirror while shaving. Rinses razor in washer.
Washing/Wetting of Hair	Crew member position in front of washer using either suction cup foot restraint or barefoot restraint. Bends to get head at washer for wetting or rinsing. Weightless posture using both arms up with hands on head for scrubbing hair.
Brushing Teeth (Also Mouth Rinse)	Crew member position in front of washer using either suction cup foot restraint or barefoot restraint. Bends to rinse mouth at washer after brushing teeth.

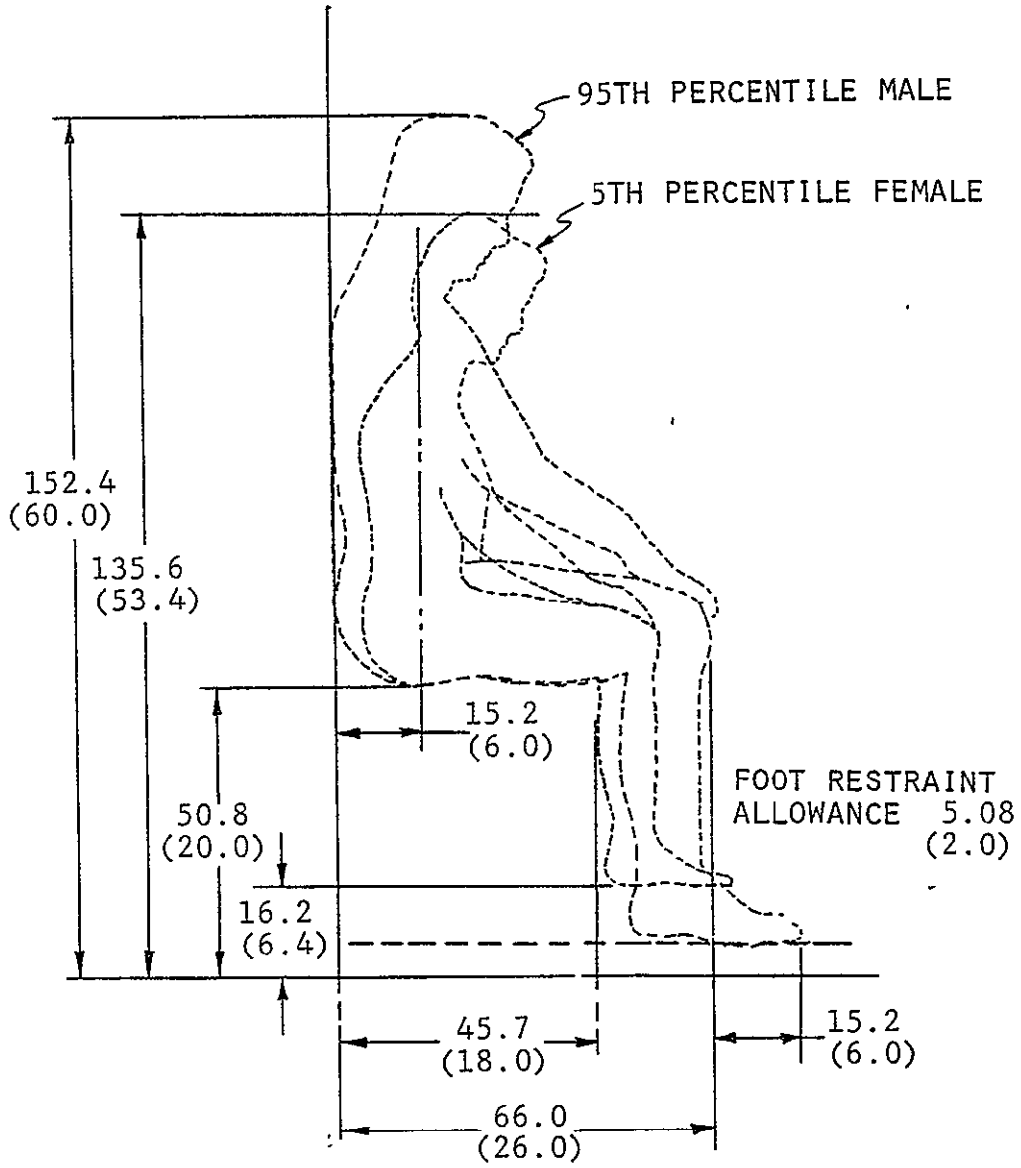


FIGURE 18 5TH PERCENTILE FEMALE/95TH PERCENTILE MALE CONVENTIONAL SEATED ENVELOPE FOR WMC (SIDE VIEW)

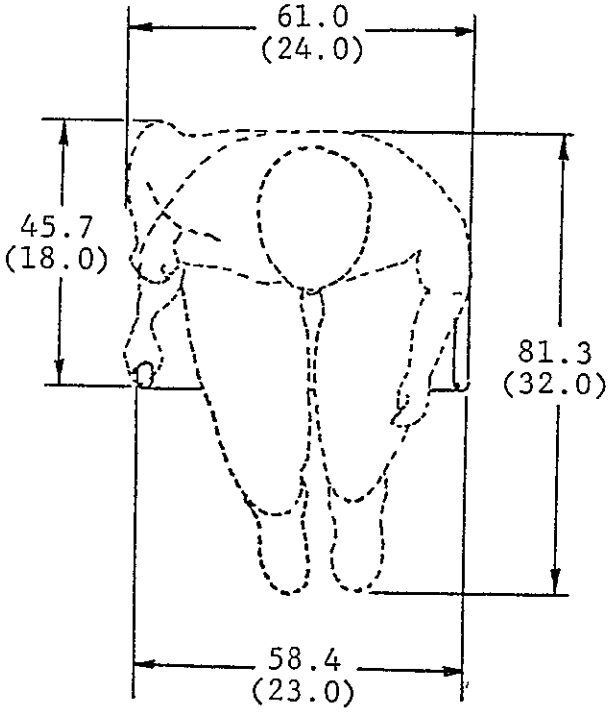


FIGURE 19 95TH PERCENTILE MALE CONVENTIONAL SEATED ENVELOPE FOR WMC (TOP VIEW)

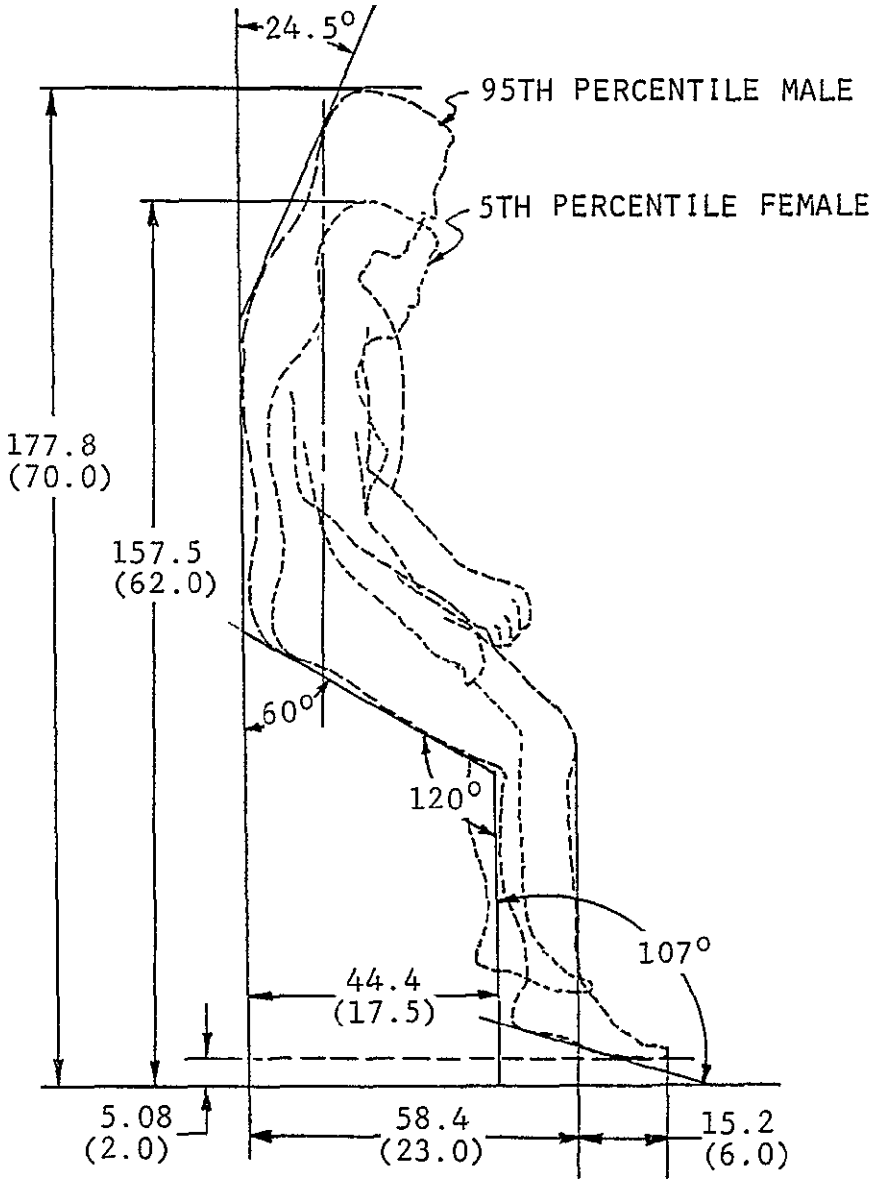


FIGURE 20 5TH PERCENTILE FEMALE/95TH PERCENTILE MALE WEIGHTLESS SEATED POSTURE ENVELOPE FOR WMC

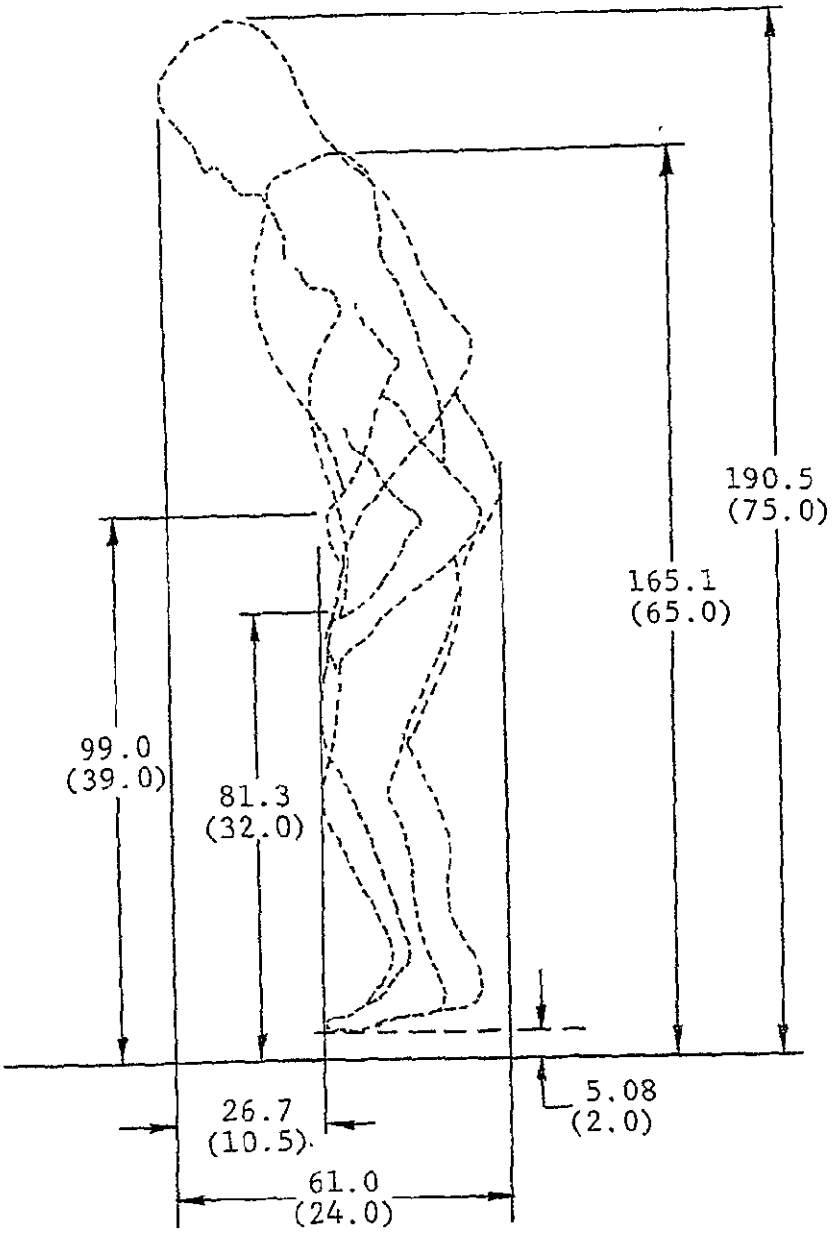


FIGURE 21 5TH PERCENTILE MALE/95TH PERCENTILE MALE STANDING POSITION FOR URINAL USE - LEANING FORWARD (SIDE VIEW)

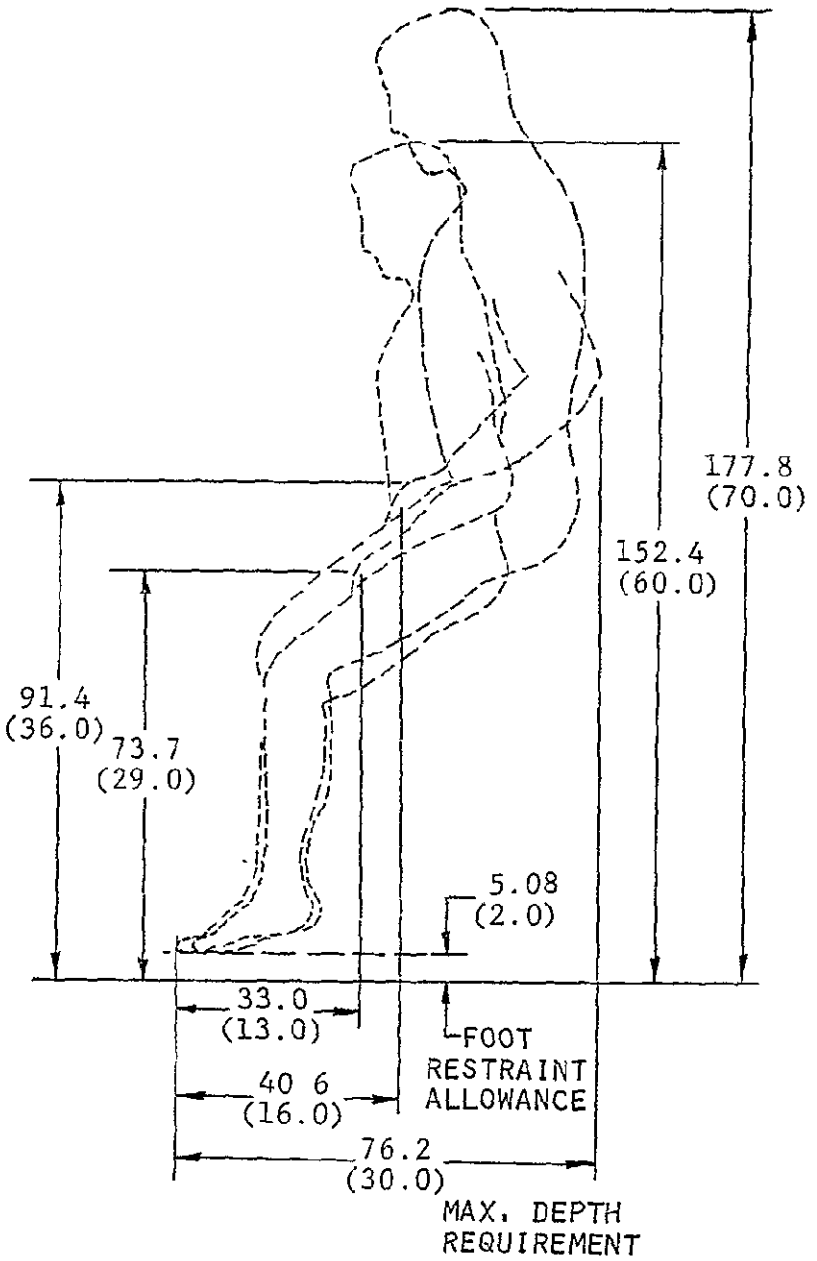


FIGURE 22 5TH PERCENTILE MALE/95TH PERCENTILE MALE STANDING POSITION FOR URINAL USE - NEUTRAL BODY POSTURE (SIDE VIEW)

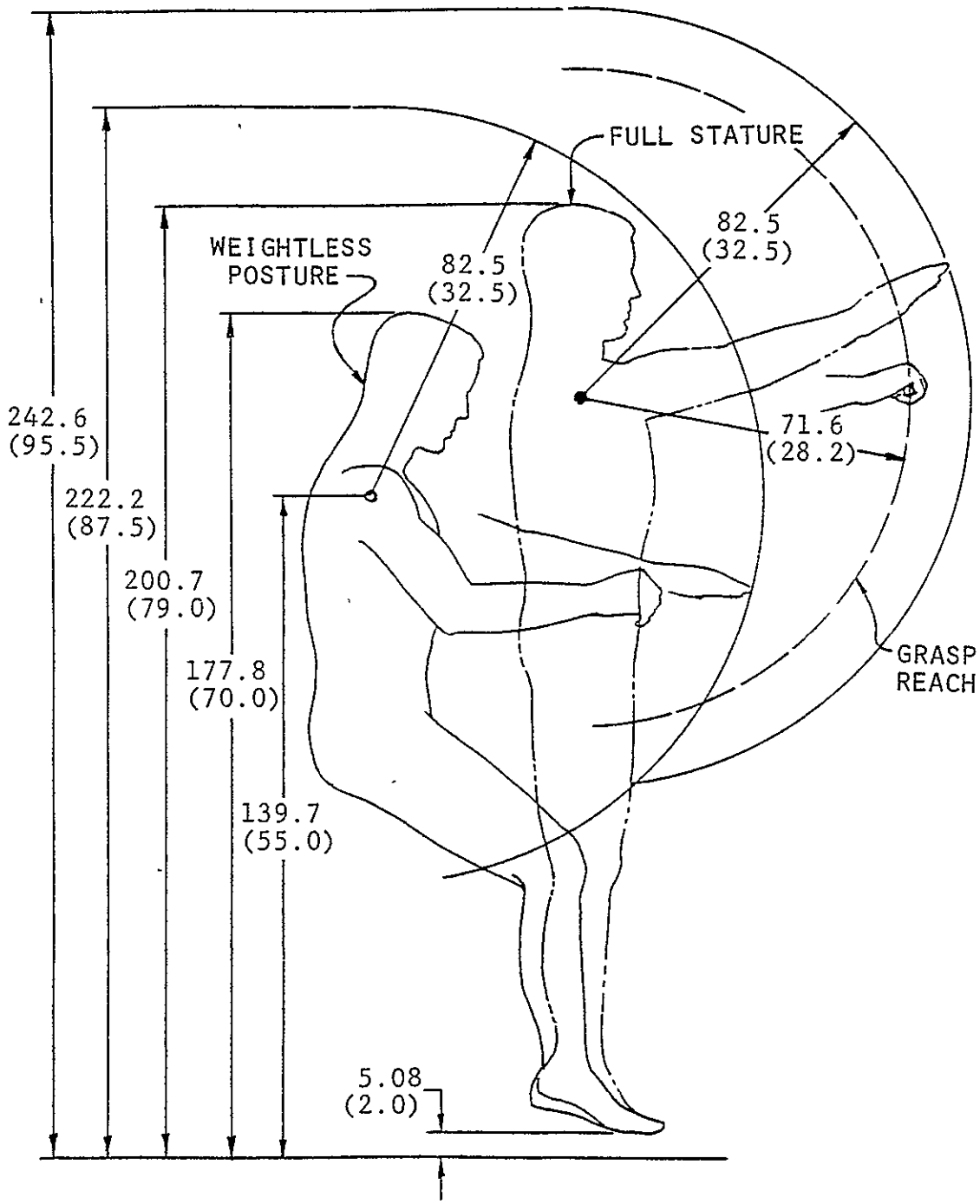


FIGURE 23 REACH ENVELOPE - 95TH PERCENTILE MALE - SIDE VIEW

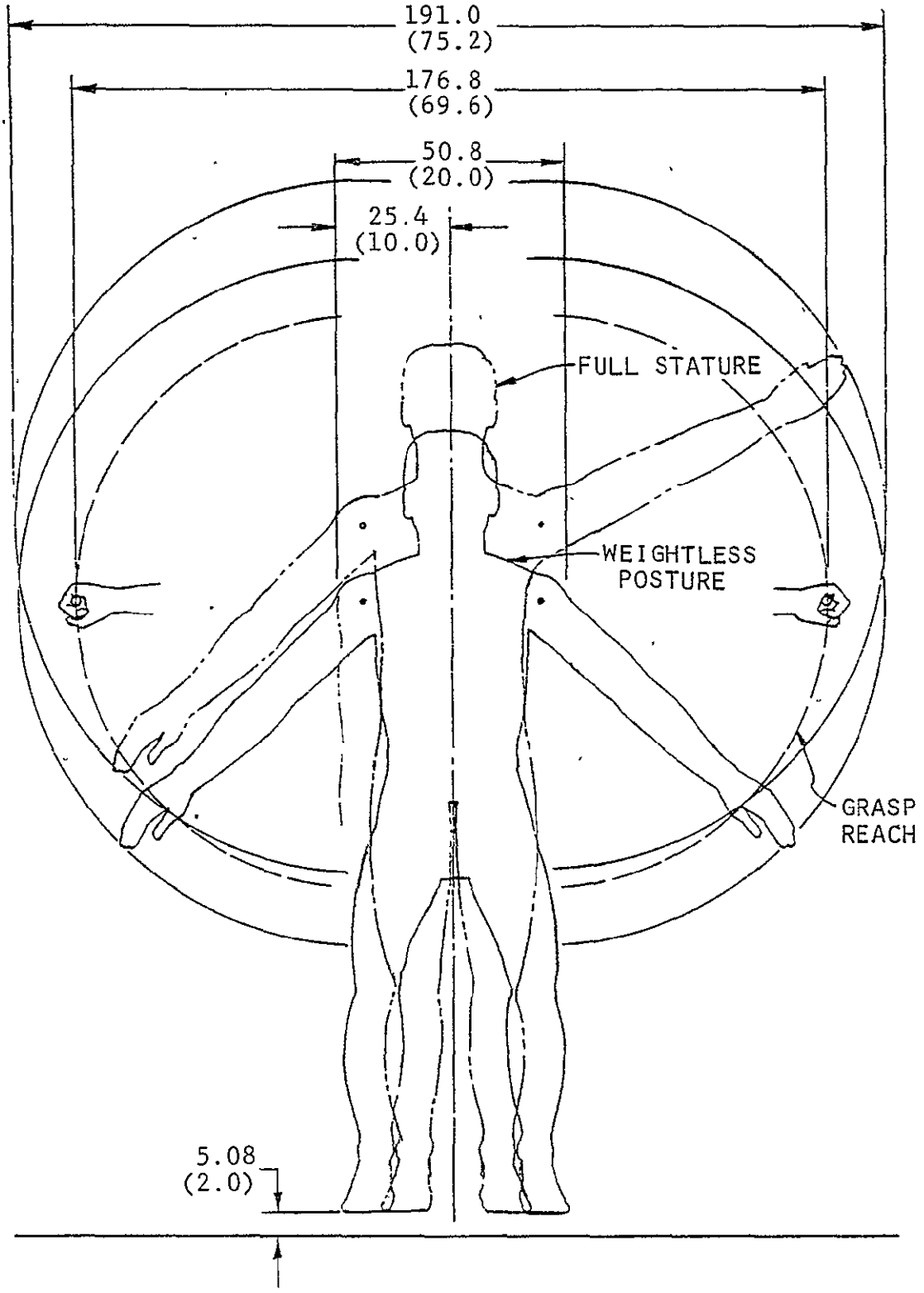


FIGURE 24 REACH ENVELOPE - 95TH PERCENTILE MALE - FRONT VIEW

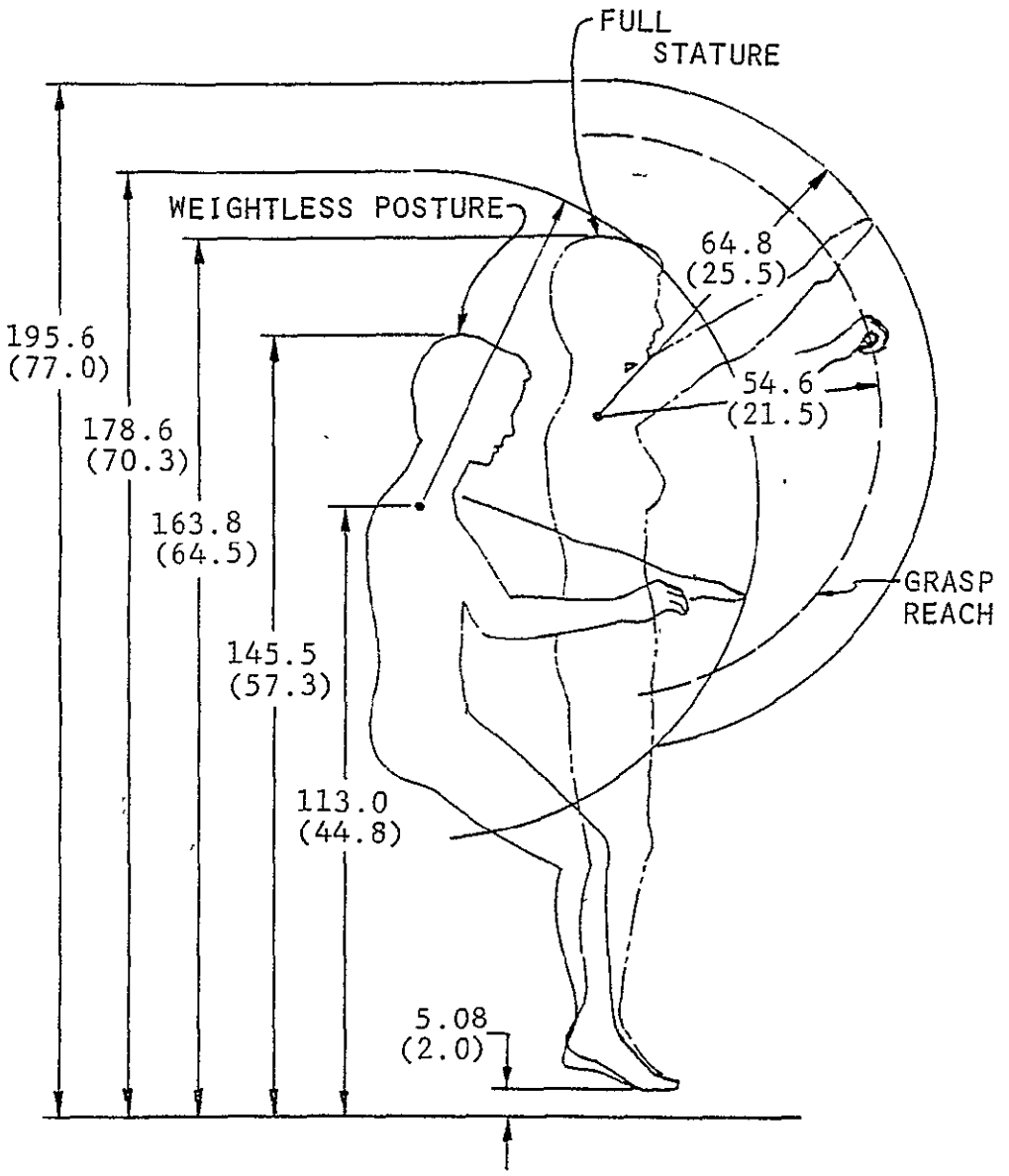


FIGURE 25 REACH ENVELOPE - 5TH PERCENTILE FEMALE - SIDE VIEW

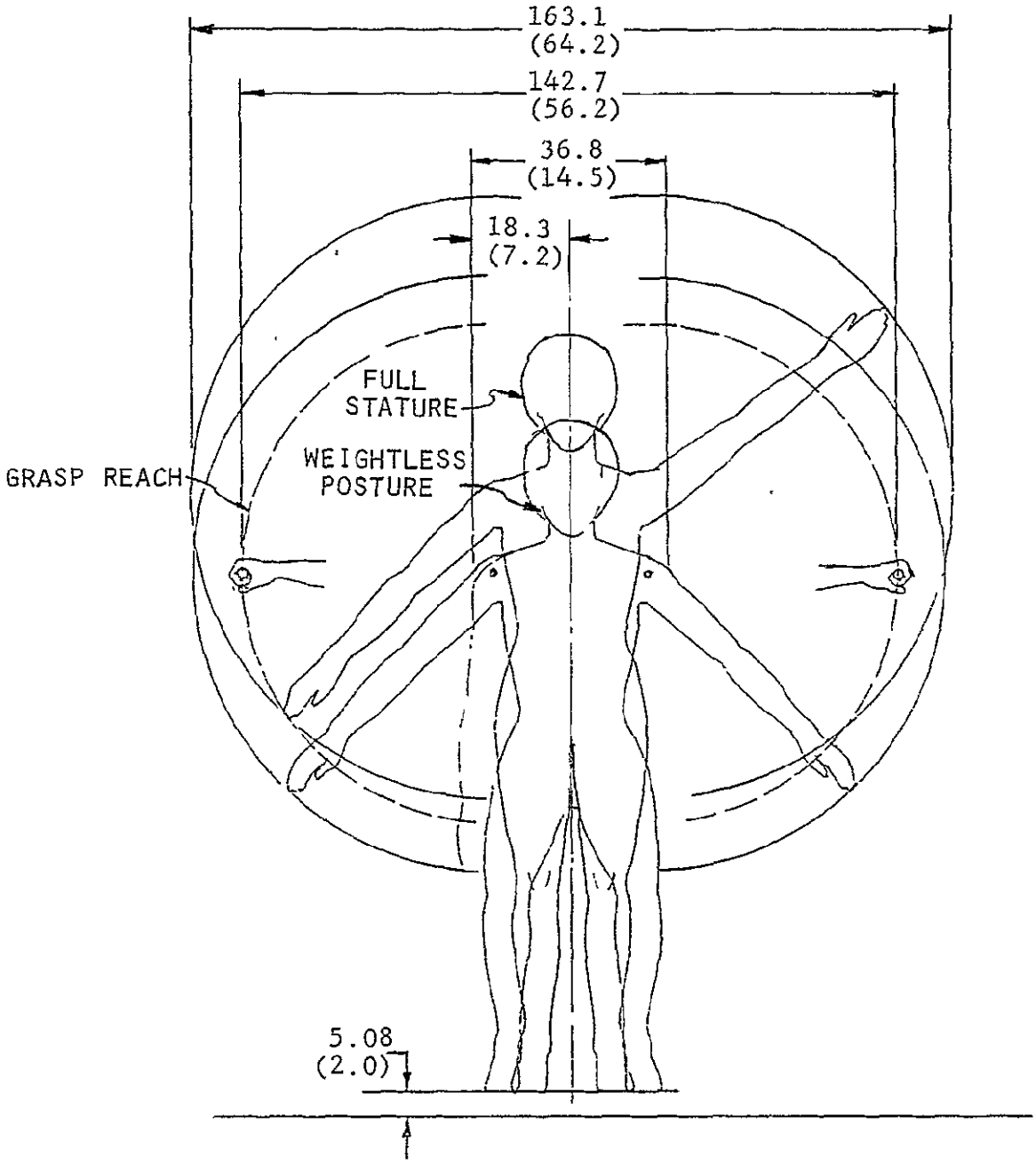


FIGURE 26 REACH ENVELOPE - 5TH PERCENTILE FEMALE - FRONT VIEW

TABLE II

SHUTTLE ORBITER MISSIONS AND CREW COMPLIMENT

A. REFERENCE MISSIONS

MISSION	PURPOSE	BASIC NOMINAL CREW	PASSENGERS	TOTAL CREW PERSONNEL	MAN-DAY PROVISIONS	DURATION (DAYS)
Mission 1	For payload delivery to orbit	4	0	4	28	7
Mission 2	For revisit and sortie missions	4	2 (nominal)	6	42	7
			3 (max)	7	42	6
Mission 3a	For payload delivery to orbit	4	0	4		Within single revolution
Mission 3a	For payload retrieval from orbit	4	0	4		Within single revolution

B. ADDITIONAL MISSION REQUIREMENTS

30-day mission	(Undefined)	4	3 (max)	7	210	30
Rescue	To recover personnel from orbit	3	7 (max)	10		Within 96 hours (4 days)

TABLE III

SHUTTLE ORBITER MID-DECK BASELINE ACCOMMODATIONS

ACCOMMODATION REQUIREMENT	PROVISIONS	COMMENTS
Food Management	A GFE galley provides food and equipment storage, food preparation center, water heating, hot and cold water dispensers.	Galley located on left side of Mid-Deck just forward of side hatch. The aft side of galley is allocated as the location for the personal hygiene washer.
Eating	A single table surface to accommodate up to four crew members at a time.	Table is hinged at the forward locker tier. It folds flat against lockers for launch and landing phases. Four modular stowage lockers are placed under table during orbit.
Waste Management	A fecal and urine collection/storage system usable by male and female personnel.	Commode seat is in conventional parallel to floor orientation.
Personal Hygiene Station	A GFE personal hygiene station consisting of a hand washer installation.	Washer is installed as part of the galley aft side. The WMC door with an extension curtain to the galley provides the privacy closeout for both the WMC and PHS use.

TABLE III (CONTINUED)

ACCOMMODATION REQUIREMENT	PROVISIONS	COMMENTS
Sleep Provisions	A maximum of four sleep stations providing support and restraint during sleep located for quiet and privacy.	Four sleep stations (3 horizontal/1 vertical) located on right side of Mid-Deck. Privacy curtains used for closeout.
Exercising Provisions	Currently undefined.	To be performed in Mid-Deck area
Recreation Provisions	Currently undefined.	To be performed in Mid-Deck area.
Passenger Seating	Seating for three passengers for nominal missions with hard points and space capability for three additional passengers for rescue mission (Total accommodation for six passenger seats).	For rescue mission, all four sleep station installations will be removed as well as the nine aft stowage lockers to provide space for the three additional passenger seats.
Seat Stowage	Seats/restraints to be removable and stowable during orbital operations.	Seat stowage area is forward of galley.
Airlock and Associated Extravehicular Activity (EVA) Equipment	An integral airlock with EVA equipment recharge station in or near the airlock.	Airlock in Mid-Deck area for some missions, otherwise it is installed aft of Mid-Deck area. Airlock hatch is hinged at lower segment and is stowed in open position just above floor in front of opening.

TABLE III (CONTINUED)

ACCOMMODATION REQUIREMENT	PROVISIONS	COMMENTS
Internal Lighting	Nine fluorescent light fixtures installed in ceiling above translucent paneling.	A light fixture is required in each of the four sleep stations.
Stowage	Removable modular stowage containers, plus under-the-floor stowage compartments and above-the-floor stowage areas.	Thirty-three stowage containers at forward wall, five stowage containers at aft wall, four movable containers under table.
Mobility/Restraint	Suction cup shoes to provide foot restraint. Handrail provided at primary interdeck hatch.	No other handrails currently identified in Mid-Deck area.

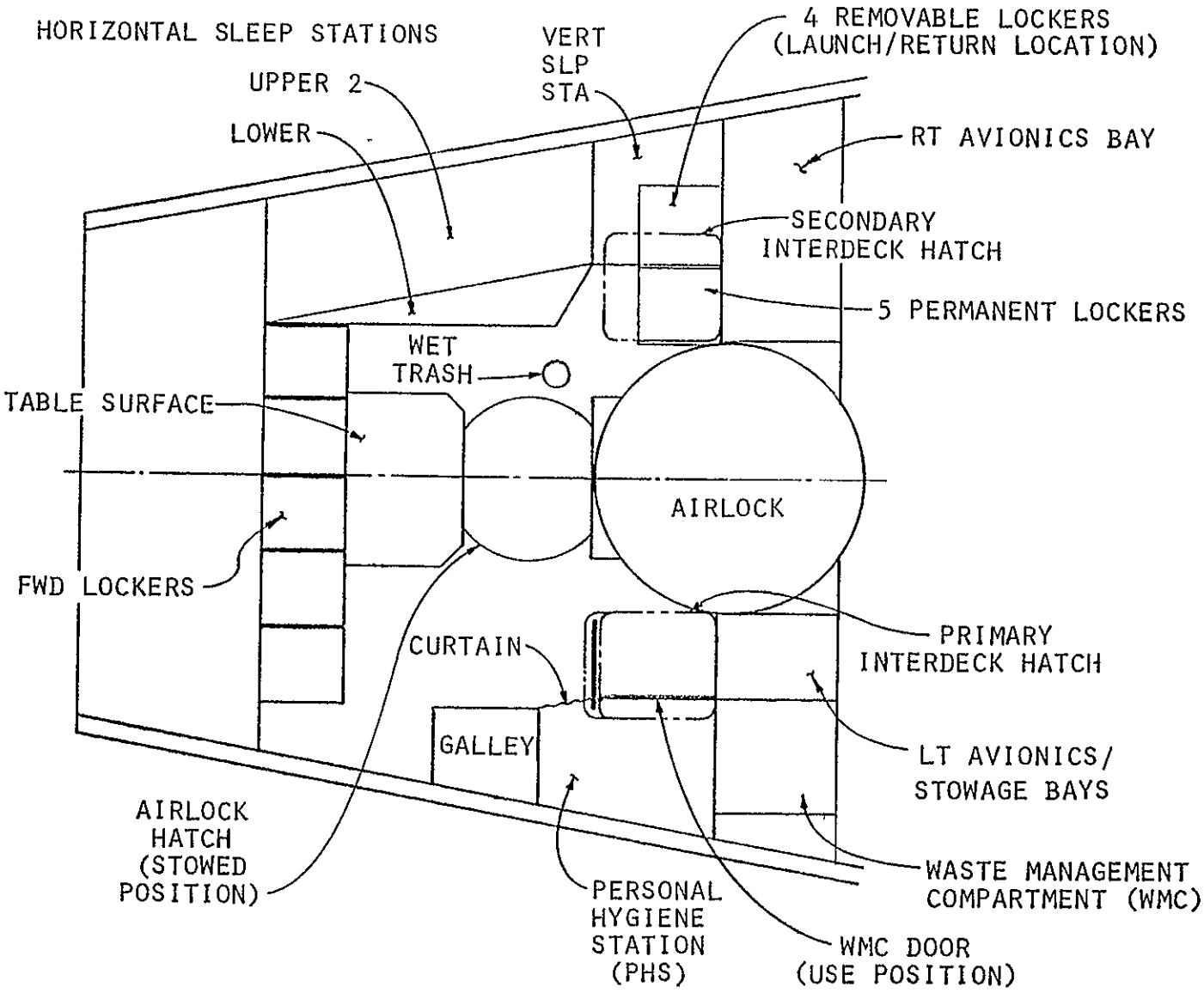


FIGURE 27 MID-DECK BASELINE ARRANGEMENT WITH AIRLOCK

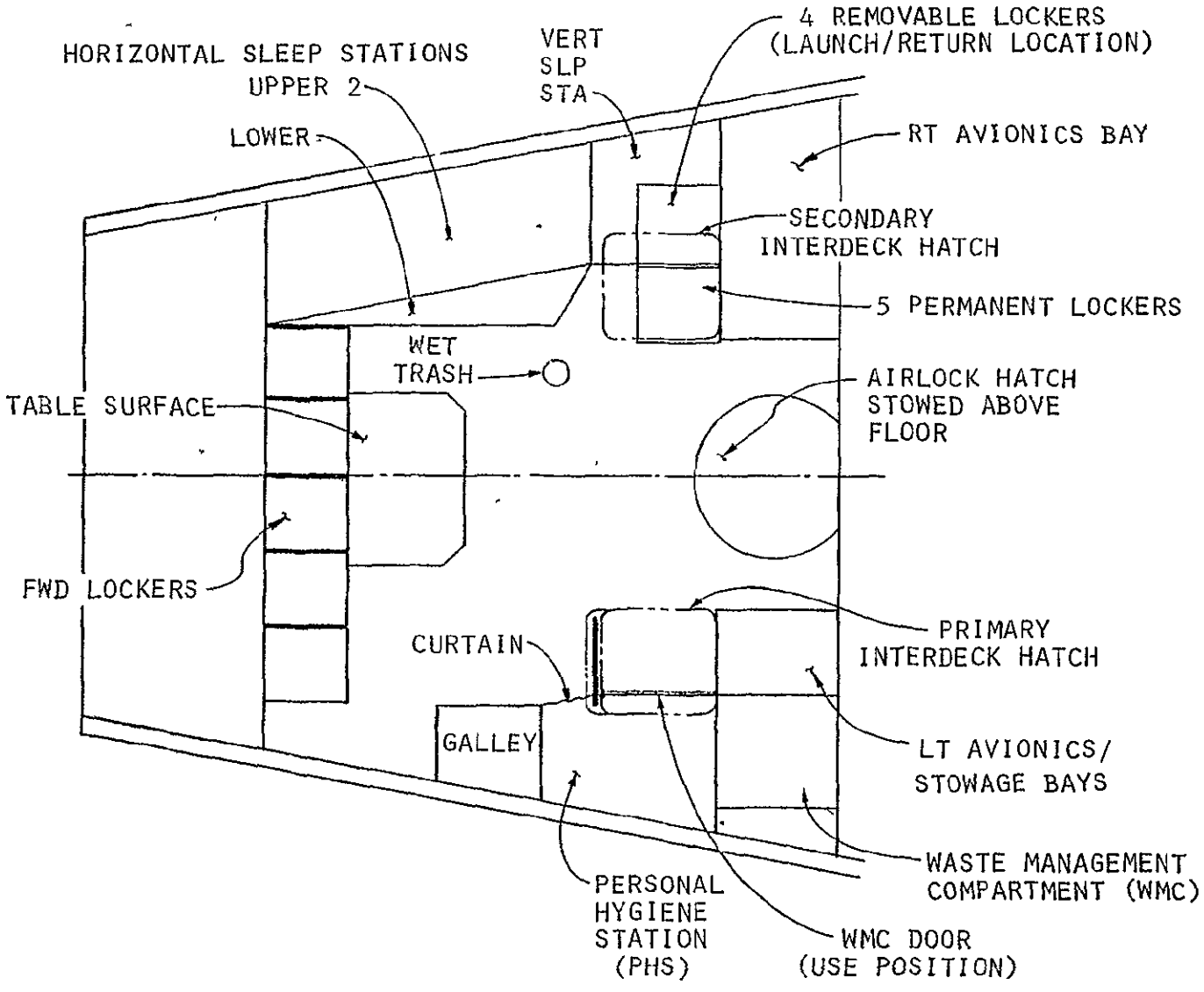


FIGURE 28 MID-DECK BASELINE ARRANGEMENT WITHOUT AIRLOCK

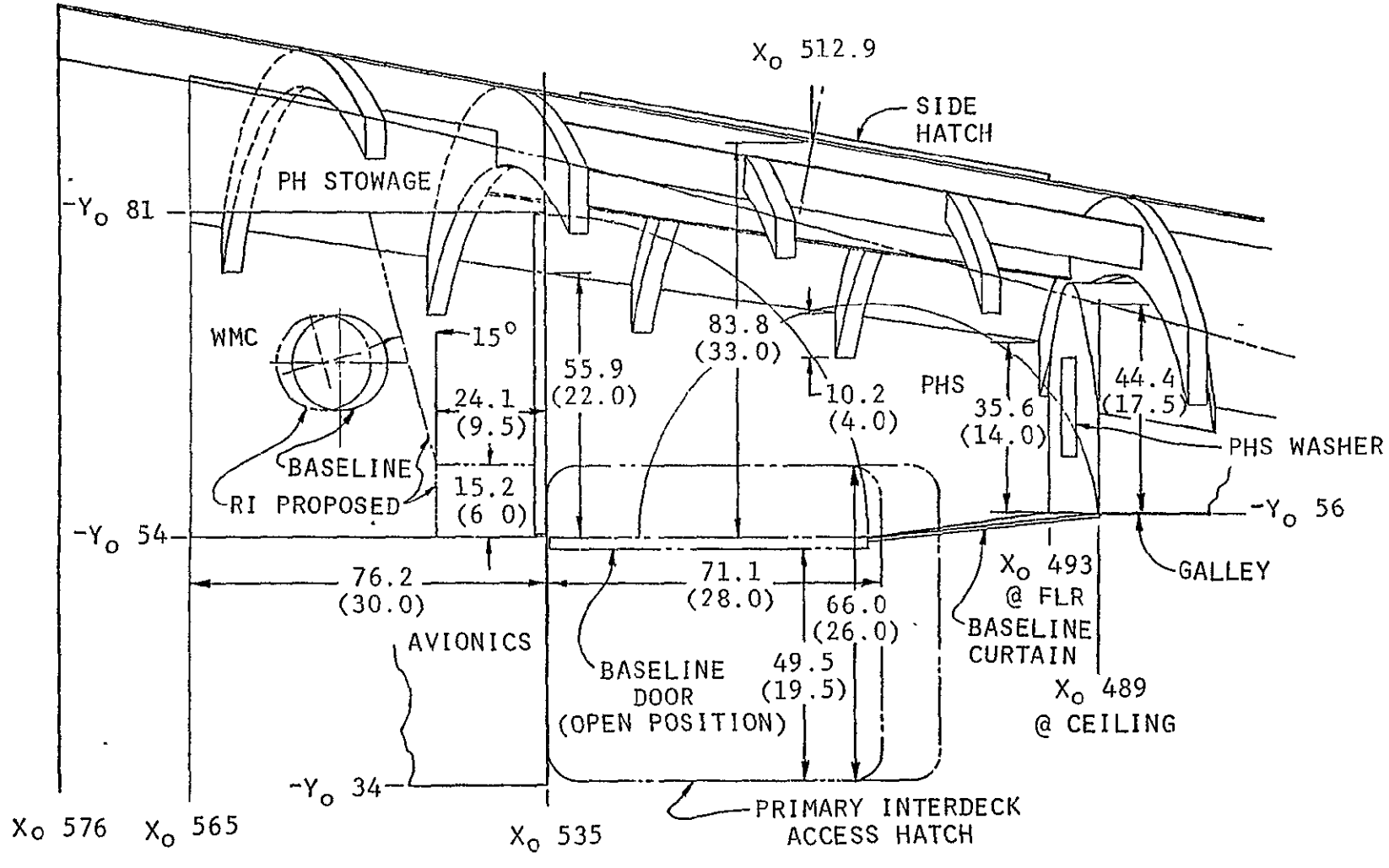


FIGURE 29 ORBITER MID-DECK LEFT SIDE AREA ALLOCATED FOR PERSONAL HYGIENE STATION AND WASTE MANAGEMENT COMPARTMENT (PLAN VIEW)

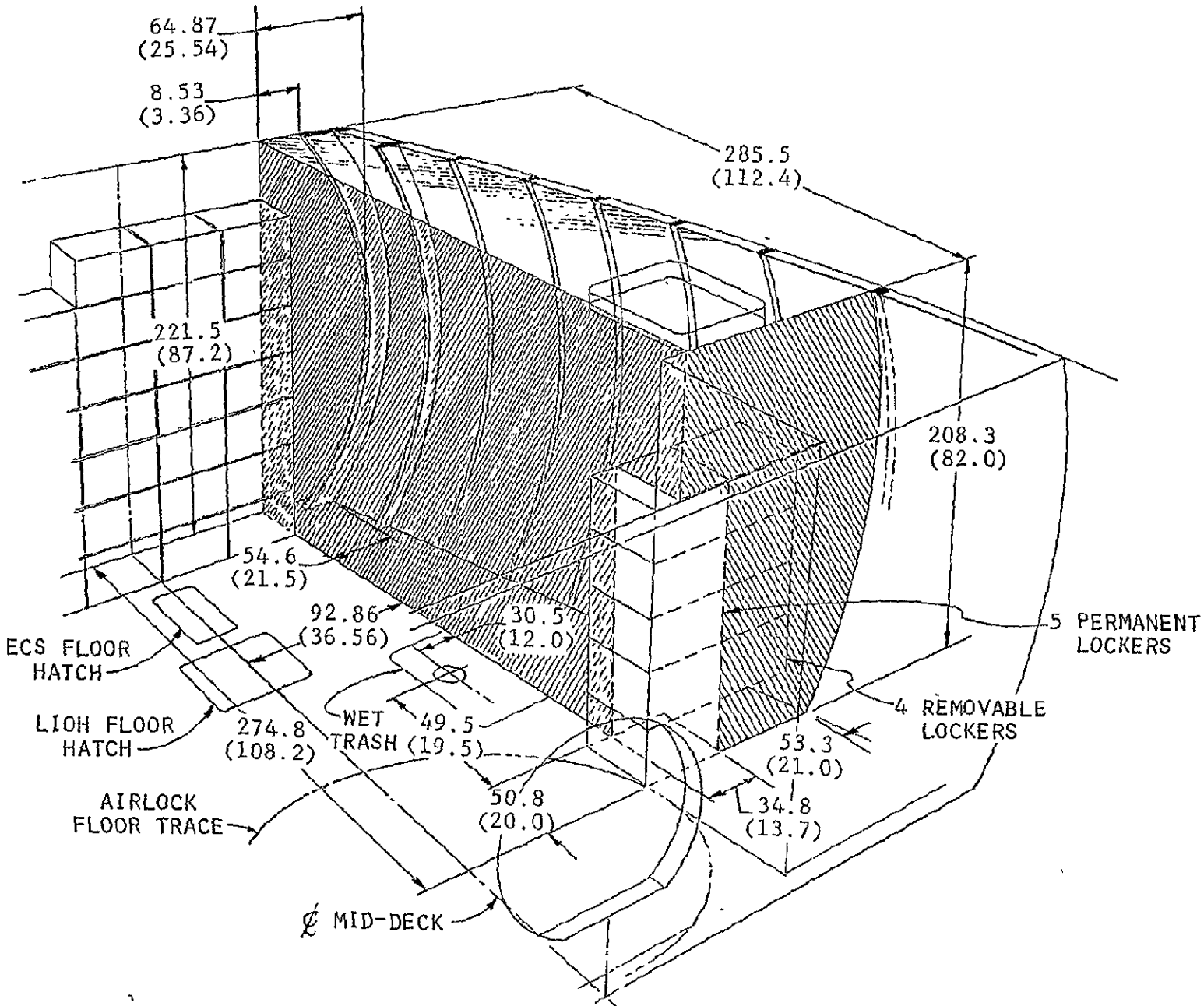


FIGURE 30 ORBITER MID-DECK RIGHT SIDE WALL AREA ALLOCATED FOR SLEEP STATIONS

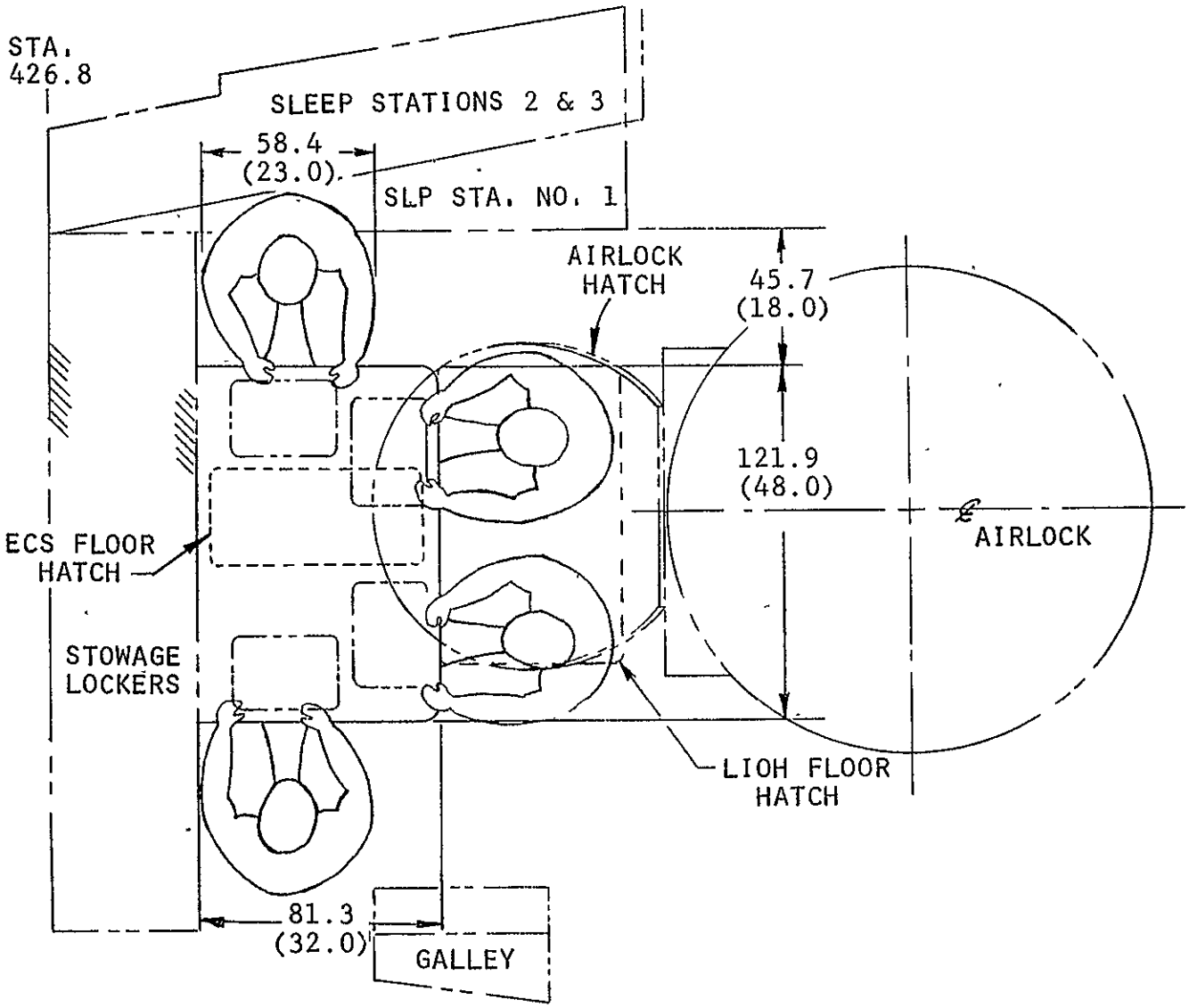


FIGURE 31 BASELINE EATING/WORK TABLE ARRANGEMENT - PLAN VIEW

the habitable Mid-Deck area. A bank of 33 modular stowage containers (lockers) are installed at this forward wall. The aft boundary is a pressure bulkhead with an enclosed avionic bay on the right side (looking forward) and a stowage area and the waste management compartment on the left side. For certain missions, a cylindrical airlock with fore and aft access hatches is installed in the Mid-Deck area, centrally located with the aft access hatch at the pressure bulkhead. The alternate location of the airlock is aft of the bulkhead, leaving the area forward of the airlock hatch as open habitable area. Nine modular stowage containers are installed on the right side of the airlock area at the avionic bay wall. The 4 outboard containers are relocated after launch to an orbit stowage location under the eating/work table surface which is located at the forward locker tier. The right side wall area of the Mid-Deck is allocated to 4 sleep stations. The left side wall area is allocated to the personal hygiene station/waste management compartment (PHS/WMC), the galley, and stowage area for passenger seats (just forward of the galley). The one-g access hatch is on the left side between the galley and the WMC areas. For access into the Mid-Deck in a vertical launch position, a hard door is provided at the WMC opening to serve as a stepping surface for ingress/egress through the side hatch. Six floor hatches are provided for access to under-the-floor stowage compartments. A seventh floor hatch is provided for access to the environmental control equipment bay. All floor hatches swing open into the Mid-Deck area. The floor stowage compartment on the right side is allocated for use as a wet trash stowage compartment and has a 15.2-centimeter (6-inch) diameter access cover for flight use.

2.5 Typical Crew Activities - Current activity timeline planning for mission operations with a nominal crew of 4 is based on a single-shift operation. Figure 32 presents the simplified summary of a typical planned timeline for each crew member based on the preliminary data provided for this study. This timeline indicates that all 4 crew members will eat and sleep at the same time and spend approximately 15 hours out of every 24 hours or 62.5 percent of the daily time in the Mid-Deck area.

For a maximum crew of 7, current activity timeline planning is based on a two-shift operation that starts after achieving orbit. Figures 33, 34, and 35 present simplified summaries of the typical timelines for each crew member for the launch day, orbit day, and return day, respectively. Each shift will spend as much as 12 hours or 50 percent of their daily time in the Mid-Deck area for such activities as personal hygiene, eating, and sleeping.

FIGURE 32

TYPICAL DAILY TIMELINE FOR
NOMINAL CREW SIZE OF FOUR

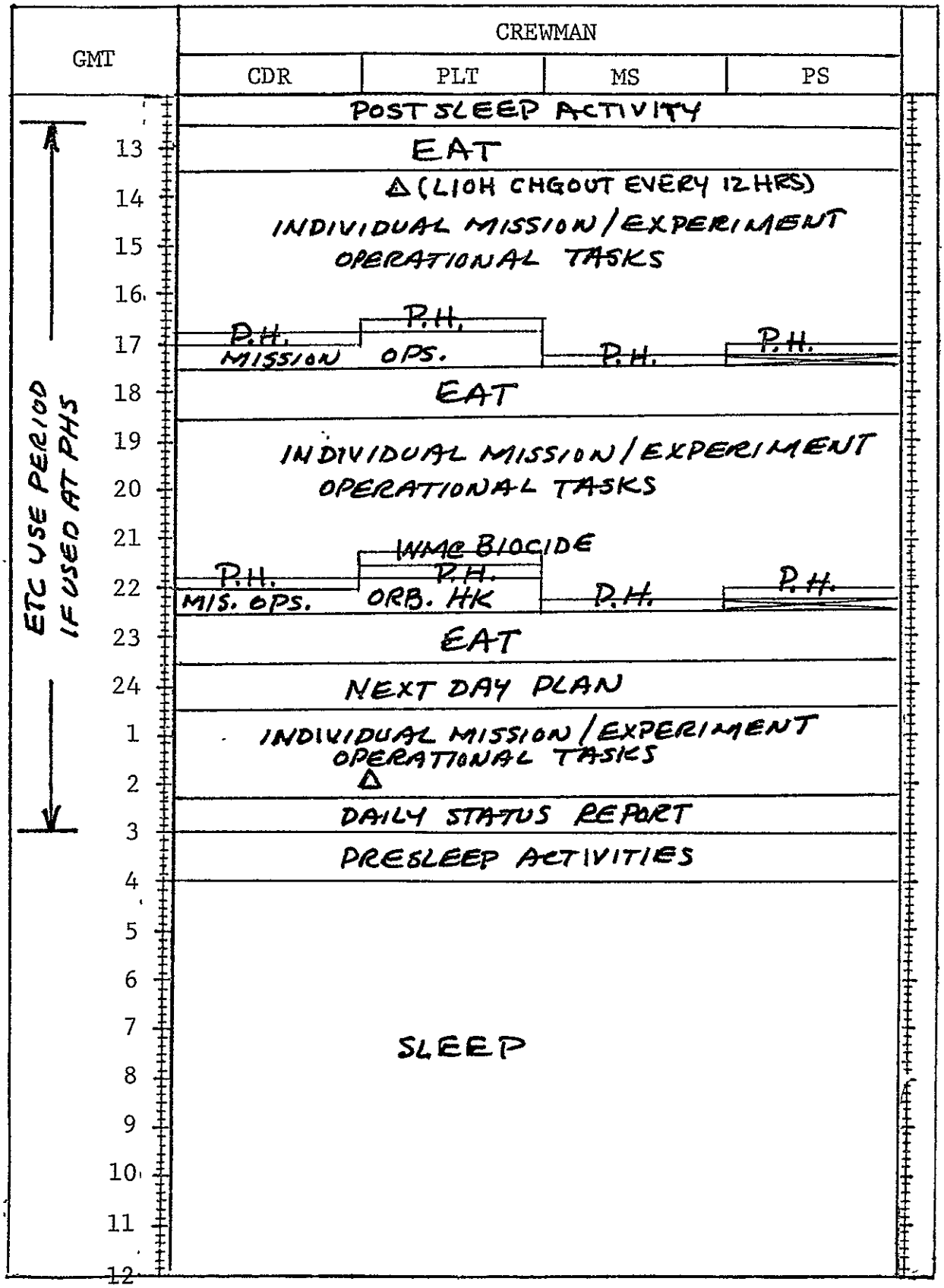
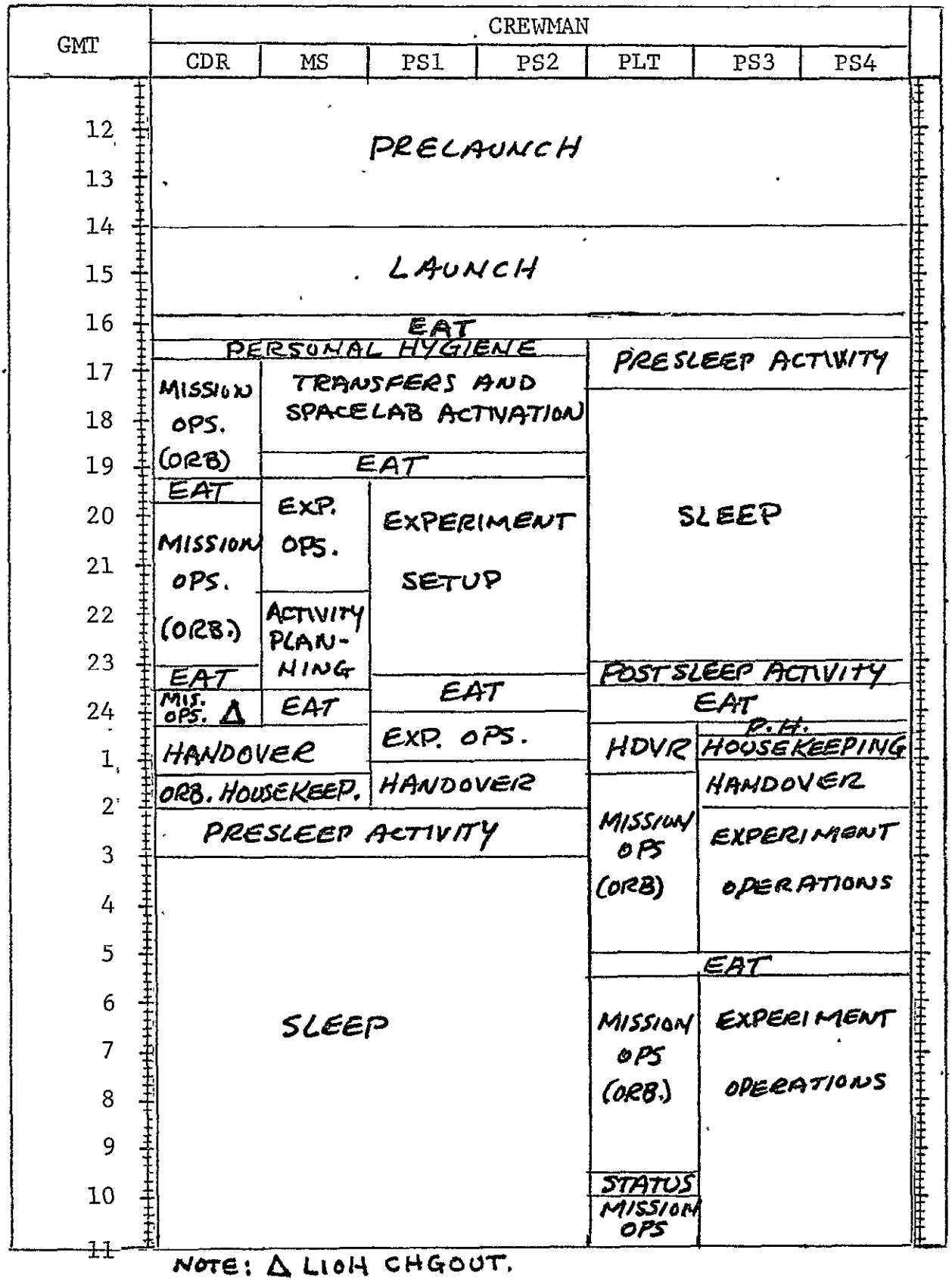


FIGURE 33

TYPICAL LAUNCH DAY TIMELINE

FOR ORBITER CREW OF SEVEN



NOTE: Δ LiOH CHGOUT.

FIGURE 34

TYPICAL ORBIT DAY TIMELINE
FOR ORBITER CREW OF SEVEN

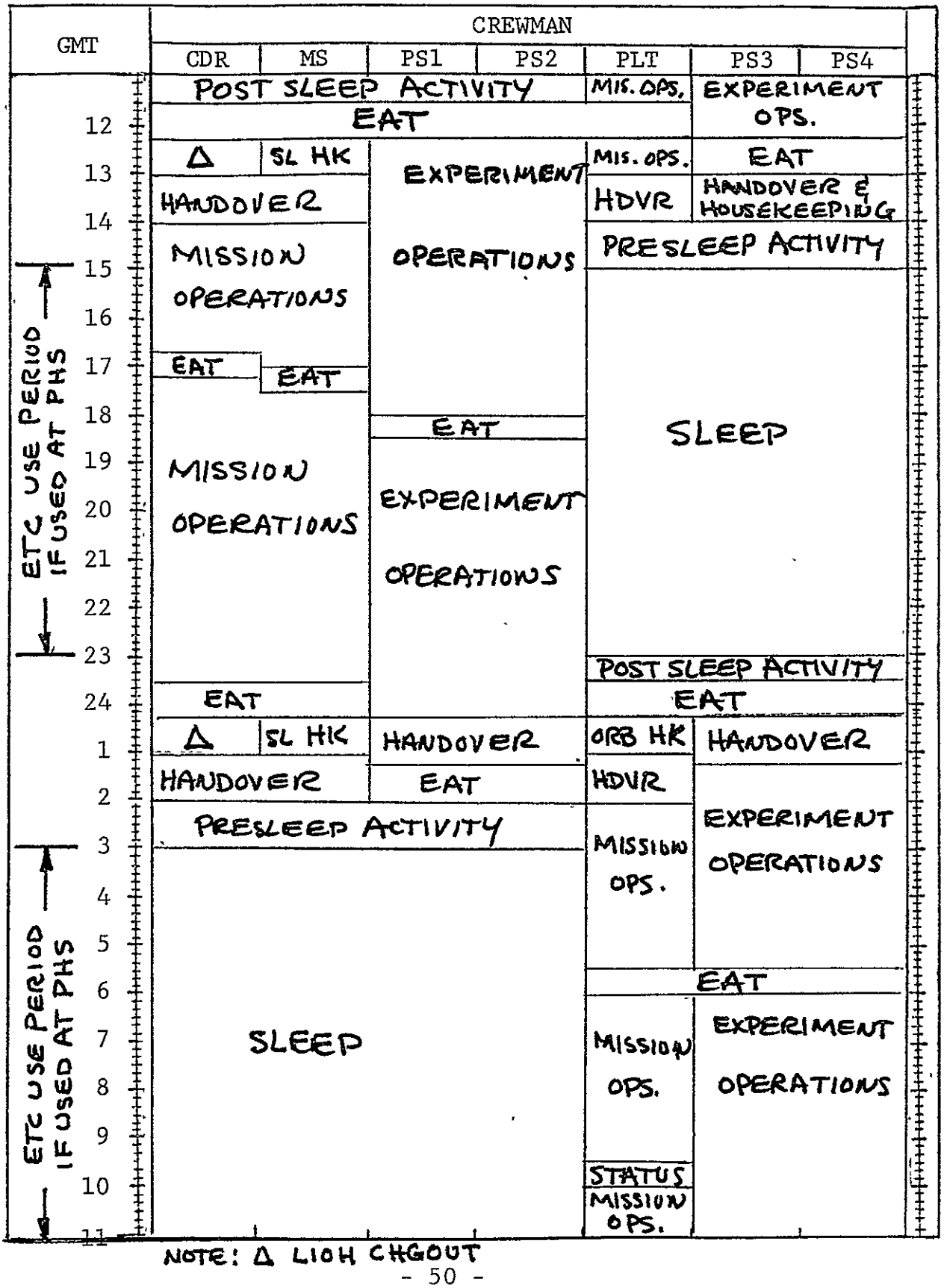
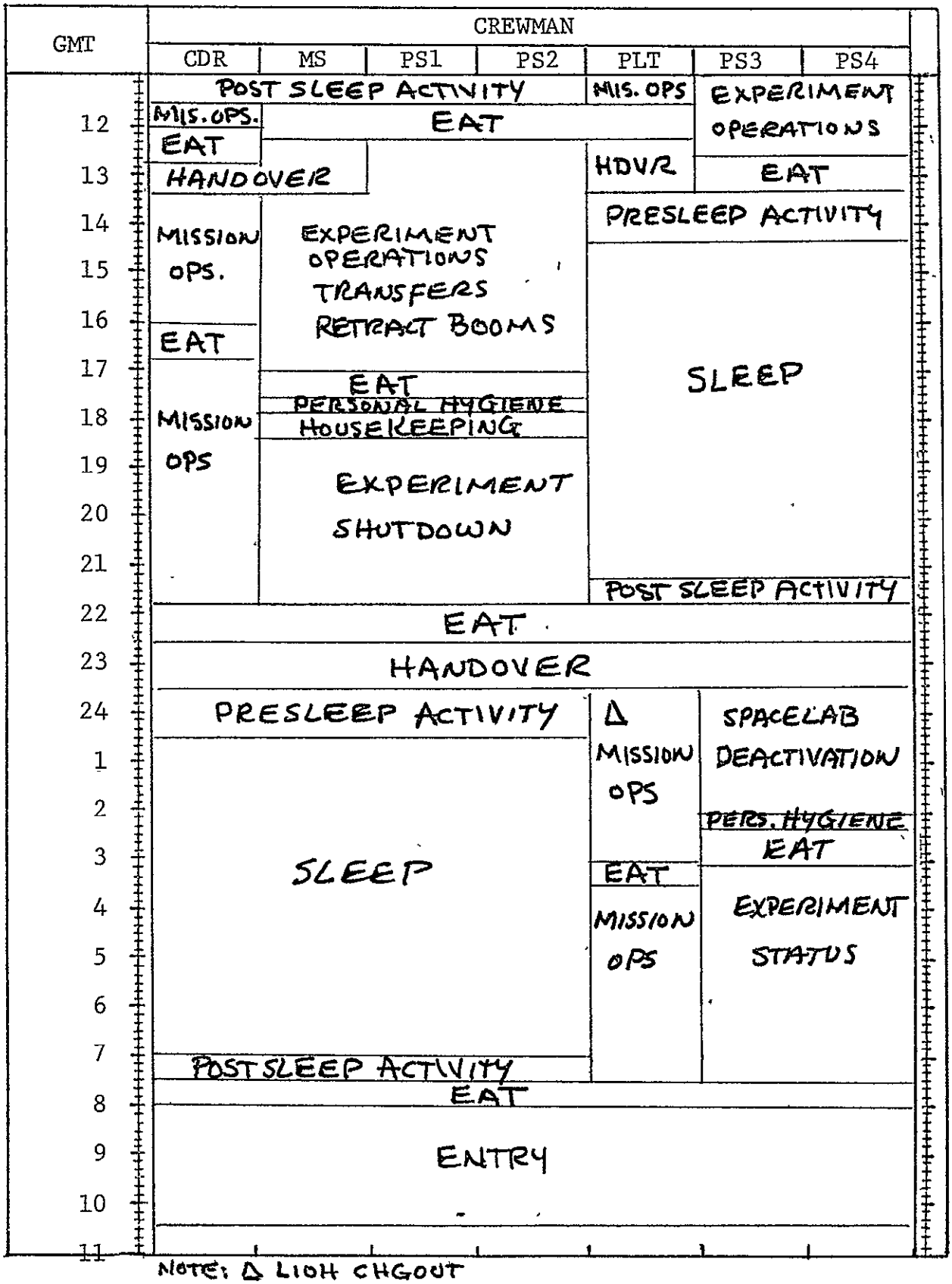


FIGURE 35

TYPICAL RETURN DAY TIMELINE

FOR ORBITER CREW OF SEVEN



NOTE: Δ LIOH CHGOUT

2.6 Airlock Hatch Stowage Evaluation - When the airlock is located in the Mid-Deck area, its forward hatch can present an obstacle to crew habitability by virtue of its size. An evaluation of hatch stowage location concepts was conducted to determine a stowage location that would have the least impact on crew habitability. As presented in Reference 10, a total of 8 different stowage location concepts were developed in addition to the baseline concept for evaluation. Interferences with other Mid-Deck areas were identified based on the hatch swing envelope and stowage location. The assumptions and evaluation criteria utilized for this study task are presented in Tables IV and V, respectively.

2.7 Sleep Station Evaluation - With the basic Mid-Deck arrangement designating the right side as the sleep station area, an evaluation study was conducted as presented in Reference 11. This study task progressed to evaluate the baseline and alternate concepts considering anthropometric, architectural, and environmental design requirements. These requirements are summarized in Table VI.

Figures 4, 5, and 6 presented previously in Section 2.2, were developed to provide dimensional anthropometric evaluation criteria. The basic requirement utilized for size evaluation is that a compartment size must be compatible with the dimensions and activities of a 95th percentile male crew member. Therefore, a compartment must accommodate a standard size sleep restraint frame having 195.6-centimeter (77-inch) length and a 71.1-centimeter (28-inch) width. The next dimension that must be satisfied is that of depth. The absolute minimum depth requirement utilized is 63.5 centimeters (25 inches) considering 58.4 centimeters (23 inches) for body breadth plus 5.1 centimeters (2 inches) for sleep restraint/frame thickness. The 58.4-centimeter (23-inch) dimension is the minimum arm-to-arm work space dimension identified in Reference 9. This minimum depth value along with a compartment that is capable of accepting the standard size sleep restraint frame should allow a 95th percentile person enough room to orient his body with shoulders perpendicular to the sleep restraint and utilize the 71.1-centimeter (28-inch) frame dimension for raising leg/legs for don/doffing of clothes. A compartment depth of 71.1 centimeters (28 inches) is considered fully capable of providing satisfactory space for a 95th percentile person. Any depth value less than 71.1 centimeters (28 inches) but not less than 63.5 centimeters (25 inches) will be a size compatible for full activities of a percentile size less than 95th percentile; however, as discussed previously, can still be considered adequate for use by a 95th percentile person.

TABLE IV

AIRLOCK FORWARD HATCH LOCATION STUDY ASSUMPTIONS

1. The hatch will be installed in the closed position during launch/landing phases of the mission.

2. The hatch will be stowed in the open position at all times during orbital operations except during an EVA on certain missions.

3. The dining/work table will be deployed during orbital operations and will have four modular storage lockers stowed under the table top mounted to table structure. The dining/work table will be of sufficient size to accommodate four food trays.

4. Five modular storage lockers remain installed on the right side of the airlock.

5. Access to compartments under the Mid-Deck floor forward of the airlock will be required at least twice a day for LIOH canister changeout.

6. The waste management compartment hard door will normally be opened to form a privacy area with a curtain extended to the corner of the galley.

7. Primary traffic flow between decks is through the interdeck access hatch located to the left of the airlock particularly during split-shift operations with maximum size crews.

TABLE V

AIRLOCK FORWARD HATCH LOCATION EVALUATION CRITERIA

CRITERIA	DEFINITION
Traffic flow interference	Crew mobility inhibited either to interdeck or about the Mid-Deck
Locker access interference	Access inhibited to either modular stowage lockers or under floor stowage locations
Table interference	Hatch swing would require re-stowing of table and four lockers
Usable space interference	Mid-Deck space that could be used otherwise is blocked
Lighting interference	Ceiling lights are blocked
Handling interference	Requires more than one crew-man for handling
Structural interference	Requires change from baseline structure

TABLE VI

PRELIMINARY DESIGN REQUIREMENTS AND
PROPOSED DESIRED FEATURES FOR SLEEP STATIONS

	JSC/EW54 REQUIREMENT SUMMARY	PROPOSED DESIRED FEATURES
Sound	Attenuate external noise to 50 db within compartment except for caution/warning signals.	Less than 55 db provided caution/warning signal can be piped in through intercom. Allow for exposure to Mid-Deck if so desired.
Temperature, Airflow, Humidity	Personal comfort box 20°C to 25.6°C (68°F to 78°F). Flow rate for air change every 4 to 8 minutes, airflow variable not exceeding 15.24 meters (50 feet) per minute. Airflow controllable away from nasal area.	Adjustment of one flow does not interfere with other compartments. Compartment arrangement and crewman orientation compatible with vehicle duct runs for air supply/exhaust.
Light	Completely darken capability. Permanent light fixture for reading, controllable to 323 lumen/meter^2 (30 footcandles).	Allow for exposure to Mid-Deck if so desired.
Communications	Provide intercoms at usable location.	
Orientation	Any orientation architecturally convenient.	Compatible with ingress/egress and vehicle ECLSS.
Volume/ Dimensions	Accommodate 95th percentile male and provide clothing/personal item stowage. Accommodate sleep restraint. Accommodate don/doff clothing.	Functional reach must accommodate 5th percentile female.

TABLE VI (CONTINUED)

	JSC/EW54 REQUIREMENT SUMMARY	PROPOSED DESIRED FEATURES
Interference	Structurally rigid closeout between compartments to prevent disturbance from other crewmen.	Soft surface to minimize noise of impacts.
Temporary Stowage	Overnight stowage of pocket-type items and clothing.	Accommodate temporary and semipermanent stowage for personal items and clothing to allow compartment use by two crew members on alternate shifts.
Off-duty Equipment	Provide individual off-duty tape player system.	

In addition to the crew member size and activities, each compartment requires space/volume to provide accommodations for the provisions identified in Table VII along with typical dimensional allowance requirements.

Two different types of compartment arrangements were considered as the only logical arrangements that can fit within the space allocation. These arrangements are defined as:

a. 3 horizontal/1 vertical

b. All vertical.

Various orientations of a 95th percentile size crew member within each compartment for these arrangements were considered. Table VIII summarizes the concepts for which layouts were made to enable dimensional determinations for evaluation purposes.

Compartment size and arrangement advantages/disadvantages were evaluated for the following features:

a. Compatibility for 95th percentile size crew and standard size sleep restraint frame.

b. Compatibility with open frame spaces to accommodate air ducts and wiring for compartments.

c. Compatibility with egress/ingress and simple closure design.

d. Compatibility with wall curvature for use as stowage area or activity space.

e. Compatibility with ground servicing of wet trash compartment under floor.

f. Compatibility with activity space for rest of Mid-Deck.

2.8 Eating/Work Table Evaluation - An evaluation study was conducted as presented in Reference 12 to select and define an eating/work table configuration. This study task considers the airlock installed in the Mid-Deck area. The overall concept requirement was to provide a device suitable for use by crew members to support the following:

a. Restrain and support food trays at meal time.

b. Serve as an "office desk" to support general paper work and administrative chores.

TABLE VII

SLEEP COMPARTMENT PROVISION REQUIREMENTS

PROVISION	DIMENSIONS	MATERIALS	LOCATION REQTS	REQUIREMENT
a. Separating Walls	2.54 centimeters (1.0 inch) thick	Aluminum skinned honeycomb or foam core that provides required strength and noise attenuation. Surfaces may require thin covering of foam to help absorb impact noises from crewman movements.	Between compartments and at sides where vehicle surfaces do not provide suitable closeout surfaces.	To separate indivi-ual compartments and prevent one crewman from disturbing an adjacent crew member as he moves about within his own enclosure. To provide light and noise isolation from rest of Mid-Deck and vehicle.
b. Access Opening Closure	2.54 centimeters (1.0 inch) thick	Sound absorbing curtain for soft type closure. Hard closure - same as for walls.	At each compartment access opening.	To permit ease of ingress/egress with rapid egress design feature. To provide light and noise isolation from rest of Mid-Deck and vehicle.
c. Sleep Restraint	5.08 centimeters (2.0 inch) thick backing with 2.54 centimeters (1.0 inch) clearance on sides of crewman (Anthropometric envelopes include these allowances.)	Tube frame with stretched fabric back and fabric covering and restraints.	Mounted within a compartment in any position architecturally convenient.	To restrain the sleeping crewman, have integral attachment within compartment providing use stability, ease of mounting and demounting.

TABLE VII (CONTINUED)

PROVISION	DIMENSIONS	MATERIALS	LOCATION REQTS	REQUIREMENT
d. Stowage Space for Clothing/ Shoes	Unfolded clothing: 15.2 x 101.6 x 10.2 centimeters (6 x 40 x 4 inches) deep or folded clothing: 30.5 x 101.6 x 7.6 centimeters (12 x 20 x 3 inches) deep Shoes (pair): 15.2 x 30.5 x 20.3 centimeters (6 x 12 x 8 inches) side by side.	Fabric restraint straps or spring bungees. May require a fabric covering to form a closet type area.	Within functional reach of crewman assuming crewman is floating within compartment for donning/doffing clothing/shoes.	To provide temporary stowage of clothing/ shoes of the crewman using the compartment. Design alternate: Consider expanding stowage provision to accommodate both temporary and semipermanent stowage to allow compartment use by two crew members on alternate shifts.

TABLE VII (CONTINUED)

PROVISION	DIMENSIONS	MATERIALS	LOCATION REQTS	REQUIREMENT
e. Stowage Space for Personal Pocket Items	Swiss army knife: 8.9 x 2.54 x 2.54 centimeters (3.5 x 1 x 1 inch) Penlight: 12.7 x 2.54 centimeters (5 x 1 inch) diameter Checklist book (1) 15.2 x 22.8 x 2.54 centimeters (6 x 9 x 1 inch) thick Pocketbook (2). 11.4 x 17.8 x 2.54 centimeters (4.5 x 7 x 1 inch) thick (each)	Fabric restraint straps or spring bungees that hold items against a surface or within a recessed area.	Within functional reach of crewman while in sleep restraint.	To provide temporary stowage of personal pocket items of crewman using the compartment. Design alternate: Same as for (d).
f. Light Fixture	11.4 x 55.6 x 7 6 centimeters (4.5 x 22.0 x 3.0 inches) deep	Same as baseline.	Control within functional reach of crewman in sleep restraint to allow on/off control.	To provide general compartment and reading illumination.

TABLE VII (CONTINUED)

PROVISION	DIMENSIONS	MATERIALS	LOCATION REQTS	REQUIREMENT
g. Ventilation Air Inlet and Outlet	15.2 centimeters (6 inch) diameter air inlet and 15.2 centimeters (6 inch) square or diameter air outlet.	Circular metal diffuser for inlet. Filter/screen on outlet.	Air inlet control within functional reach of crewman in sleep restraint to allow adjustment. Outlet at opposite end of compartment to induce total compartment ventilation.	To provide head-to-foot airflow direction and avoid airflow into face/nasal area or direct impingement on body.
h. Intercom Box	34.3 x 25.4 x 16.5 centimeters (13.5 x 10.0 x 6.5 inches) deep.	Similar to Skylab speaker/intercom assembly.	Within functional reach of crewman and at a level compatible for him to speak into box while in sleep restraint.	To provide inter-spacecraft communications.
i. Tape Player	Player: 25.4 x 17.8 x 7.6 centimeters (10 x 7 x 3 inches) Cassettes (2)	Similar to Skylab tape player.	Within functional reach of crewman in sleep restraint.	To provide tape player for off-duty listening within each compartment.

TABLE VIII

SUMMARY OF SLEEP STATION ARRANGEMENT CONCEPTS

CONCEPT NO.	DESCRIPTION
1	Baseline installation with each crew member in the three horizontal compartments facing up and the one in the vertical compartment facing inboard.
2	Baseline change proposed by prime contractor to reorient the crew member in the lower horizontal compartment so as to be back-to-back (facing down) with the middle horizontal crew member. This arrangement allows the three horizontal sleep stations to have the same inboard edge locations.
3	Baseline installation with each crew member in the three horizontal compartments facing inboard and the crew member in the vertical compartment facing inboard.
4	Prime contractor proposed change to the baseline installation with each crew member facing outboard including the one in the vertical station.
5	A 3 horizontal/1 vertical arrangement using the inboard floor trace of the baseline lowest horizontal station as the inboard edge limit for all three horizontal stations. The vertical station geometry remains the same as the baseline. All crew members are oriented facing outboard.
6	A 3 horizontal/1 vertical arrangement identical to Concept 5 but with the crew member in the lower horizontal compartment facing down, crew members in the upper two horizontal stations facing up and the crew member in the vertical station facing forward.

TABLE VIII (CONTINUED)

CONCEPT NO.	DESCRIPTION
7	All vertical arrangement with crew member orientations: forward compartment facing aft, two middle compartments facing outboard, aft compartment facing forward.
8	All vertical arrangement with all crew members facing inboard.
9	All vertical arrangement with crew member in forward compartment facing forward and remaining three facing aft.

c. Serve as a basic platform upon which tools, parts, and components can be arrayed and restrained in support of inflight maintenance activities.

d. Serve as a focal point for crew assembly in leisure periods by providing a stable platform for display and retention of small items such as books, cassette recorder, etc.

Figures 11 and 12, presented previously in Section 2.2, were developed based on the neutral body posture under weightless conditions to identify the table/tray requirements for providing a closer tray-to-mouth position than can be achieved with a conventional oriented table surface and meet height variation requirements for the range of crew sizes.

Layouts of table concepts were made with various crew member position arrangements to define space utilization and interference problems for each concept. Table IX summarizes the various concepts considered. Each concept was evaluated for the following requirements:

- Provides four eating, desk and work surface positions for 5th percentile female to 95th percentile male sizes in a face-to-face group arrangement.
- Stows four lockers with access clearance and at least 12.7-centimeter (5-inch) clearance from floor for foot restraint.
- Provides clear floor area for foot restraint use.
- Allows airlock hatch swing clearance.
- Allows LIOH floor hatch swing clearance.
- Allows ECS floor hatch swing clearance.
- Allows traffic access to airlock.
- Allows traffic flow across Mid-Deck without having to go over table.
- Allows clearance at horizontal sleep stations for egress/ingress.
- Allows access to galley by individual crew members.

TABLE IX

EATING/WORK TABLE ARRANGEMENT CONCEPT DESCRIPTION

CONCEPT NO.	DESCRIPTION
1	Baseline - Single surface rectangular table, 81.3 by 121 9 centimeters (32 by 48 inches) hinged at modular locker tier with length located laterally along locker wall
2	Single surface plate for each crew member in a baseline position arrangement. Each surface plate mounted to a support frame hinged at modular locker tier providing height adjustment with a tilt feature. Table area envelope: 55.6 by 99.7 centimeters (22 by 39.25 inches).
3	Single surface round table attached to Mid-Deck floor with height adjustment feature.
4	Single surface plate for each crew member in a circular position arrangement with support attached to Mid-Deck floor providing height adjustment and tilt features.
5	Single surface rectangular table utilizing passenger seat with crew members in a baseline position arrangement. (Assumes a double passenger seat configuration).
6	Single surface plate for each crew member with individual height and tilt adjustment. Positions located along forward locker tier with crew members side-by-side facing forward.

TABLE IX (CONTINUED)

CONCEPT NO.	DESCRIPTION
7	Single surface rectangular table attached to Mid-Deck floor with height adjustment feature. Table length located laterally across Mid-Deck with two crew members facing aft, two facing forward.
8	Single surface plate for each crew member with individual height and tilt adjustment features. Plates supported from frame attached to Mid-Deck floor. Includes two positions using surface extending out from galley. Main table rotates to provide access to stowed lockers and clearance around table for unoccupied periods.
9	Single surface plate for each crew member with individual height and tilt adjustment features. Two positions at forward locker tier. Two positions in front of galley.

- Allows access to lockers in forward tier.
- Permits temporary stowage of table.
- Provides individual height adjustment.
- Provides tilt position for tray accessibility and desk/work position.

2.9 Personal Hygiene Station/Waste Management Compartment Evaluation - An evaluation study was conducted as presented in Reference 13 to determine the following:

a. Height and opening size dimensions for the hand washer location on the aft side of the galley.

b. Adequacy of the space allocation for PHS/WMC use.

c. PHS/WMC closeout requirements for privacy.

d. Interferences and clearances created by use of the side hatch window for photographic experiment.

e. Temporary restraint provisions for personal items, towels, and washcloths.

The design requirements and assumptions utilized are presented in Table X for the waste management compartment and in Table XI for the personal hygiene station.

Layouts of the PHS/WMC area were utilized to determine clearances/interferences and desirable features for the body activity envelopes presented by Figures 13 through 22 (see Section 2.2). In all cases a WMC door was considered to provide the launch position stepping surface for Mid-Deck one-g ingress/egress through the side hatch. For orbital operations, a variety of PHS/WMC area privacy closeout concepts were considered utilizing the WMC door as part of the closeout concept. Table XII describes closeout arrangement concepts that were considered. An initial investigation covered the use of the side hatch window as a photographic experiment station with a camera mounted so as to protrude into the PHS/WMC area. Camera envelope dimensions of 16.2 by 55.9 by 35.6 centimeters (30 by 22 by 14 inches) were used as a typical size requirement. Since planning effort concerning the camera use location was changed to place emphasis on locating it in the payload bay, the evaluation study of the PHS/WMC area continued under this premise. Each concept was evaluated as to the adequacy of requirements such as:

TABLE X

WASTE MANAGEMENT DESIGN REQUIREMENTS
AND ASSUMPTIONS SUMMARY

REQUIREMENT	ASSUMPTIONS
Accommodate 5th percentile female to 95th percentile male body sizes.	Both lap strap and side handholds needed for use of fecal collection system.
Fecal collection system collects/stores feces without crew member handling.	Positions other than seated use of fecal collection equipment required for independent use of urine collection equipment, personal hygiene cleanup, WMC housekeeping.
Use capability is four times per hour.	Baseline location for airflow control is located in WMC on aft wall (X_o 565).
Area closeout for privacy.	Waste collection equipment beneath seat is on the order of a 68.6-centimeter (27-inch) diameter sphere.

TABLE XI

PERSONAL HYGIENE STATION DESIGN REQUIREMENTS AND ASSUMPTIONS SUMMARY

REQUIREMENT	ASSUMPTIONS
Accommodate 5th percentile female to 95th percentile male body sizes.	Baseline location of waste collection system airflow control(s) located in WMC on aft wall (X_o 565).
PH washer located on aft side of galley.	Suction cup foot restraint(s) worn for majority of PHS activities except body bathing.
PH washer primary operational capability to permit: a. Hand wash before/after meals, after WMC use, after various work activities. b. Body wash once per man-day.	Temporary stowage of clothing/shoes in PHS during body bathing.
PH washer secondary operational capability to provide: a. Shaving once per man-day. b. Hair wash once per man-week. c. Oral hygiene twice per man-day.	Two washcloths and one towel used by each crewman on a daily basis.
Personnel restraints required for body position and stability under weightless conditions.	
Temporary restraints for drying damp washcloths and towels.	
Lighting required for efficient use of PHS.	
Area closeout for privacy.	
Mirror for shaving/grooming activities (Desirable).	
Use washcloth/towel disposal.	

TABLE XII

PERSONAL HYGIENE STATION/WASTE MANAGEMENT COMPARTMENT ARRANGEMENT CONCEPTS DESCRIPTION

CONCEPT NO.	DESCRIPTION
1	Baseline - WMC door opens 90 degrees and a curtain extended to the galley for privacy closeout. WMC use position provides conventional seating with crew member facing forward.
2	RI Proposed Change - WMC door hinge point moved 15.24 centimeters (6 inches) outboard of baseline hinge point. Door opens 90 degrees with curtain extension to galley for privacy closeout. WMC use position rotated 15 degrees to left.
3	Similar to baseline except the upper portion of the WMC door is angled to alleviate door edge interference with the primary interdeck access hatch.
4	WMC door angled the same as for Concept 3 but door moves on roller tracks to allow opening/closing and avoid interference with ETC. Door open position with curtain extension same as Concept 3 (similar to Baseline).
5	WMC door slides inboard and is stowed in front of avionics wall. Hinged door section allows total door width to be accommodated against airlock/avionics wall space. A stretched curtain on tubular frame provides privacy closeout of area similar to Concept 3.
6	WMC door (baseline) modified to include vertical sliding panel to permit access when ETC installed without having to open complete door. An accordian-type curtain provides area closeout for privacy along Y_o = 54 plane. An extension from galley accommodates curtain stowage. Curtain is angled near ceiling to avoid primary interdeck hatch interference.

TABLE XII (CONTINUED)

CONCEPT NO.	DESCRIPTION
7	WMC door with center hinge swings outboard to permit access to WMC with ETC installed. A separate curtain closeout that is stowed in false ceiling provides privacy for PHS use.
8	WMC door hinged at outboard location (X_o 535, Y_o 81) with a flexible curtain attached between door edge and lightweight tubular frame/fabric closeout in the PHS area. This concept permits use of the WMC and PHS by two different crew members at the same time. A separate door of stretched fabric is provided for the PHS. The top portions of the closeout material are angled to alleviate interference with the primary interdeck access hatch.
9	Similar to Concept 3 except a sliding partition is used for final closeout to the galley rather than a flexible curtain.

- Accommodation capability for 5th percentile female to 95th percentile male sizes.
- Hand wash activity clearance at PHS by 95th percentile male.
- Body wash activity clearance at PHS by 95th percentile male.
- Privacy closeout adequacy for PHS/WMC area.

In addition to required features, the evaluation considers the adequacy of desirable features such as:

- Shaving and oral hygiene activity clearance at PHS by 95th percentile male.
- Hair wash/rinse activity clearance at PHS by 95th percentile male.
- Accessibility clearance to PHS by 95th percentile male.
- Accessibility clearance to WMC by 95th percentile male.
- Simultaneous occupation capability of PHS and WMC by two different crew members with privacy.
- PHS/WMC closeout feature simplicity.
- PHS/WMC feature degree g interference with other Mid-Deck areas of traffic flow paths.
- Accessibility of airflow controls in WMC from PHS.
- Independent use capability of urine collection equipment in WMC by male crew members.
- Comfortable zero-g use position for urine/fecal collection equipment in WMC.

2.10 Airlock Out Arrangement Evaluation - The alternate location of the airlock aft of the rear pressure bulkhead opens the space that it would occupy forward of the bulkhead for habitability use. In this regard, alternate arrangements considering the relocation of nine stowage containers to a position on the aft bulkhead and a pedestal mounted table away from the forward stowage container tier were evaluated as presented in Reference 14. The designs

and arrangements considered are described in Table XIII. Each arrangement was evaluated for the following requirements:

- Provides minimum interface impact on Orbiter.
- Allows access and swing clearance for the LIOH and ECS floor hatches.
- Allows access and swing clearance for modular stowage containers.
- Provides clear floor area for foot restraint use.

In addition to the above requirements, the evaluation included consideration of the following desirable features:

- Allow crew clearance at horizontal and vertical sleep stations for egress/ingress.
- Allow access to the personal hygiene and waste management area.
- Allow access to galley by individual crew members.

2.11 Mobility/Stability Aids Evaluation - An evaluation study was conducted as presented in Reference 15 to determine the location requirements for personnel mobility and stability aids. Table XIV presents the basic requirements determined from Skylab experience. Figures 23 through 26, presented previously in Section 2.2, were utilized to enable evaluation or recommendation of handrail location and lengths. Figures 36 through 41 were generated to determine typical traffic patterns for such timeline activities as pre/post sleep periods, eating periods, and mission/experiment operation periods. The various traffic paths and activity locations were reviewed to determine the boundary surfaces and availability of suitable items for grasping by hand. The reach envelope for the smallest size crew member was used to determine if surfaces and handhold items were well within reach during passage through these areas or when positioned at an activity location. It should be noted that the only baseline handrail identified was at the primary interdeck access hatch.

2.12 Sleep Restraint Evaluation - An evaluation study as presented in Reference 16 was conducted to determine sleep restraint requirements for the Mid-Deck sleep stations. The sleep station evaluation was based, in part, on the utilization of a standard size frame having a maximum width of

TABLE XIII

DESIGN AND ARRANGEMENT DESCRIPTIONS FOR AIRLOCK OUT CONFIGURATION

CONCEPT NO.	DESCRIPTION
1	Baseline - Single surface rectangular table having dimensions 81.3 by 121.9 centimeters (32 by 48 inches) hinged at modular locker tier with two crew members side-by-side facing forward and one crew member at each end of table. Four modular stowage lockers moved from Sleep Station No. 4 after launch and restowed under table. Three horizontal (Nos. 1-3) and one vertical (No. 4) sleep stations with access to the vertical sleep station restricted by five modular stowage locker tier.
2	Recommended Changes to Baseline - Individual table surfaces in a baseline position arrangement. Each table surface mounted to a support frame hinged at modular stowage locker tier providing height adjustment through a tilt feature. Table area envelope: 55.6 by 99.7 centimeters (22 by 39.25 inches). Four modular stowage lockers moved from Sleep Station No. 4 after launch and restowed under table assembly. Three horizontal (Nos. 1-3) and one vertical (No. 4) sleep stations with access to the vertical sleep station restricted by five modular stowage locker tier. The three horizontal sleep stations have a wider width than the baseline with all inboard access openings at Y_o 94 centimeters (37 inches).

TABLE XIII (CONTINUED)

CONCEPT NO.	DESCRIPTION
3	Individual table surfaces supported by a pedestal mounted to the Mid-Deck floor in front of the space between the avionics bays. The four crew members are in face-to-face positions. Each table surface provides height adjustment through a tilt feature identical to the individual table surface of Concept No. 2. The three horizontal sleep stations are identical to those proposed for Concept No. 2 with all inboard access openings at Y_o 94 centimeters (37 inches). The vertical sleep station (No. 4) is also identical to that proposed in Concept No. 2 except the available access opening is from floor to ceiling. The nine modular stowage lockers are relocated after launch to a position on the aft bulkhead above the airlock forward hatch opening between the avionics compartments.
4	Same as Concept No 3 except table pedestal attached to Mid-Deck floor just forward of the LIOH hatch in such a manner that still permits LIOH hatch opening without interference with pedestal.

TABLE XIV

DESIGN REQUIREMENTS FOR MOBILITY/STABILITY AIDS

A. Traffic Paths

Provide handrails along traffic paths to permit control of body orientation, stabilization and directional changes when equipment or structural appendages do not provide suitable hand-grip features.

B. Work Station

Provide handholds/handrails at work stations for use as temporary stabilization aids to permit initial foot restraint engagement and subsequent body positioning as required.

C. Identification

Provide handholds/handrails in a contrasting color to background color scheme so that they are easily recognized.

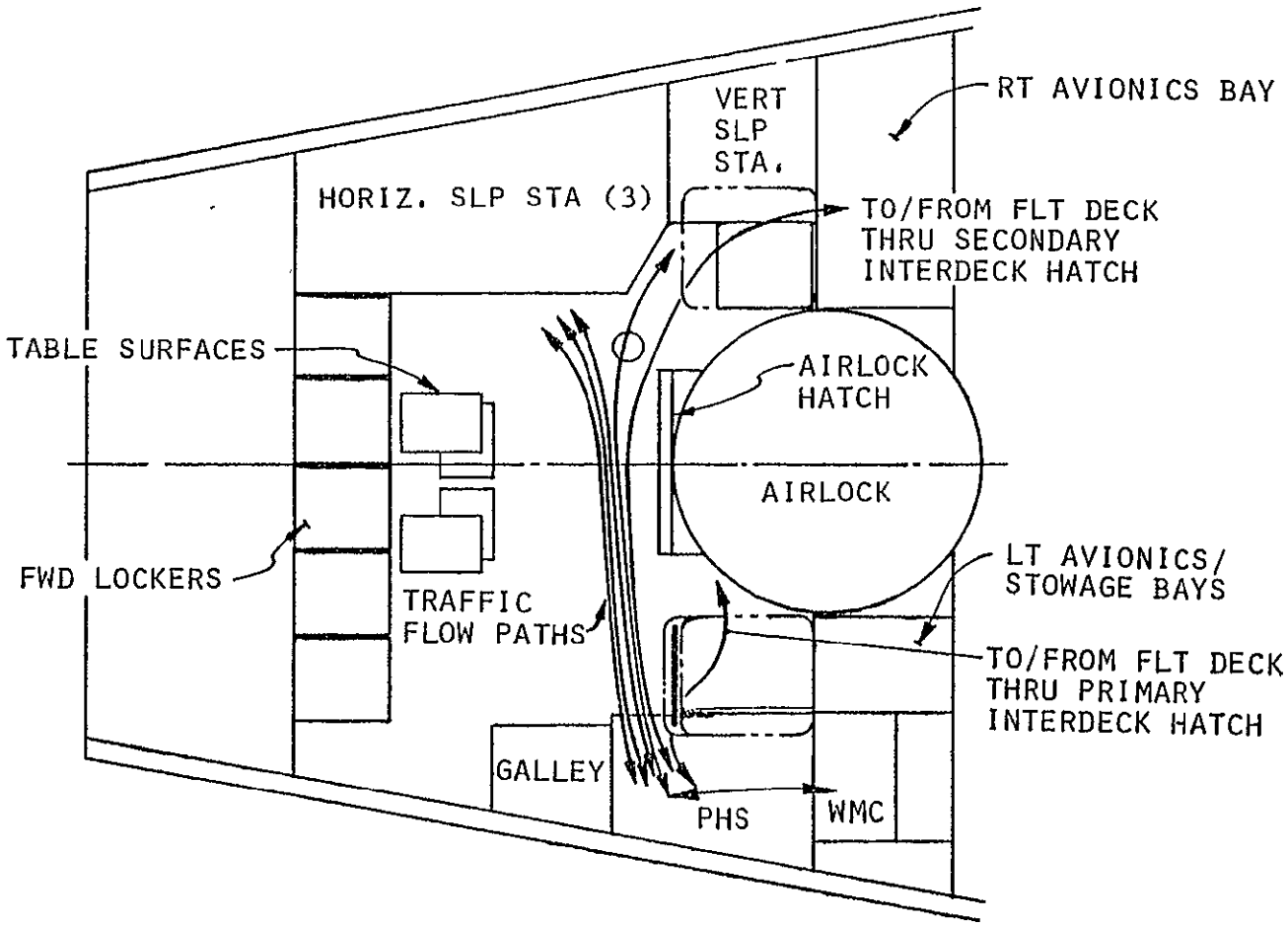


FIGURE 36 TRAFFIC PATTERN FOR PRE/POST SLEEP PERIOD - WITH AIRLOCK

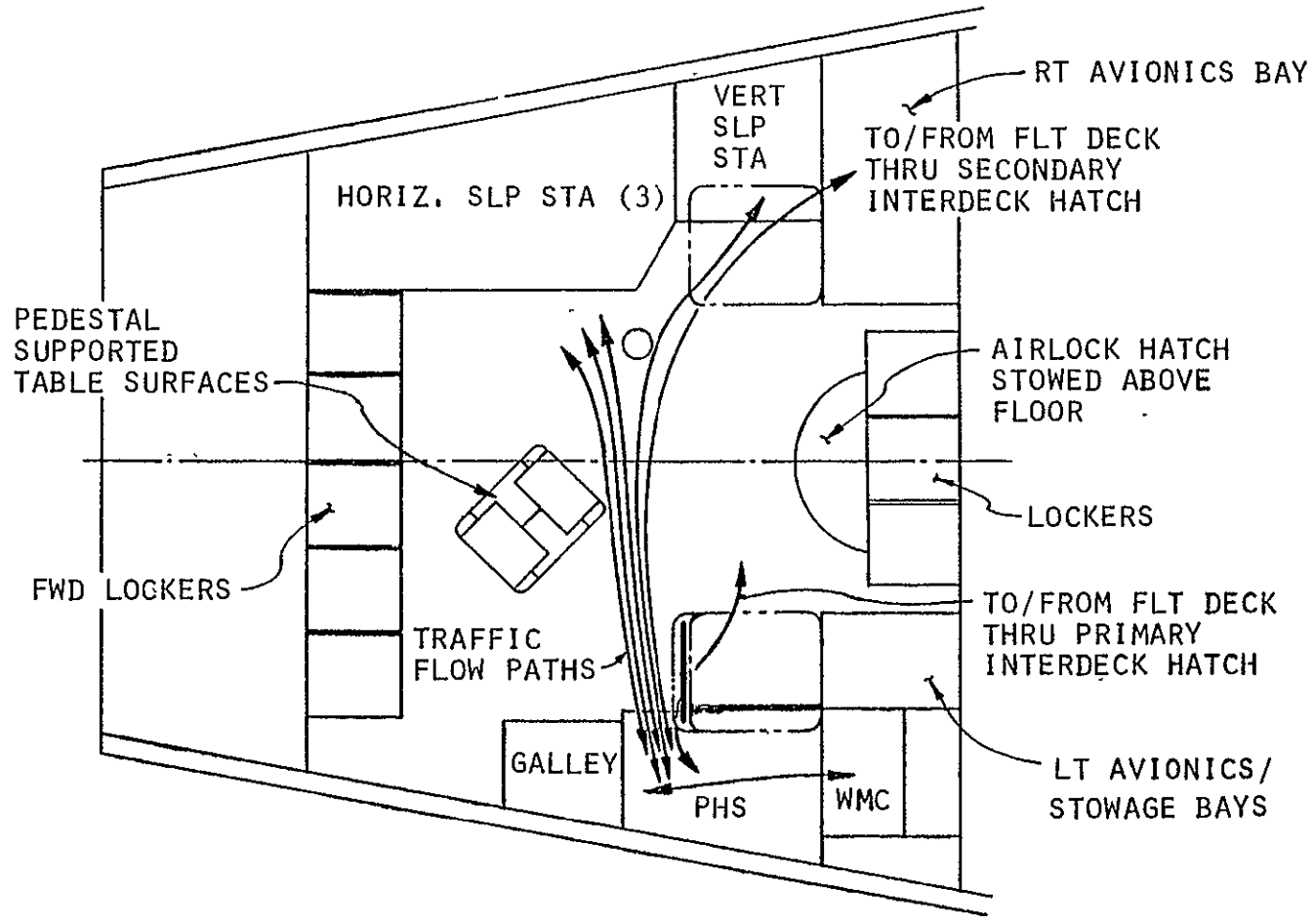


FIGURE 37 TRAFFIC PATTERN FOR PRE/POST SLEEP PERIOD - WITHOUT AIRLOCK

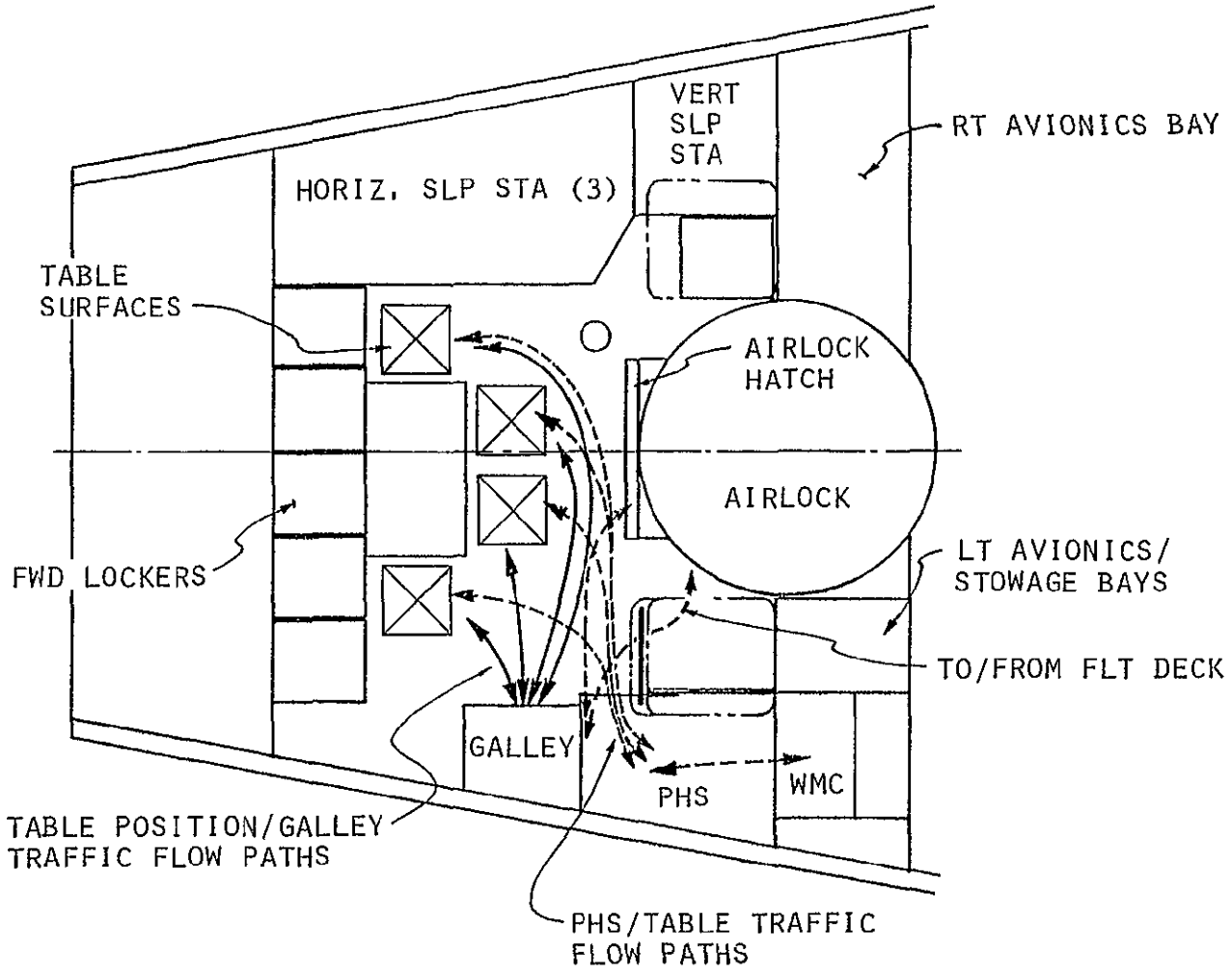


FIGURE 38 TRAFFIC PATTERN FOR EATING PERIOD - WITH AIRLOCK

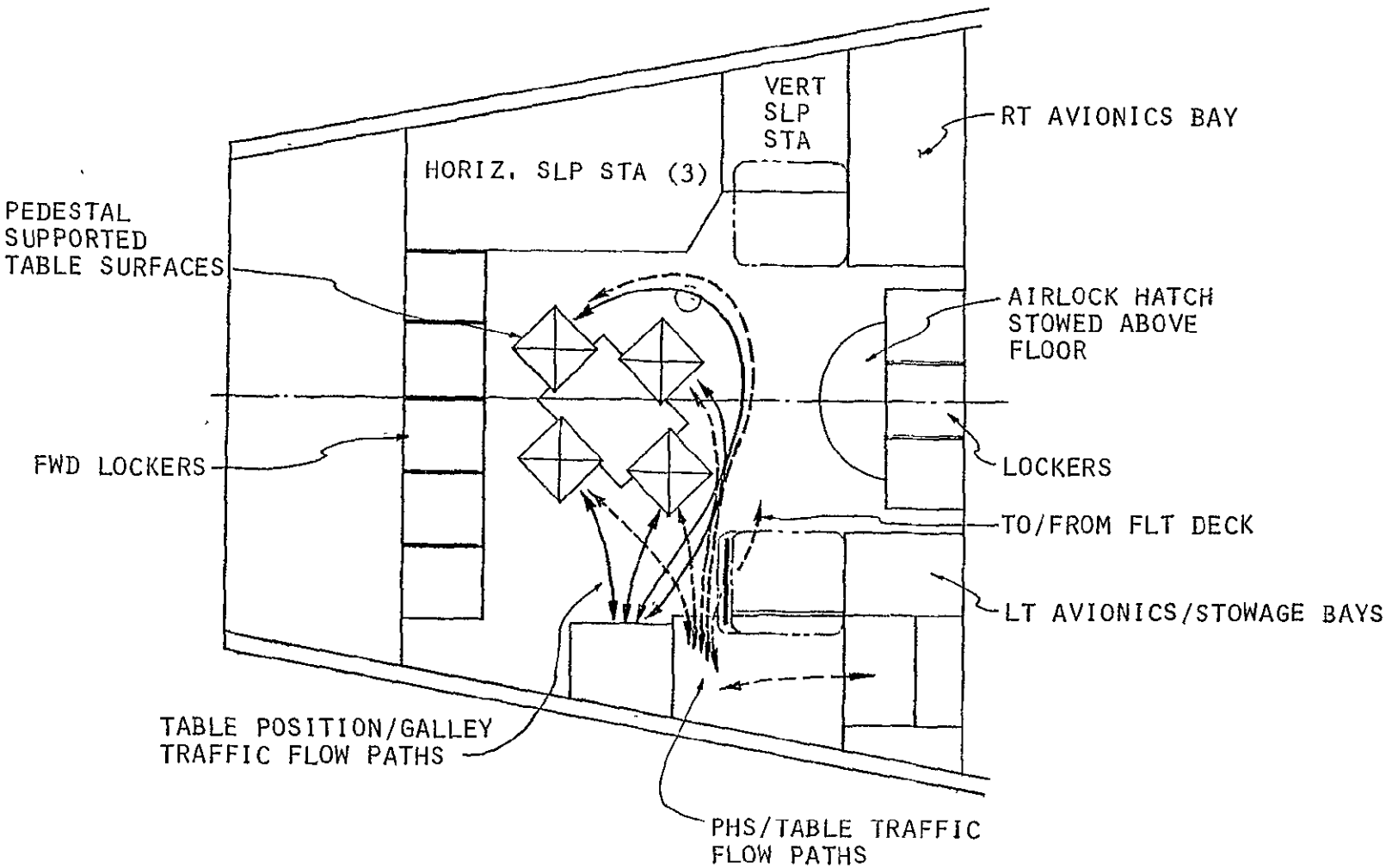


FIGURE 39 TRAFFIC PATTERN FOR EATING PERIOD - WITHOUT AIRLOCK

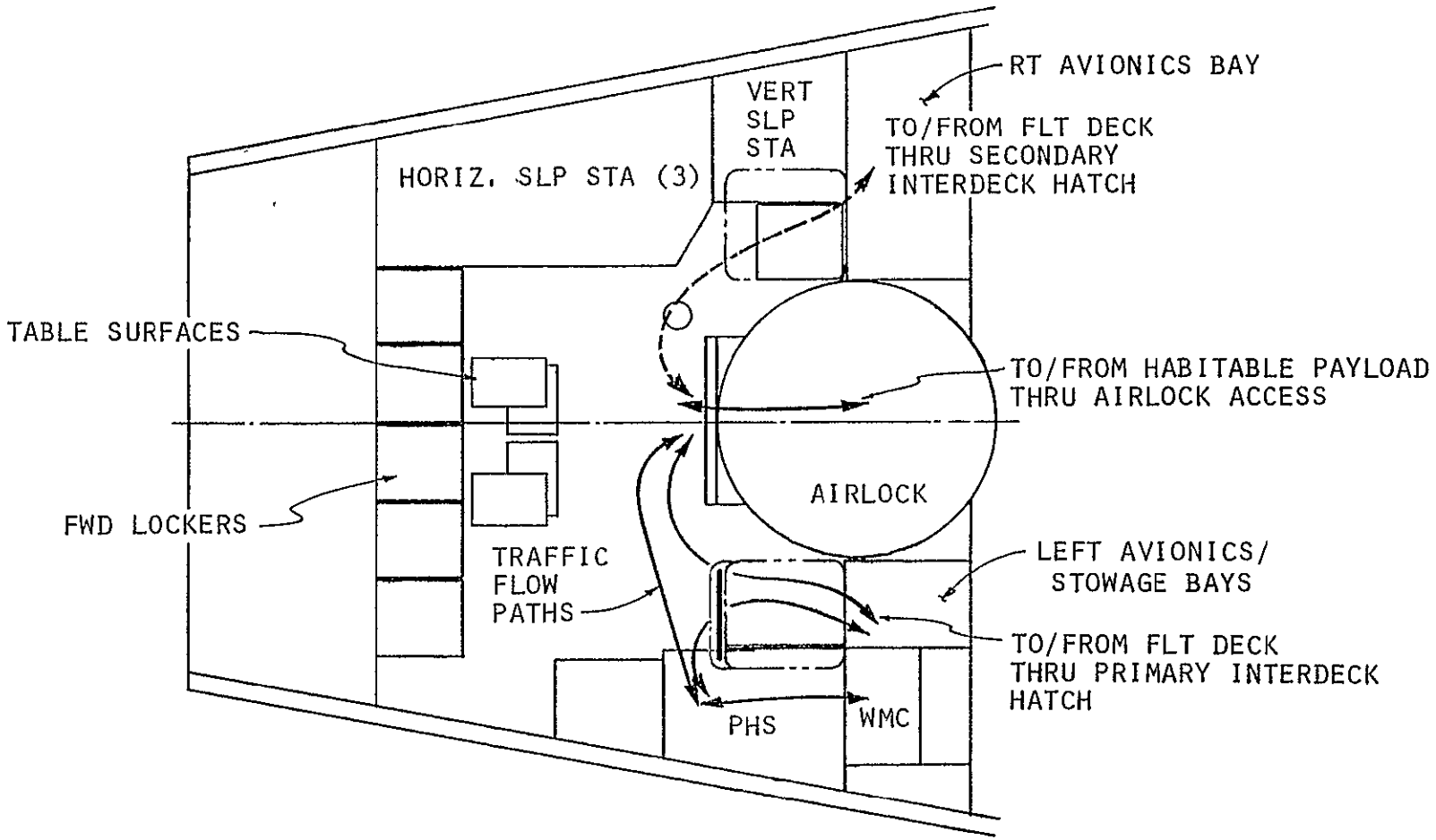


FIGURE 40 TRAFFIC PATTERN FOR MISSION/EXPERIMENT OPERATION PERIOD - WITH AIRLOCK

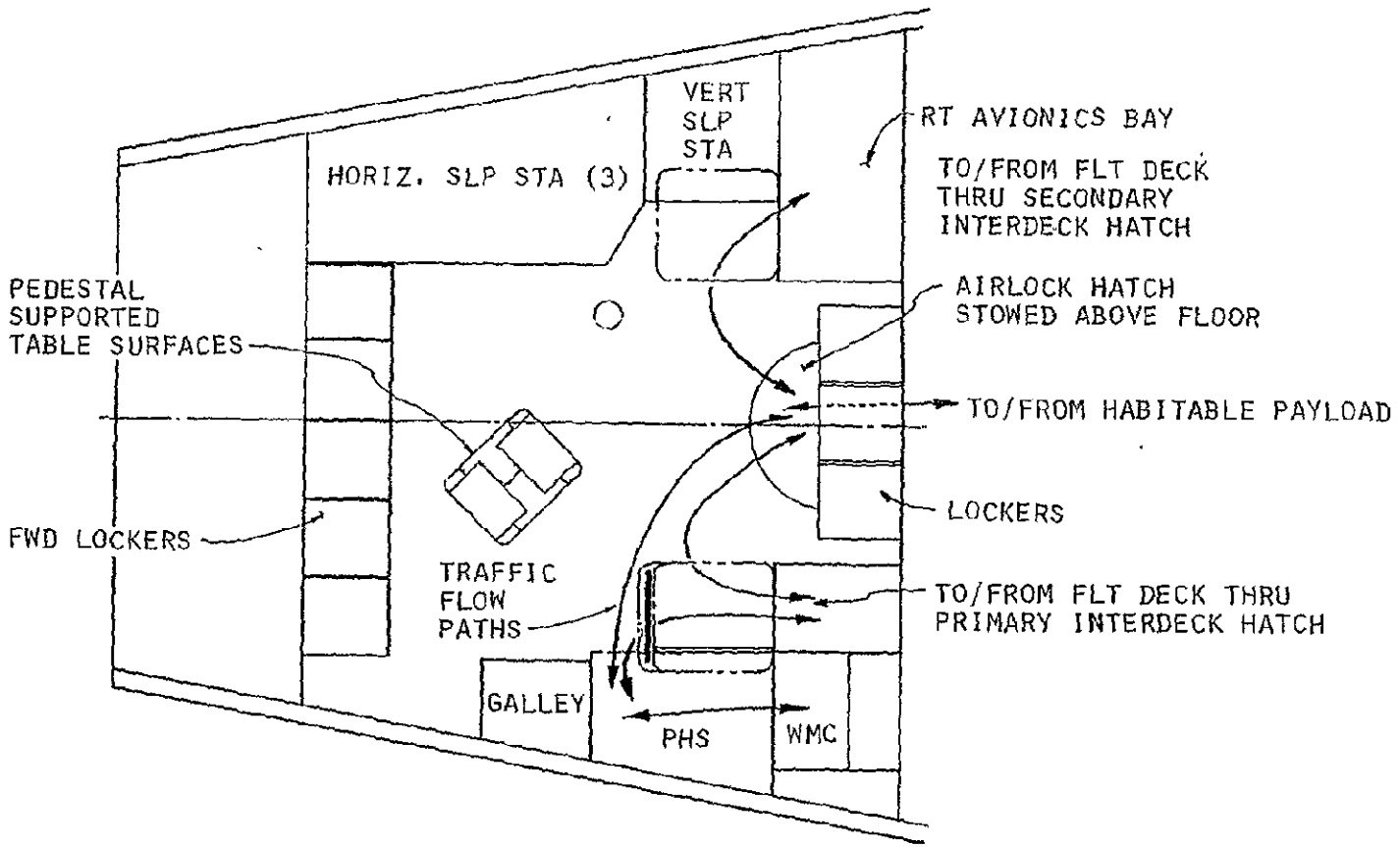


FIGURE 41 TRAFFIC PATTERN FOR MISSION/EXPERIMENT OPERATION PERIOD - WITHOUT AIRLOCK

71 centimeters (28 inches) and a maximum length of 195.6 centimeters (77 inches) to accommodate the 95th percentile male size (see Figure 4 presented previously in Section 2.2). The evaluation study for a sleep restraint proceeded on this assumption utilizing the standard size sleep restraint frame with a tightly stretched backing as the base for attaching the remainder of the restraint assembly. Figure 42 presents the dimensional details of the frame. Table XV presents the summary of the basic design requirements that were utilized for the study. Figure 43 presents the lengths required for the various restraint straps to accommodate the extremes of a 5th percentile female sleeping on her back or a 95th percentile male sleeping on his side. The study considered three sleep restraint concepts as described in Table XVI. Potential methods were also considered to provide alternate use capability of the same sleep compartment by two different crew members on a split-shift schedule. Table XVII summarizes the potential methods considered. The sleep restraint concepts were evaluated considering the Skylab sleep restraint desirable features, ease of ingress/egress, rapid egress, thermal comfort provisions, and alternate use capability to accommodate the range in crew member sizes from a 5th percentile female to a 95th percentile male.

2.13 Wet Trash Management Evaluation - A trash management evaluation study as presented in Reference 17 was conducted. It was based primarily on handling only wet trash items for return stowage in a designated area. Wet trash was interpreted as being primarily empty food containers from each meal and damp towels and washcloths. Trash handling provisions must be operable by a single crew member and facilitate "no-mess" handling for disposal through the access opening to stowage area "F" under the Mid-Deck floor. Typical wet trash generation rates were estimated based on the Skylab mission considering the number of food containers from a typical meal and from the usage rate of towels and washcloths. The wet trash generation rate from meals resulted in a value of 0.0064 cubic meters per man-day (0.227 cubic feet per man-day). The towel/washcloth trash generation rate was estimated to be 0.0018 cubic meters per man-day (0.064 cubic feet per man-day). Allowing a 25 percent increase to account for miscellaneous wet trash items, the total estimated wet trash generation rate was 0.01 cubic meters per man-day (0.364 cubic feet per man-day). Two mechanical trash compactor concepts were considered as described in Table XVIII.

2.14 Lighting Evaluation - The baseline light locations in the Mid-Deck ceiling that were initially identified for this study are best described by the outlined locations on the 1/10-scale model plexiglass top as shown in Figure 44,

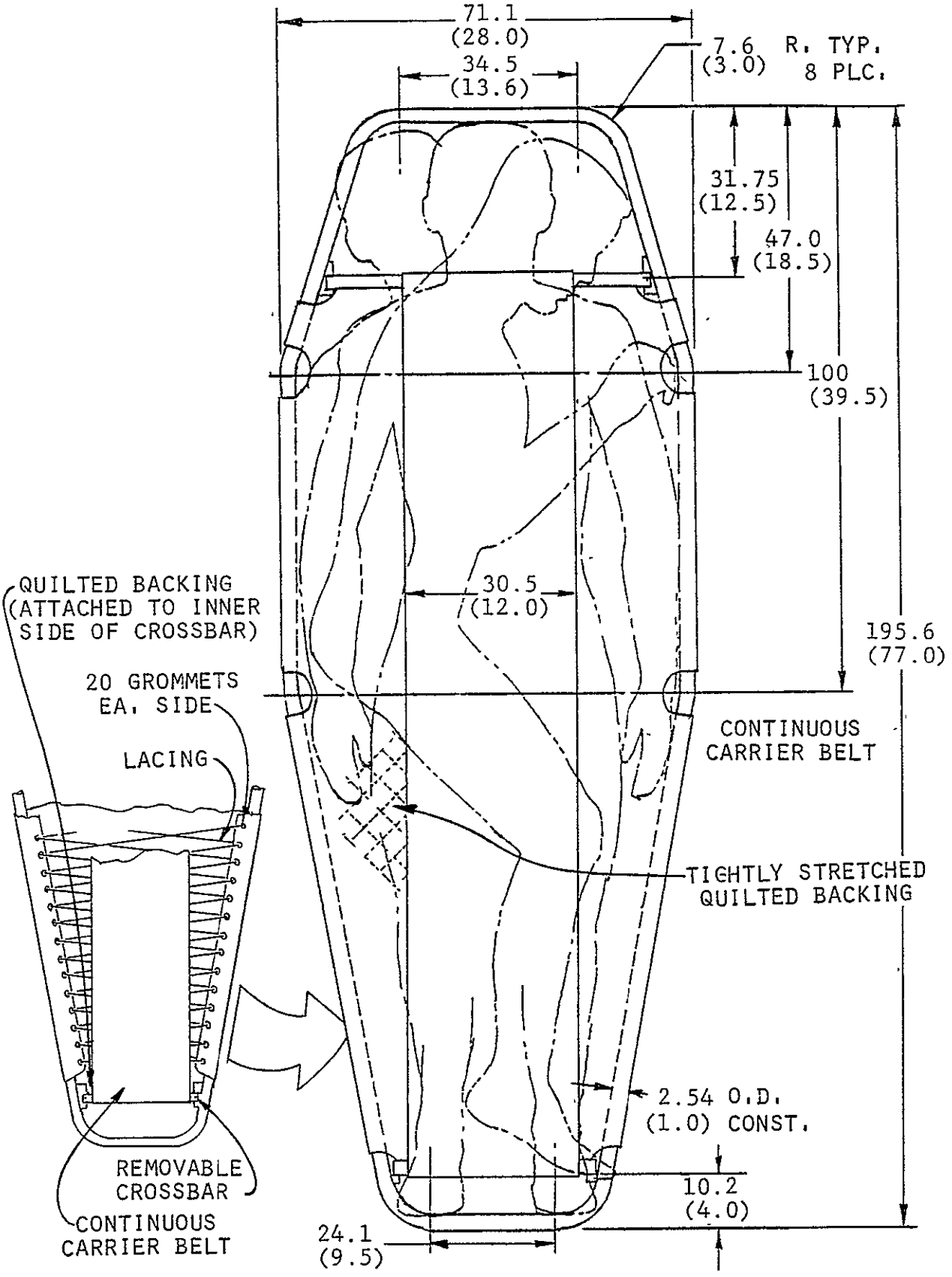


FIGURE 42 RECOMMENDED STANDARD SLEEP RESTRAINT FRAME DIMENSIONS

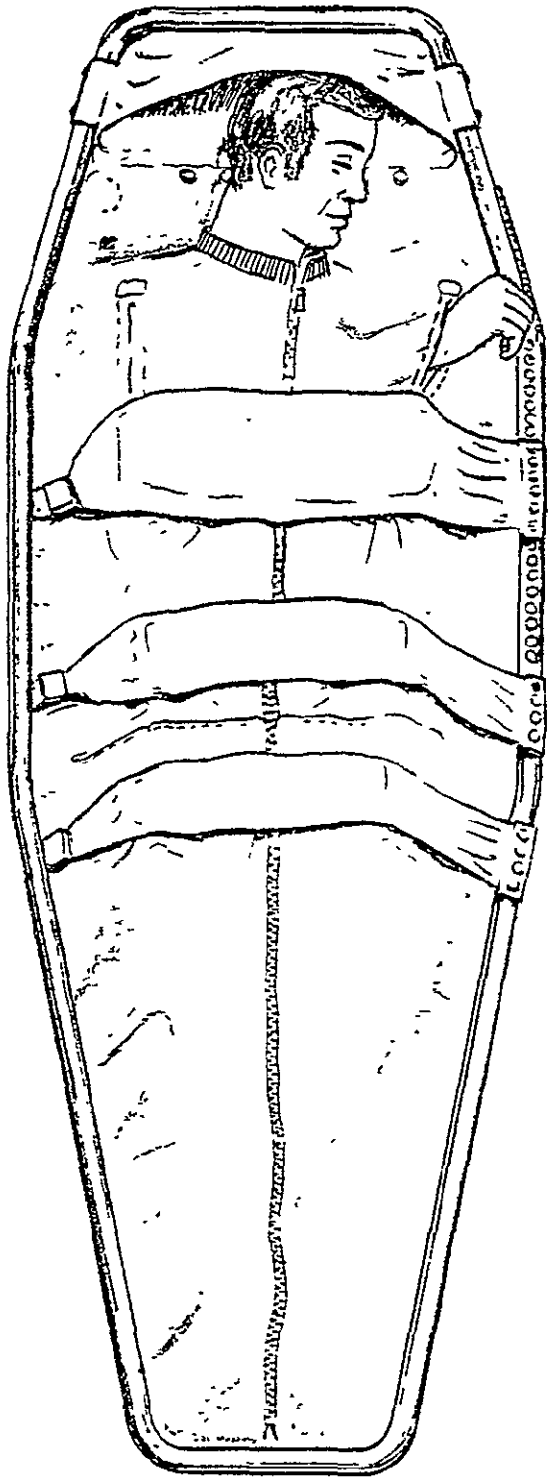
TABLE XV

PRELIMINARY DESIGN REQUIREMENTS AND
PROPOSED DESIRED FEATURES FOR SLEEP RESTRAINT

	JSC/EW54 REQUIREMENT SUMMARY	PROPOSED DESIRED FEATURES
Retention	Provide adjustable restraint capability for crew sizes from 5th percentile female to 95th percentile male.	
Ingress/Egress	Provide unencumbered ingress and egress, particularly rapid egress capability for emergency.	
Utility Openings	Provide arm openings to allow use of arms while in restraint.	
Thermal Flexibility	Provide adjustable thermal covering provisions.	
User Motion	Provide flexibility to permit body and limb flexure and full 360 degree yaw about the erect body axis.	Allow back, front and side sleeping postures with straight or bent legs.
Mounting Provisions	Provide integral mounting provisions for attaching device in sleep compartment.	Provide for easy removal or installation. Installed frame should be rigidly attached to prevent movement noise.
Use	Provide for split-shift use of a sleep compartment.	Provide for simplicity of split-shift changeout and ability to identify various components.

TABLE XV (CONTINUED)

	JSC/EW54 REQUIREMENT SUMMARY	PROPOSED DESIRED FEATURES
Use Rate	Restraint or restraint liner and pillow cover to be replaced on a weekly schedule.	
Materials	Compatible with NHB 8060-1A.	Provide comfort comparable to cotton fabric.



	95TH PERCENTILE MALE (ON SIDE)	5TH PERCENTILE FEMALE (ON BACK)	ADJUSTMENT REQUIRED	
TOP STRAP	129.5 51.0	81.3 32.0	48.3 19.0	CENTIMETERS INCHES
MID STRAP	109.2 43.0	78.7 31.0	30.5 12.0	CENTIMETERS INCHES
BOTTOM STRAP	99.1 39.0	71.1 28.0	27.9 11.0	CENTIMETERS INCHES

FIGURE 43 SLEEP RESTRAINT STRAP ADJUSTMENT REQUIREMENTS

TABLE XVI

SLEEP RESTRAINT CONCEPT SUMMARY

CONCEPT NO.	DESCRIPTION
1	Skylab Sleep Restraint - Straight adaptation of the Skylab restraint with only dimensional modification to fit Mid-Deck sleep compartments. As on Skylab, thermal comfort is controlled by adjusting three layers of blanket material. The top overblanket is fastened to the sleep restraint frame on three sides by a continuous zipper; this layer provides the greatest warmth. Beneath this layer is the sleeping liner made of a lightweight soft fabric having harmholes and an elastic neck ring for ingress/egress. This liner is attached to the frame through a peripheral zipper. A half blanket, covering only the top part of the body, can be used at the option of the crew member. When not in use, this half blanket is rolled up and stowed below the pillow. Three elastic straps provide restraint for the crew member's body. They are fastened to the sleep restraint frame on one end by a series of snaps with their length being adjusted by "D" rings located at the opposite ends. Restraint ingress/egress is through the neck ring. Pillow height is adjustable by varying the number of foam panels. A head restraint is provided to keep the crew member's head against the pillow.

TABLE XVI (CONTINUED)

CONCEPT NO.	DESCRIPTION
2	Modified Skylab-type Sleep Restraint - In addition to the dimensional modifications made in Concept 1, this approach incorporates several other changes. The overblanket is retained by a lightweight frame that holds the blanket away from the sleep restraint until pulled into place by the sleep restraint occupant. The sleeping liner has been divided into a top half and lower half which are joined together with velcro, providing the option to cover either the upper or lower part of the body while eliminating the separate half blanket. The liner upper half has a zipper which zips downward from the neck ring to facilitate ingress/egress. Utility armholes are also provided in the upper half. The zipper on the lower half opens upward, allowing the feet to be uncovered, if desired. Three restraint straps are used but the "D" rings have been replaced by quick-opening adjustable buckles. Normally, only the top strap needs to be opened to allow ample access. Additional snaps are mounted on equal centers to form a continuous row along one side of the sleep restraint frame. These snaps allow for up/down adjustment of the straps or even the addition of a fourth strap according to personal preference. The pillow features use of a single foam pad held with height adjustment tabs which snap onto the side frame. A pillow cover with a head restraint is provided. The pillow assembly is reversible. The different components are made of varying color shades for easier identification.
3	Whole Body Sheet Sleep Restraint - This restraint concept utilizes a single sheet of elastic stretch material which would act over the entire body, thus eliminating the need for straps. The restraint sheet wraps around the edges of the frame and is fastened to the bottom with a series of snaps. A zipper located in the front provides access for ingress/egress. The overblanket and pillow features are identical to Concept No. 2.

TABLE XVII

SLEEP RESTRAINT ALTERNATE USE CAPABILITY CONCEPTS

CONCEPT NO.	DESCRIPTION
1A	Replaceable Sleep Liner - This concept requires that the sleep liner be removed, folded and stowed by the arising crew member. The next crew member to use the sleep compartment would have to obtain a sleep liner and install it in the compartment before retiring.
2A	Reversible Frame Sleep Restraint Assembly - This concept specifically addresses the problem of sequentially sharing a sleep compartment by two crew members. Sleep restraints are mounted on both sides of the restraint frame. The frame can be mounted in the compartment with quick release fasteners. To reverse the frame for alternate crew member use, the frame could be partially removed, turned over and replaced in the compartment. Another scheme would have the frame mounted on head/foot tracks. In this case, the frame is raised, rotated 180 degrees, lowered and latched in place.
3A	Sleep Restraint with Belt Mounted Liners - Two lightweight sleeping liners are attached to a continuous carrier belt running along the vertical axis of the restraint frame. Each sleep liner is identical to that of Concept 2 (Table XVI). A single overblanket and single set of restraint straps are provided as in Concept 2. To change liners for the alternate crew member, the sides of the exposed liner are folded to the center, restrained by straps, and the belt is pulled to advance the alternate liner into its use position. A belt lock is provided.

TABLE XVIII

TRASH COMPACTOR CONCEPT DESCRIPTION

CONCEPT NO.	DESCRIPTION
1	Can Crusher - This concept is similar to the Skylab can crusher except that it permits successive crushing of cans and retains the cans from an individual meal in a trash bag which can be deposited through the 15.24-centimeter (6-inch) diameter wet trash access hatch.
2	Trash Compactor - This concept utilizes the space volume of one standard stowage locker to accommodate all crushable wet trash items. A trash stowage bag is inserted in the compactor compartment. After the bag has been filled with all meal trash items, the door is closed and the crew member operates the compactor to achieve compaction. Dual levers with ratchet gear advance mechanisms are incorporated to transmit torque to power screws which are installed on the sides of the compactor. The trash bag in a compacted state, is tied to ensure retention of the reduced volume. The bag is removed and deposited in the wet trash stowage compartment. A new trash bag is reinstalled in the compactor to be ready for the next cycle.

presented in Section 2.16. A baseline light location was also identified at one of the aft corners in the waste management compartment. A light installation for each sleep compartment was also indicated. No detailed evaluation of lighting was conducted, however, when problem areas were noted, they were identified.

2.15 Color Schemes Evaluation - An evaluation study as presented in Reference 18 was conducted to compare an alternate color scheme with the baseline light gray for walls and light green for lockers. The requirements for the alternate color scheme were reviewed based on meeting harmonious, aesthetic, functional, and contemporary usage rationale wherein:

- Warm and luminous colors are used in the main activity space to provide a tendency to increase alertness and outward orientation.
- Warm and bright colors are used in the small private confines of the personal hygiene and waste management area to provide a visually larger appearance.
- Cool but not cold colors are used in the sleep stations for a restful environment.
- Light flat colors are used on floors and walls to provide highly reflective surfaces without glare.
- Colors selected should be acceptable to large cross section of population.

The 1/10-scale Mid-Deck model was utilized with interior surfaces painted first to represent the baseline color schemes and then painted to represent the alternate color scheme selected to meet the above rationale. Color photographs of each representation were taken and presented in copies of Reference 18.

2.16 Scale Modeling Activity - A 1/10-scale model of the Mid-Deck area was constructed and utilized throughout the program as a visual aid to present various arrangement concepts. Scale models of the various items such as airlock, lockers, sleep stations, table, galley, commode seat, and waste management compartment door were constructed for the baseline configuration and then for the recommended configuration. Four 1/10-scale male dolls having height representative of the 95th percentile male and one smaller doll representing the 5th percentile female were also utilized. Figures 44 through 52 present some of the photographs that were taken during the scale modeling activity.

The scale model was utilized at two informal presentations held at JSC to acquaint the Technical Monitor and other interested parties with the progress of the study.

2.17 Full-Scale Mockup Activity - Full-scale mockups of the recommended configurations of the eating/work table, the sleep restraint, and the trash compactor were constructed. Figures 53 through 59 present photographs of these full-scale mockups. In addition, the Mid-Deck full-scale mockup at JSC was changed by the on-site mockup contractor to represent the recommended sleep station arrangement with maximum width horizontal compartments and bi-fold doors, a tilted commode seat installation, and representative waste management compartment door with angled top and sliding extension. This activity made final preparations to these metal/wood and foam core installations to give a uniform appearance and to highlight the location of certain features such as the washer/mirror on the aft side of the galley, the wet trash access opening, and the outline of a sleep restraint in the middle horizontal compartment. The eating/work table concept mockup was installed at the front of the foam core panel representing the forward locker tier. The major review of this mockup configuration representing the recommended architectural features was accomplished during the sixth month of the contract schedule. Subsequently, the sleep restraint mockup was completed and installed in the middle horizontal compartment. A separate review was held during the eighth month of the contract schedule for the sleep restraint and the trash compactor mockups.

2.18 Photographic Record - Tables XIX and XX summarize the color photographs taken to maintain a photographic record of the model and mockup activities, respectively. Copies of these color photographs were delivered to the Technical Monitor. The photographs of selected views showing the pertinent features were reprocessed and the black and white version included in this report, see Sections 2.16 and 2.17.

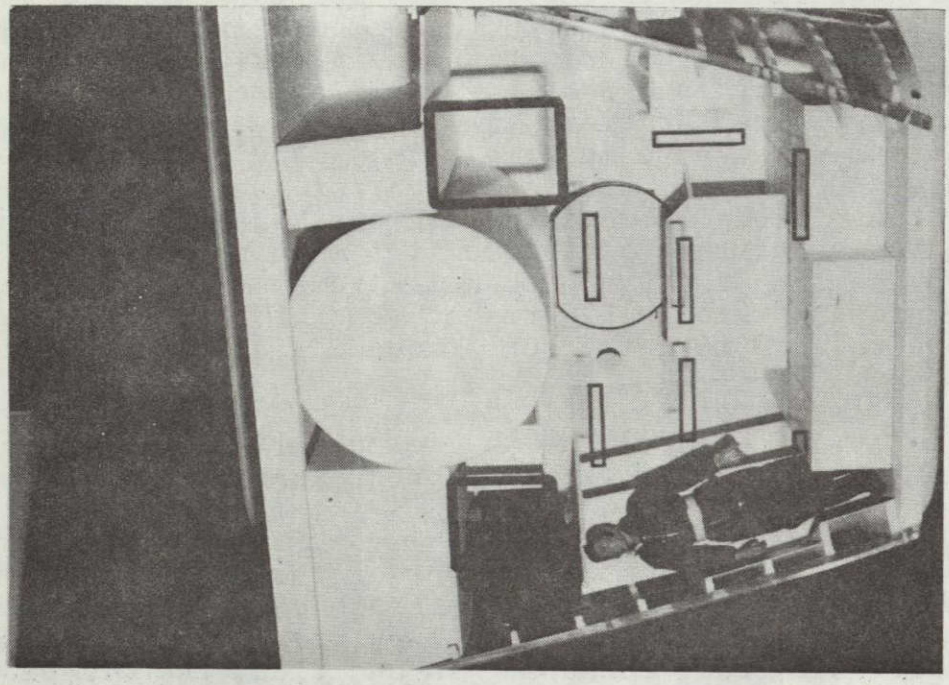


FIGURE 44 MID-DECK BASELINE ARRANGEMENT WITH CEILING LIGHT LOCATIONS (1/10-SCALE MODEL)

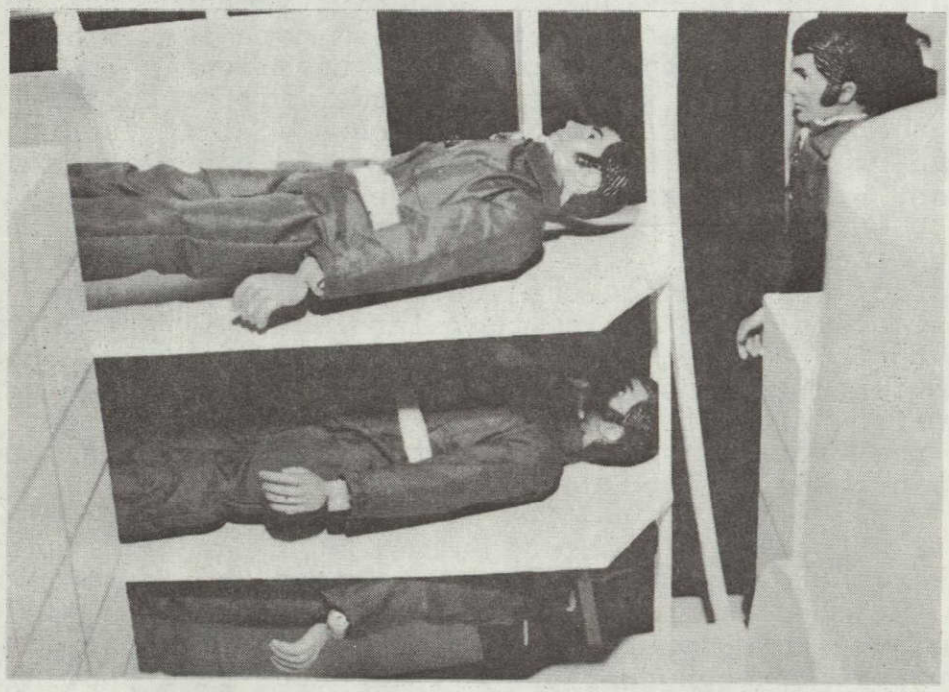


FIGURE 45 SLEEP STATIONS, RECOMMENDED CONFIGURATION (1/10-SCALE MODEL).

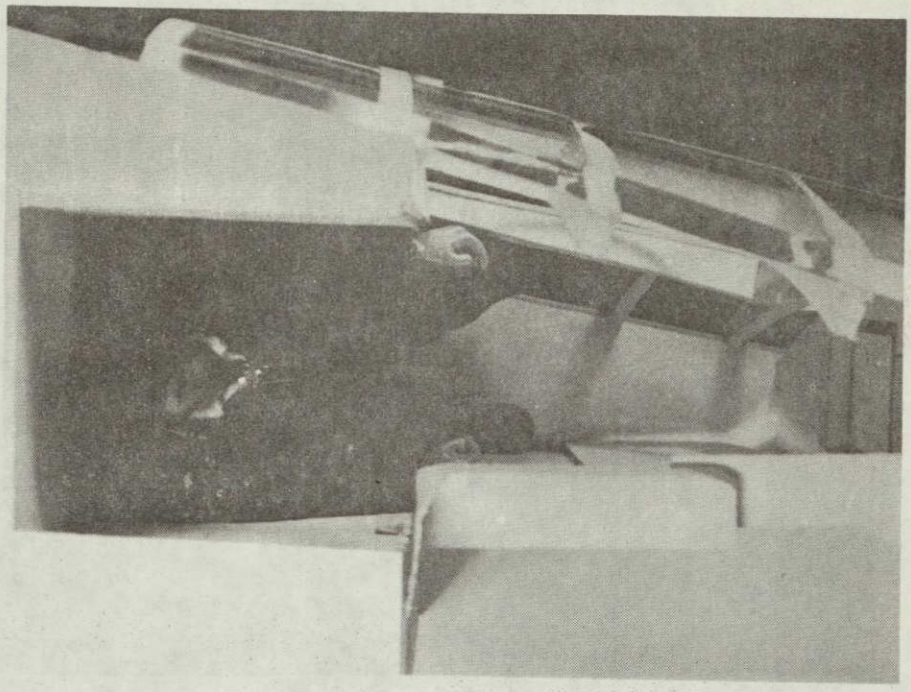


FIGURE 46 WASTE MANAGEMENT COMPARTMENT, RECOMMENDED CONFIGURATION (1/10-SCALE MODEL)

FIGURE 47 PERSONAL HYGIENE STATION, RECOMMENDED CONFIGURATION (1/10-SCALE MODEL)

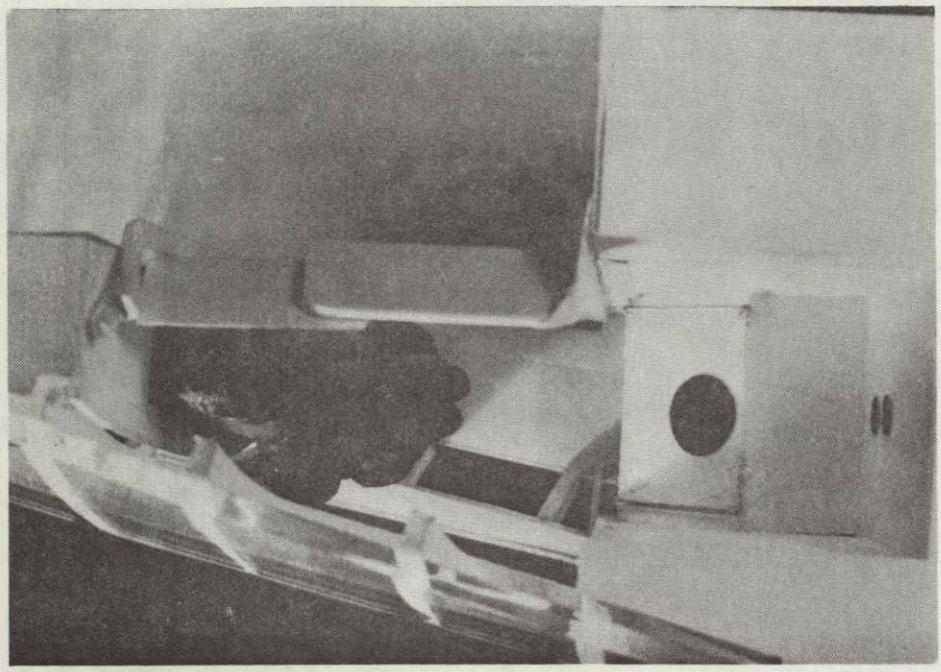


FIGURE 48 PERSONAL HYGIENE STATION, RECOMMENDED CONFIGURATION (1/10-SCALE MODEL)

FIGURE 49 EATING/WORK TABLE, RECOMMENDED CONFIGURATION INCLUDING AIRLOCK HATCH STOWAGE (1/10-SCALE MODEL)

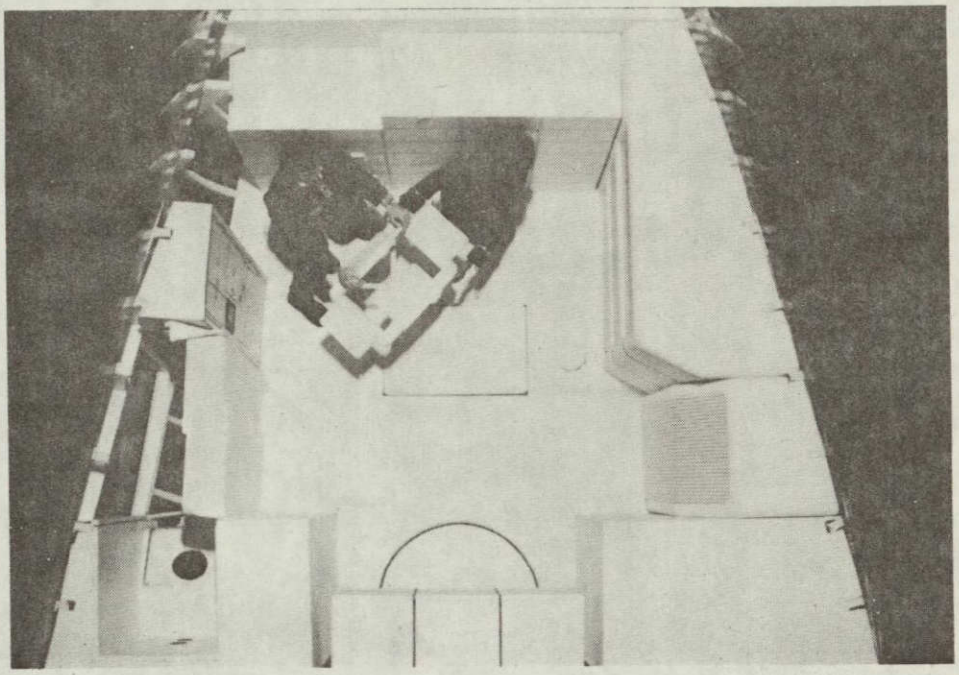


FIGURE 50 AIRLOCK REMOVED, RECOMMENDED ARRANGEMENT (1/10-SCALE MODEL)

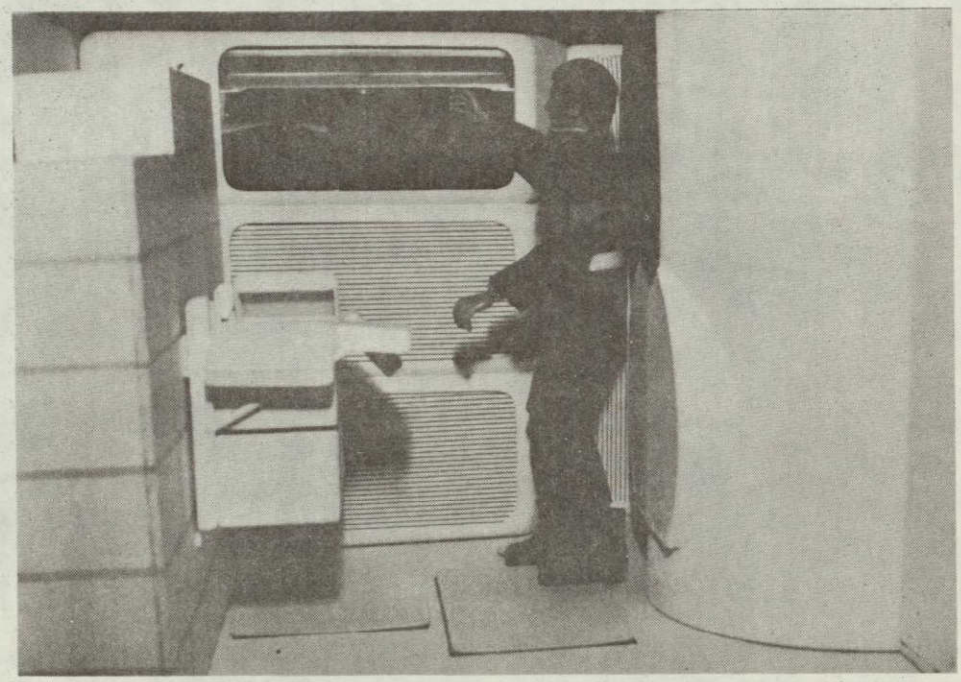


FIGURE 51 SLEEP COMPARTMENT ENCLOSURE, RECOMMENDED CONFIGURATION (1/10-SCALE MODEL)

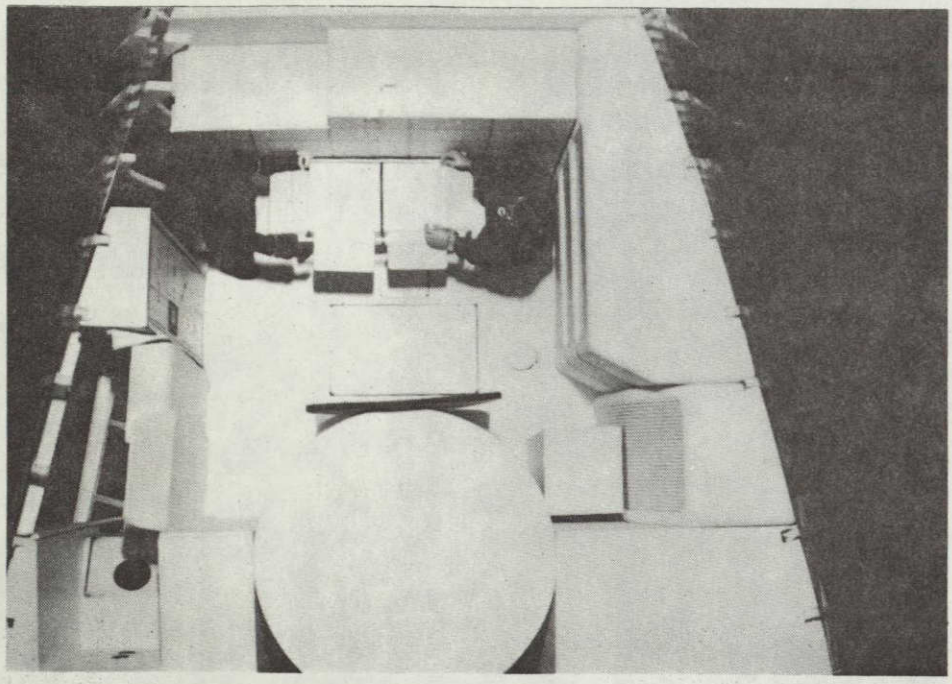


FIGURE 52 MID-DECK ARRANGEMENT WITH AIRLOCK, RECOMMENDED CONFIGURATION (1/10-SCALE MODEL)

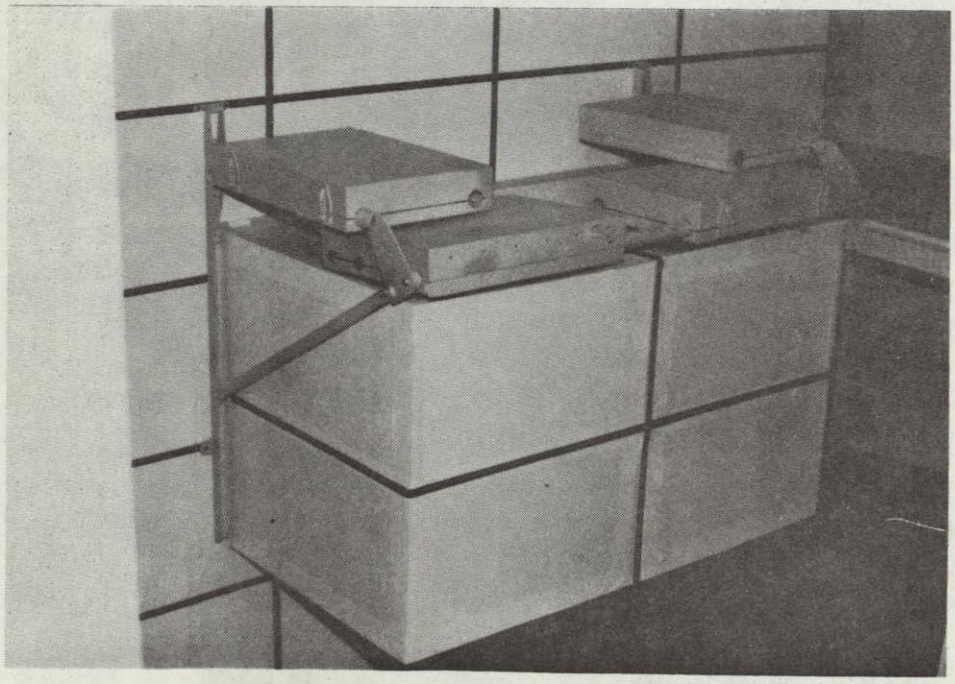


FIGURE 53 EATING/WORK TABLE MOCKUP INSTALLED IN MID-DECK MOCKUP (FULL SCALE)

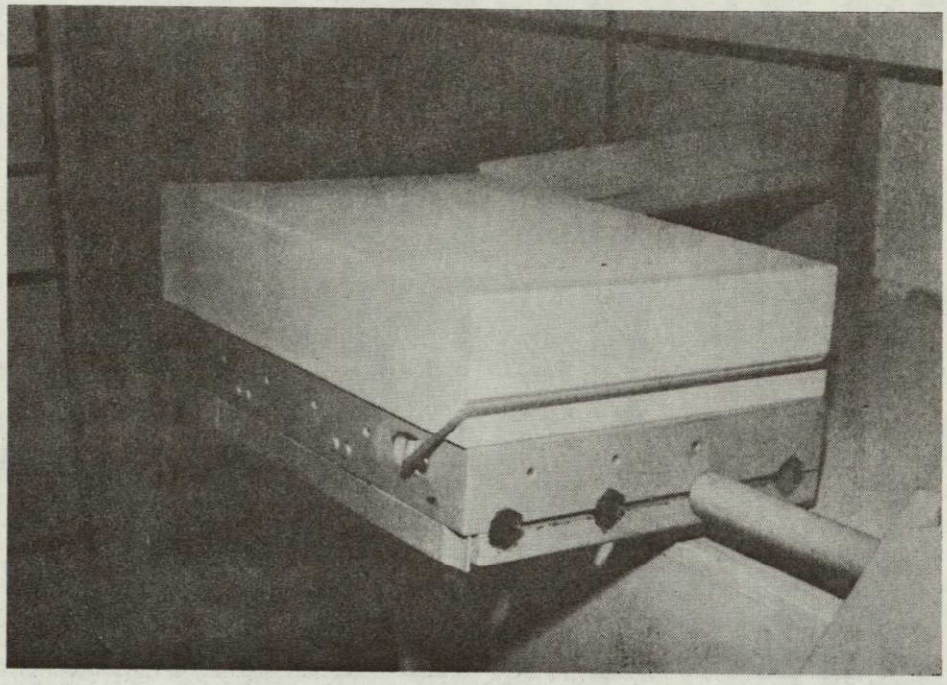


FIGURE 54 EATING/WORK TABLE MOCKUP SHOWING FOOD TRAY RESTRAINT CONCEPT (FULL SCALE)

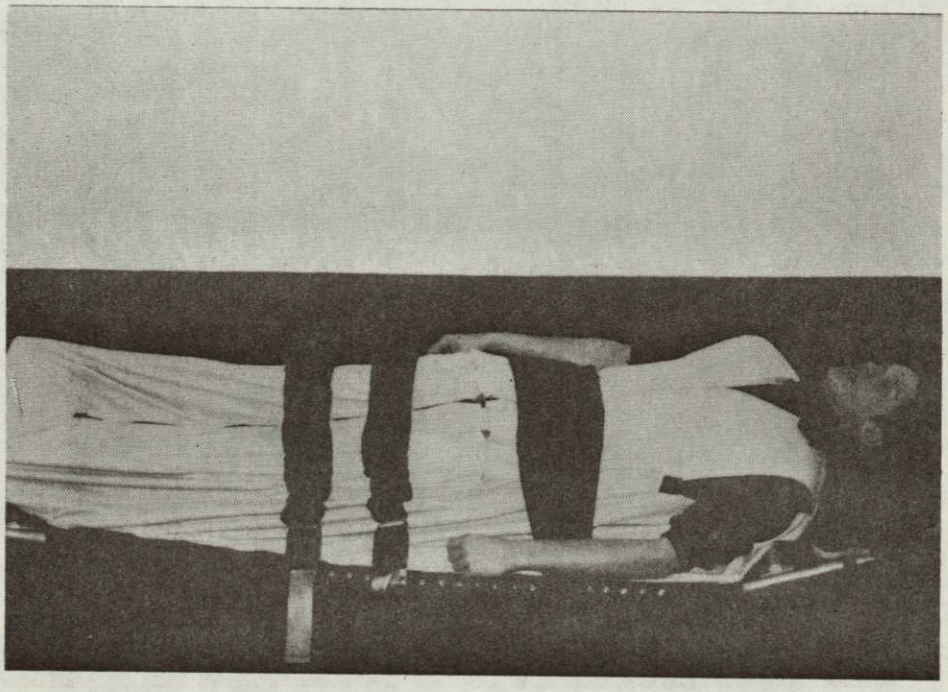


FIGURE 55 SLEEP RESTRAINT MOCKUP - 95TH PERCENTILE MALE

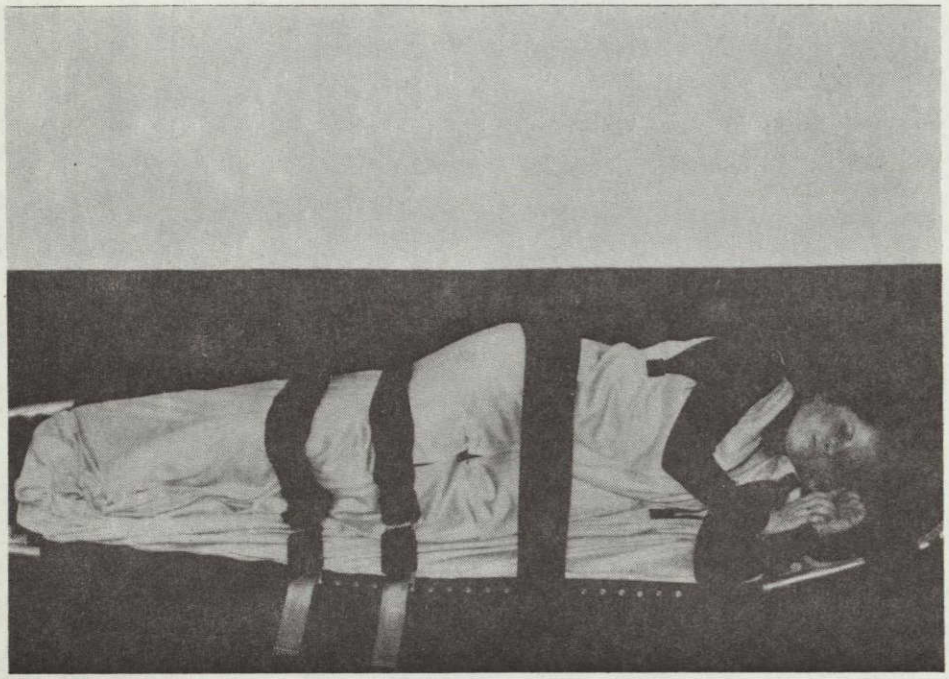


FIGURE 56 SLEEP RESTRAINT MOCKUP - 5TH PERCENTILE FEMALE

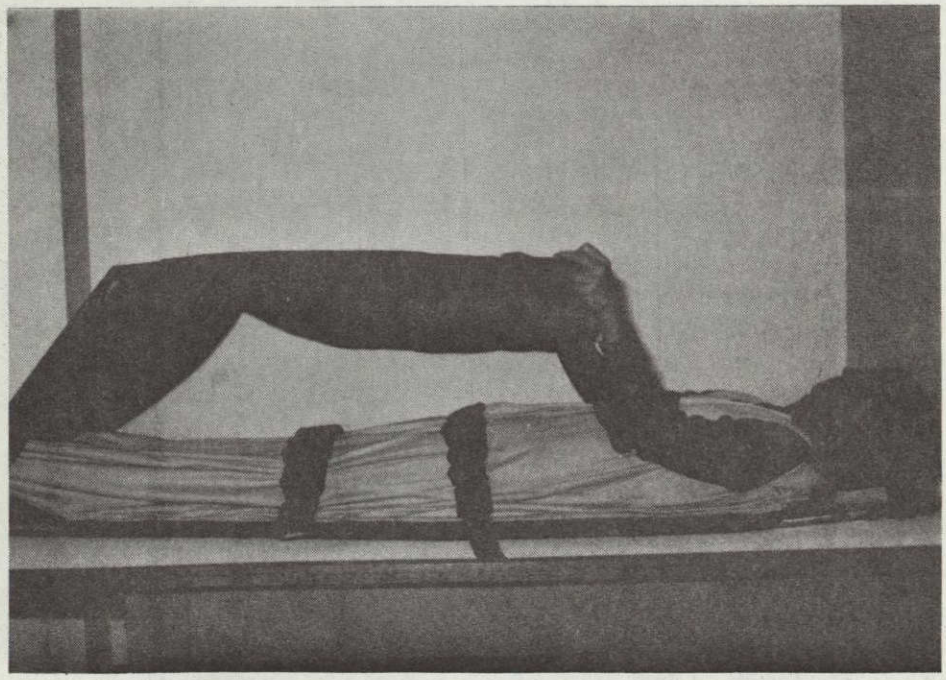


FIGURE 57 SLEEP RESTRAINT MOCKUP - 95TH PERCENTILE MALE - DEPLOYING OVERBLANKET

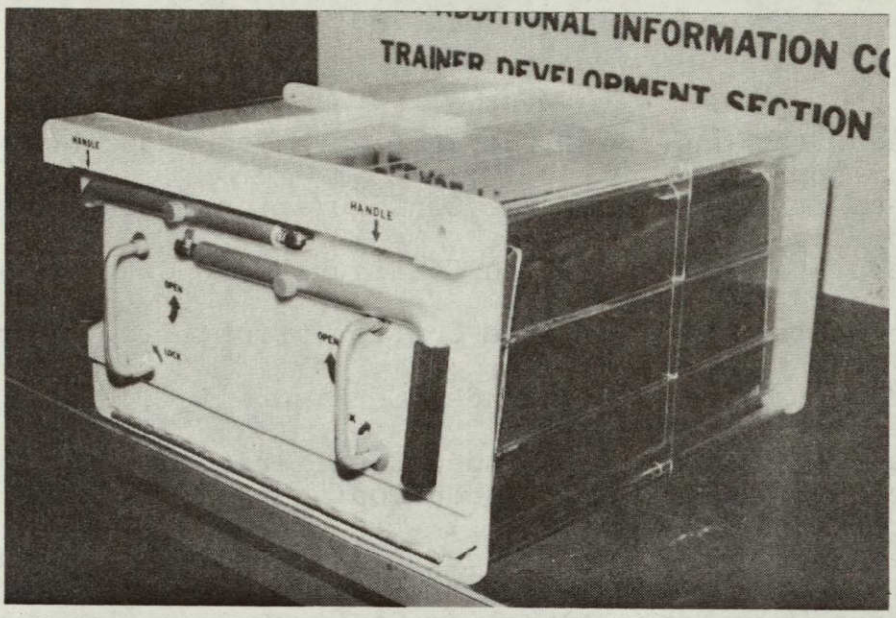


FIGURE 58 TRASH COMPACTOR - CONCEPT MOCKUP

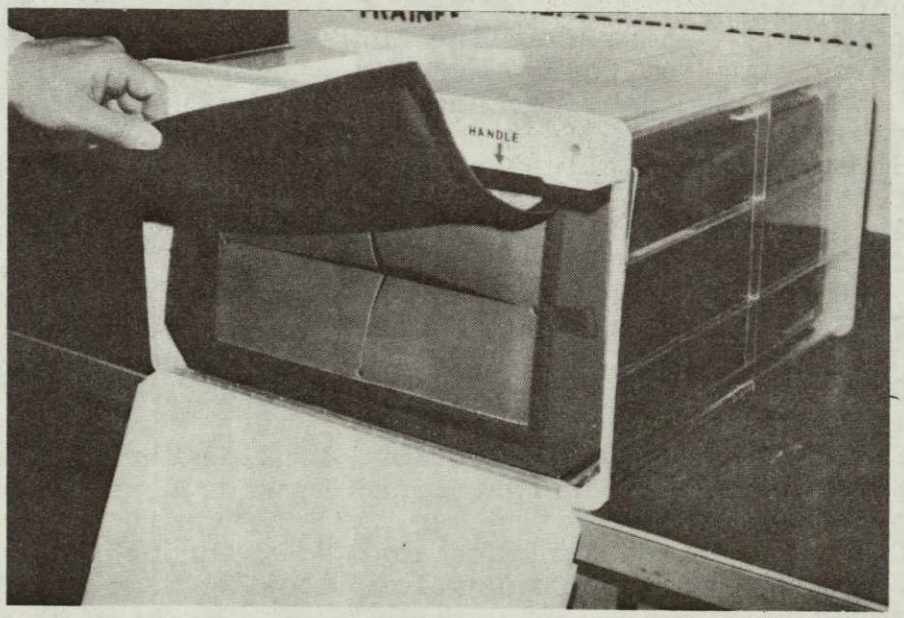


FIGURE 59 TRASH COMPACTOR - CONCEPT MOCKUP
SHOWING LINER BAG ACCESS

TABLE XIX

SCALE MODEL PHOTOGRAPHS

1. Sleep Stations, Baseline Configuration, Looking forward from top
2. Sleep Stations, Baseline Configuration, Looking outboard from top
3. Sleep Stations, Baseline Configuration, Closeup looking outboard
4. Sleep Stations, Baseline Configuration, View through ceiling
5. Sleep Stations, Recommended Configuration, Looking forward from top
6. Sleep Stations, Recommended Configuration, Looking outboard
7. Sleep Stations, Recommended Configuration, Closeup looking outboard
8. Sleep Stations, Recommended Configuration, View through ceiling
9. Eating/Work Table, Baseline Configuration, Looking forward from top
10. Eating/Work Table, Baseline Configuration, Looking from left side
11. Eating/Work Table, Baseline Configuration, Looking aft from top
12. Eating/Work Table, Baseline Configuration, Looking through left side (shows airlock hatch interference with use of floor)
13. Eating/Work Table, Baseline Configuration, Stowed position looking aft from top
14. PHS/WMC Area, Baseline Configuration with camera in side hatch window
15. PHS/WMC Area, Baseline Configuration with camera in side hatch window, looking outboard
16. WMC, Baseline Configuration, View through ceiling
17. WMC, Baseline Configuration, Looking down, ceiling removed
18. PHS, Baseline Configuration, Looking down
19. PHS, Baseline Configuration, Looking through left side
20. WMC, RI Proposed Configuration, View through ceiling
21. WMC, RI Proposed Configuration, Looking down, ceiling removed.
22. PHS, RI Proposed Configuration, Looking through left side
23. PHS, RI Proposed Configuration, Looking down, ceiling removed
24. WMC, Recommended Configuration, View through ceiling
25. WMC, Recommended Configuration, Looking down, ceiling removed
26. PHS, Recommended Configuration, Looking through left side
27. PHS, Recommended Configuration, Looking down, ceiling removed

TABLE XIX (CONTINUED)

28. Eating/Work Table, Recommended Configuration, Looking down, ceiling removed
29. Eating/Work Table, Recommended Configuration, Looking forward from side (also shown recommended airlock hatch stowage)
30. Eating/Work Table, Recommended Configuration, Looking from right (also shows recommended airlock hatch stowage)
31. Eating/Work Table, Recommended Configuration, Looking from right (also shows recommended PHS/WMC sliding door)
32. Eating/Work Table, Baseline Configuration, Looking from right (also shows baseline PHS/WMC curtain closure and airlock hatch stowage)
33. Eating/Work Table, Baseline Configuration, Looking from right side (also shows RI proposed PHS/WMC curtain closure and the airlock hatch stowage)
34. Airlock Removed, Recommended Arrangement View through ceiling (shows pedestal supported table, modular sleep compartments, PHS/WMC area with tilted seat, and lockers stowed on aft bulkhead)
35. Airlock Removed, Recommended Arrangement, Looking down with ceiling removed
36. Sleep Compartment Enclosures, Recommended Configuration, Looking from left (shows bi-fold door open, also recommended table assembly)
37. Sleep Compartment Enclosures, Recommended Configuration, Looking down (also shows recommended eating/work table and airlock hatch stowage)
38. Mid-Deck Arrangement (Airlock Installed) Recommended Configuration, View through ceiling
39. Mid-Deck Arrangement (Airlock Installed), Recommended Configuration, Looking down, ceiling removed
40. Mid-Deck Baseline Color Scheme Series
41. Mid-Deck Recommended Color Scheme Series

TABLE XX

FULL-SCALE MOCKUP PHOTOGRAPHS

1. Eating/Work Table Mockup installed at forward locker tier in Mid-Deck Mockup
2. Eating/Work Table Closeup showing food tray restraint concept
3. Eating/Work Table Mockup installed at forward locker tier in Mid-Deck Mockup showing table surfaces folded in non-use configuration
4. Eating/Work Table Mockup installed at forward locker tier in Mid-Deck Mockup showing table assembly
5. Sleep Restraint - 95th Percentile Male
6. Sleep Restraint - 95th Percentile Male (With Overblanket in Place)
7. Sleep Restraint - 95th Percentile Male (Side Position)
8. Sleep Restraint - 95th Percentile Male (With Overblanket Removed)
9. Sleep Restraint - 5th Percentile Female (Side Position)
10. Sleep Restraint - 5th Percentile Female (Back Position without Overblanket)
11. Sleep Restraint - 5th Percentile Female (Lower Blanket Removed)
12. Sleep Restraint - 5th Percentile Female (Upper Blanket Removed)
13. Sleep Restraint - 5th Percentile Female
14. Sleep Restraint - 5th Percentile Female (With Overblanket in Place)
15. Comparison of Subjects (95th Percentile Male and 5th Percentile Female)
16. Sleep Restraint (Liner in Stowed Position)
17. Sleep Restraint (Back Side)
18. Sleep Restraint - 95th Percentile Male (Flexing Knees Upward)
19. Sleep Restraint - 95th Percentile Male (Deploying Overblanket)
20. Sleep Restraint - 5th Percentile Female (Deploying Overblanket)
21. Sleep Restraint - 5th Percentile Female (Flexing Knees Upward)
22. Trash Compactor Concept Mockup
23. Trash Compactor Concept Mockup showing liner bag access

2.19 Reliability, Safety, and Quality Assurance - Although minimal in nature, reliability, safety, and quality assurance efforts were conducted as an integral part of the conceptual design effort. All recommended concepts are based on either similarity to items having prior flight use or the simplicity of the design concept indicates a high degree of success can be assured if a detailed design effort were to be pursued.

3.0 NEW TECHNOLOGY

3.1 Summary - The progress of the conceptual study was reviewed for potential new technology items. No subcontracts were involved that required invoking the new technology clause. All conceptual design effort was performed by in-house staff personnel and the selected items were duly reported to the JSC New Technology Officer. The following sections define the items selected for new technology reporting based on the premise that they are innovative new ideas with potential for use in other applications.

3.2 Eating/Work Table Concept - The eating/work table concept as shown in Figures 70 and 74 (Section 4.3) was reported as a new innovation for a table surface applicable to manned space flight. It provides a tilted surface which is compatible with the zero-g weightless posture expected when a crew member has feet restrained in front of the table to provide ease of accessibility to items on the surface. The hexagonal clamping feature will permit height adjustment to accommodate various size crew members. The table surface is detachable and can be used at other crew stations that have a hexagonal mounting bar.

3.3 Trash Compactor Concept - The trash compactor concept as shown in Figures 108, 109, and 110 (Section 4.8) was reported as a new innovation applicable to trash management onboard manned spacecraft. The concept provides for temporary stowage of crushable trash items. When the trash liner bag is full, the compactor is manually operated to reduce the bulk volume of the trash. The compressed trash liner bag is tied to help maintain its reduced volume. The compressed trash bag is removed for disposal and a new liner bag installed in the compactor housing.

3.4 Sleep Restraint Adjustable Buckle - The sleep restraint adjustable buckle concept as presented in Figure 102 (Section 4.7) was reported as a new innovation to allow two different size crew members to establish individual strap lengths when alternate use of a sleep restraint is required. A restraint strap is required to hold a sleeping person in place under weightless conditions. Two pressure plate units are installed on the nonelastic strap segment. The large knob is turned to release the pressure plate to allow movement of the unit along the strap for position adjustment. The knob is tightened so that the pressure plate is clamped against the strap web. A quick-release buckle unit is attached to the end of the elastic body strap. It is operable by one hand for releasing and connecting to the knob of the particular pressure plate unit desired.

3.5 Belt Mounted Sleep Restraint Liner - The movable belt concept to deploy a sleep restraint liner as presented in Figures 103 and 104, Section 4.7, was reported as a new innovation to avoid the need for removal/reinstallation of a sleep liner in a sleep restraint. When two crew members have to share the alternate use of a sleep compartment, the belt merely has to be pulled to deploy the particular sleep liner to be used. The alternate liner is automatically stowed in back of the restraint assembly. This concept minimizes crew procedure time to prepare the compartment and also eliminates the need to stow alternate liners elsewhere in the Mid-Deck area.

4.0 CONCLUSIONS

4.1 Airlock Hatch Stowage - The airlock hatch stowage evaluation as presented in Reference 10 determined that for a hinged hatch installation, the only point allowing the hatch swing to clear the baseline table installation was the segment line hinge point as used for the baseline hatch installation, Figure 60. Hinge points around the opening periphery will require crew procedures to move the table and four lockers out-of-the-way to allow hatch opening or closure. Although the baseline hatch swing does not interfere with the table/locker envelope, its stowage location blocks the use of floor area which will be required for restraint use by crew members at the table. Furthermore, access to floor stowage compartments will require additional crew procedures to swing the hatch out-of-the-way. The hatch stowage concept that appears to present the least interference from a habitability viewpoint is that shown on Figure 61 featuring an unhinged hatch design. The same version of this stowage concept with a detachable hinge design is given by Figure 62 and is considered as the only acceptable alternate should requirements to handle an unhinged hatch prove to be imcompatible with crew procedures. The stowage location for these latter two concepts requires a recessed opening in the ceiling in front of the airlock. A change to the ceiling secondary structure was found to be an acceptable approach during the Crew Station Review No. 12 held at Rockwell International, July 29-31, 1975.

4.2 Sleep Stations - As presented in Reference 11, the baseline concept and that proposed by the prime contractor were found to have insufficient width allowance for any orientation within the three horizontal stations to accommodate a 95th percentile sleep restraint frame size. Variations of an all-vertical arrangement were found to be incompatible with meeting size requirements for the largest crew member and do not appear to present the best utilization of the allocated sleep area dimensions. A version of the baseline configuration (3 horizontal/1 vertical sleep station compartments) utilizing the maximum available width for the horizontal compartments was found to provide a sleep station arrangement which can accommodate four 95th percentile crew members. Crew member orientation in this compartment arrangement is as follows:

Lower horizontal – facing down
Middle horizontal – facing up
Top horizontal – facing up
Vertical – facing forward.

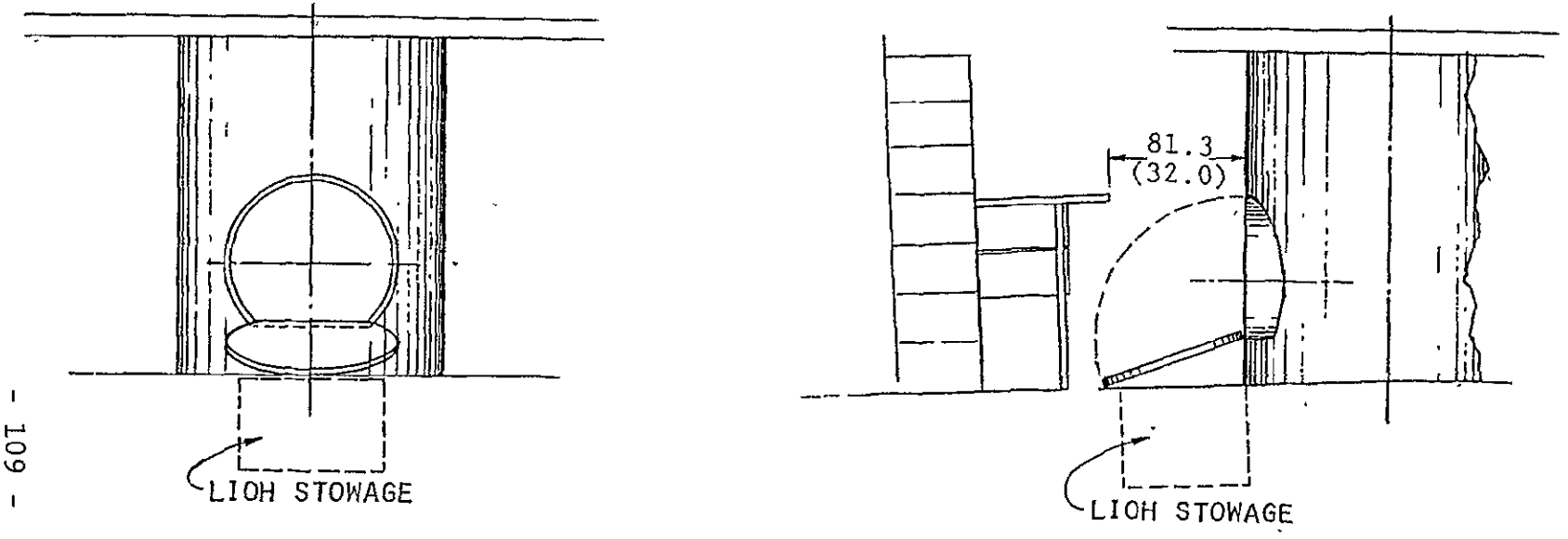


FIGURE 60 AIRLOCK HATCH STOWAGE CONCEPT - BASELINE

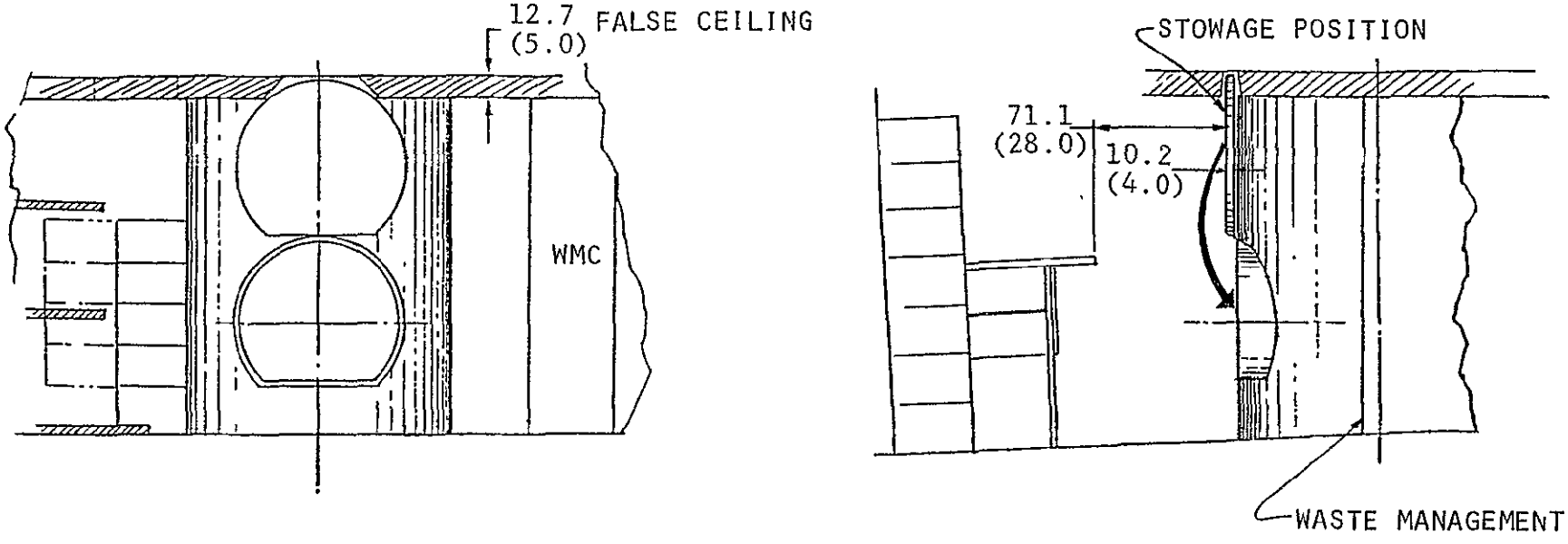


FIGURE 61 AIRLOCK HATCH STOWAGE CONCEPT - NO HINGE WITH RECESSED CEILING STOWAGE (RECOMMENDED CONCEPT)

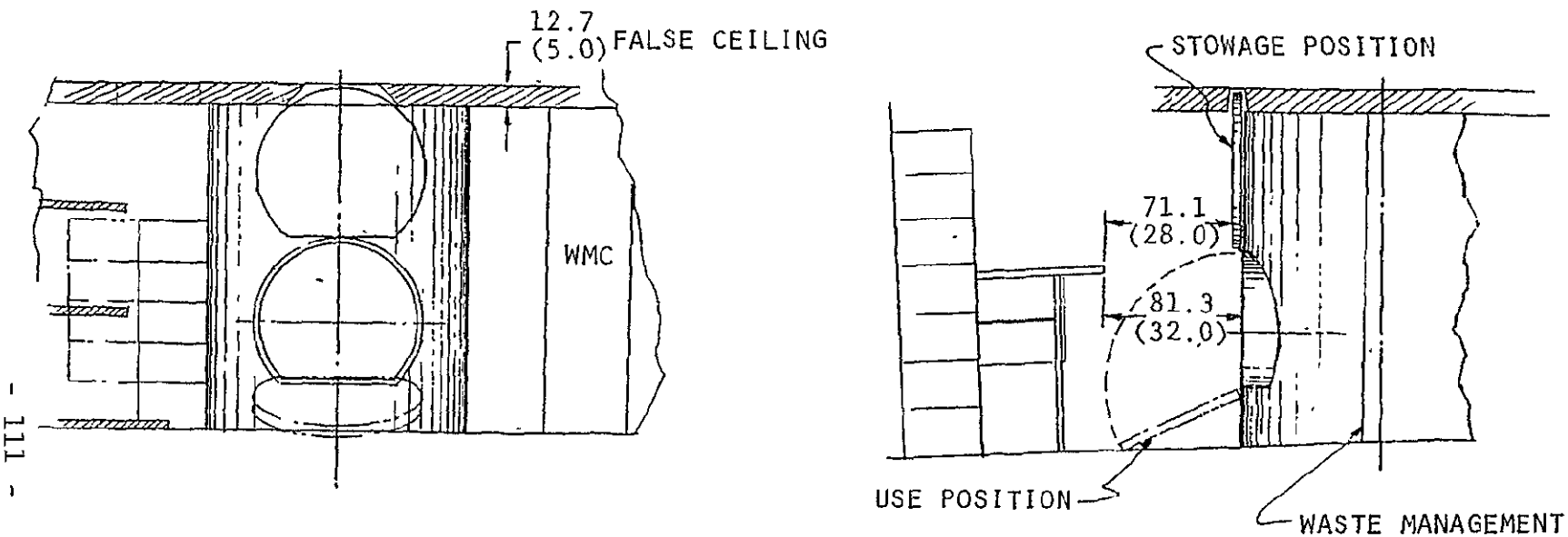


FIGURE 62 AIRLOCK HATCH STOWAGE CONCEPT - DETACHABLE HINGE WITH RECESSED CEILING STOWAGE

Figure 63 presents this arrangement based on the horizontal compartments having the same inboard location dimension which is approximately 94 centimeters (Y_o 37 inches) to the right of the Mid-Deck centerline.

Compartment provisions for closure, stowage, lighting, ventilation, intercom, and tape player were found to be satisfied without reduction of activity space for the above concept with the wider horizontal compartments. The space between the side wall frame was utilized as shown in Figure 63 to accommodate stowage requirements. Adequate space for temporary stowage of clothing and shoes appears feasible for individual use of a compartment. Dual clothing stowage was found to require division of the available space in half to provide separate spaces in compartments if utilized by different crew members on a split-shift schedule. The resulting reduced space will require compact folding of the clothing items as compared to loosely folded clothing on a larger individual stowage basis.

Of several closeout concepts reviewed, a modular appearing closeout featuring bi-fold access doors as shown in Figure 64 was considered the best concept to enhance the Mid-Deck appearance. This closeout concept utilizes rigid closeout material to provide individual privacy and sound/light attenuation from the general Mid-Deck area. In order to enable sleep compartment reconfiguration for certain missions requiring less than four sleep stations and to provide accessibility to mission stowage areas or items in the sleep station area, it was determined that this hard closeout method will require removable panels such as indicated by Figure 65. In addition, a mounting method for the horizontal sleep restraint assemblies as shown in Figure 66 will be required to permit access to the four stowage lockers initially located in the vertical sleep station area for launch and return phases. Figure 67 illustrates the procedure that can permit relocation of these four lockers by a crew member. Access to a forward floor stowage compartment can be accomplished by having the lowest forward closeout panel hinged. Figure 68 illustrates the method by which access can be gained to the forward floor compartment.

4.3 Eating/Work Table - As determined by the evaluation study presented in Reference 12, the main disadvantage with the baseline table concept was the lack of height adjustment and blockage of traffic flow when table positions in front of the airlock were occupied. A table height difference of approximately 13 centimeters (5 inches) ranging from 97 centimeters (38 inches) for a 5th percentile female and 109 centimeters (43 inches) for a 95th

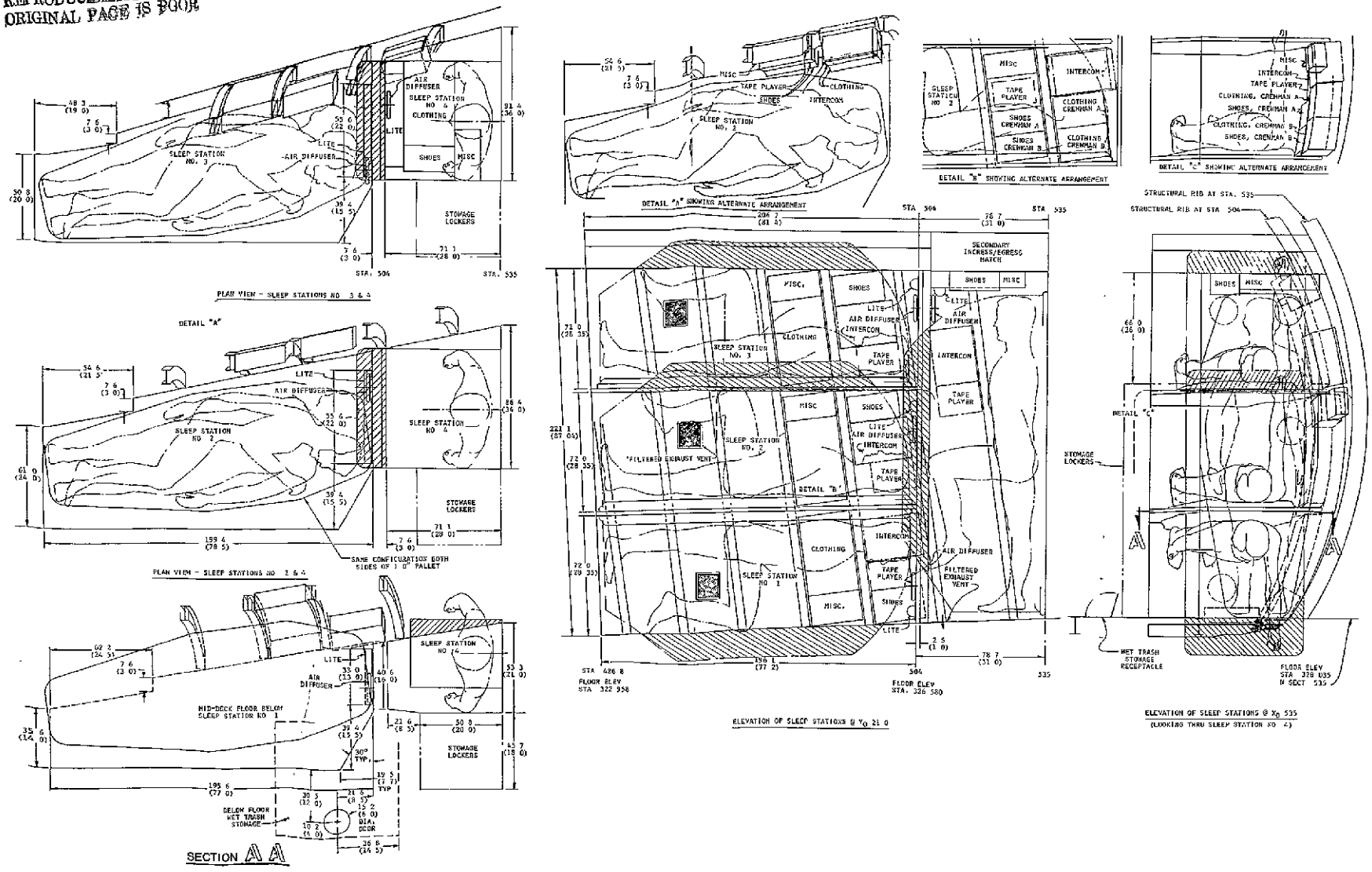


FIGURE 63
SLEEP STATION ARRANGEMENT,
RECOMMENDED CONCEPT

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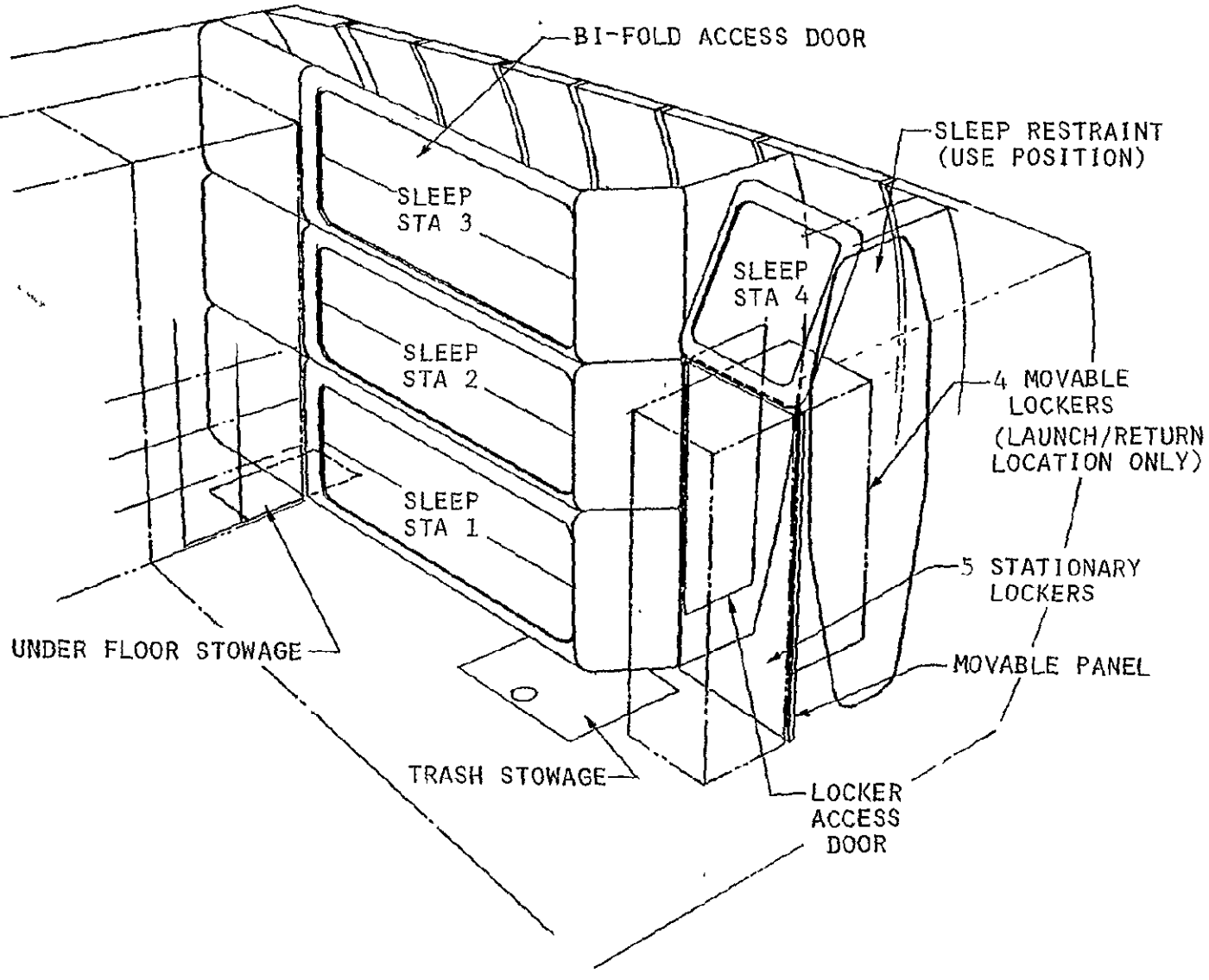
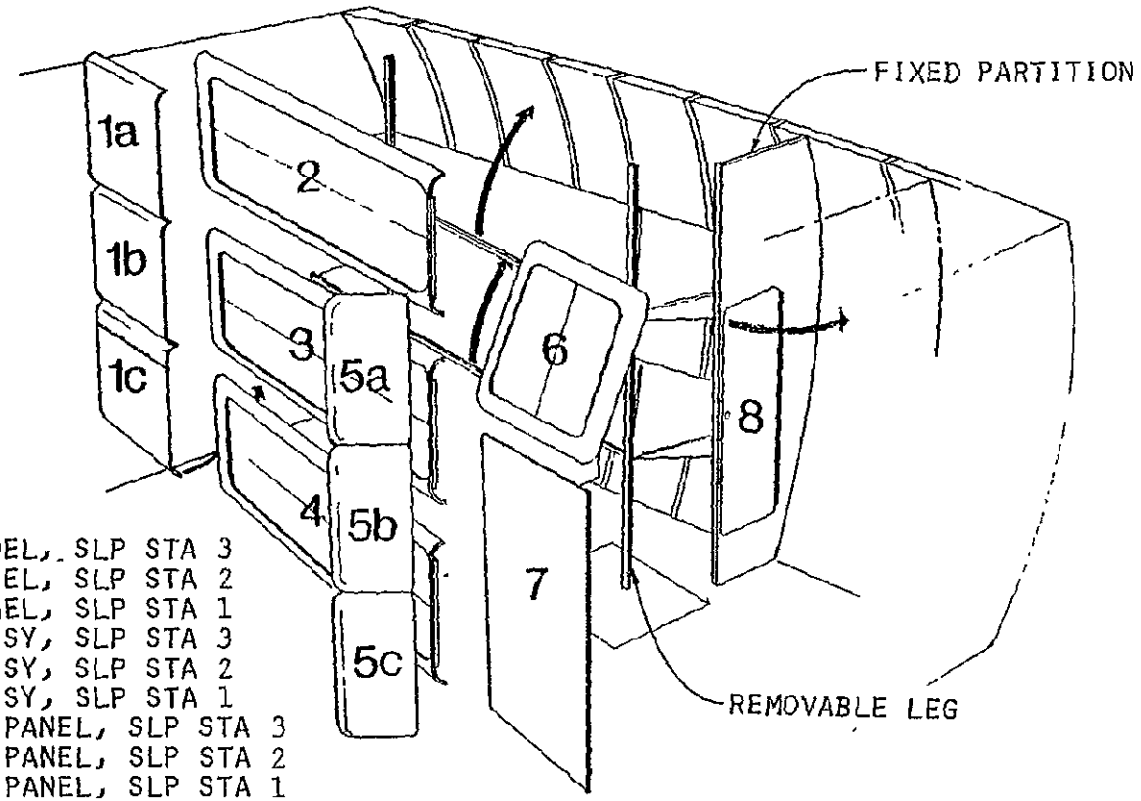


FIGURE 64 MID-DECK SLEEP STATION MODULAR CLOSEOUT CONCEPT



1a	FWD PANEL, SLP STA 3
1b	FWD PANEL, SLP STA 2
1c	FWD PANEL, SLP STA 1
2	DOOR ASSY, SLP STA 3
3	DOOR ASSY, SLP STA 2
4	DOOR ASSY, SLP STA 1
5a	CORNER PANEL, SLP STA 3
5b	CORNER PANEL, SLP STA 2
5c	CORNER PANEL, SLP STA 1
6	DOOR ASSY, SLP STA 4
7	MOVABLE PANEL, SLP STA 4
8	LOCKER ACCESS DOOR

FIGURE 65 SLEEP STATION CLOSEOUT REMOVABLE PANEL CONCEPT

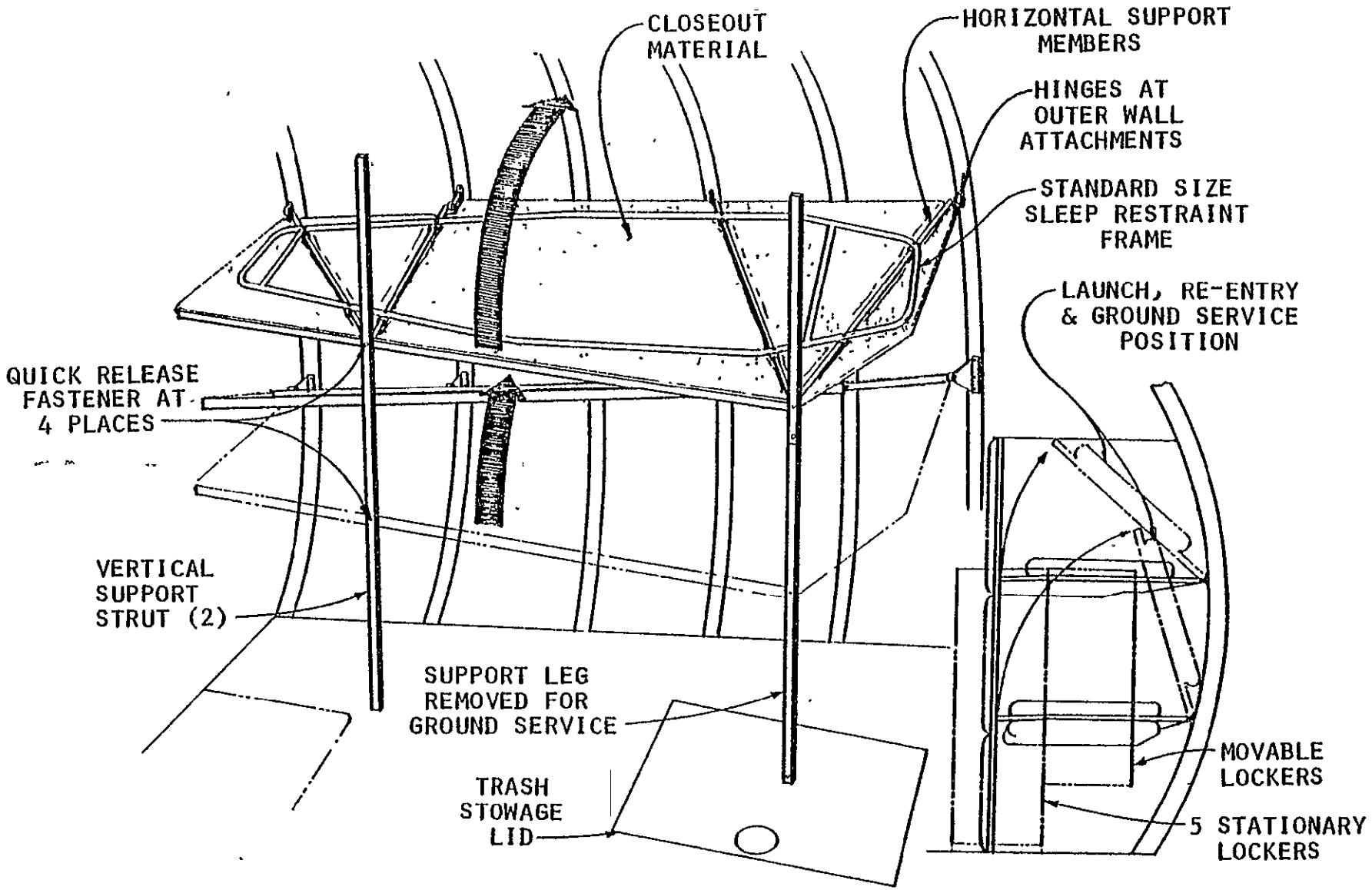


FIGURE 66 HORIZONTAL SLEEP RESTRAINT FRAME SUPPORT CONCEPT

ON ORBIT PROCEDURE

1 LOCKERS REMOVED THRU AFT ACCESS OPENING AND PASSED OUT OF SLP STA 1 OR 2
2 LOCKER ACCESS DOOR CLOSED
3 MOVABLE PANEL SECURED AGAINST STATIONARY LOCKERS
4 SLEEP RESTRAINT SWUNG INTO PLACE
5 SLP STA 3 FRAME SWUNG INTO PLACE
6 SLP STA 1 & 2 FRAME SWUNG INTO PLACE
7 PERSONAL LIGHT SWUNG INTO PLACE

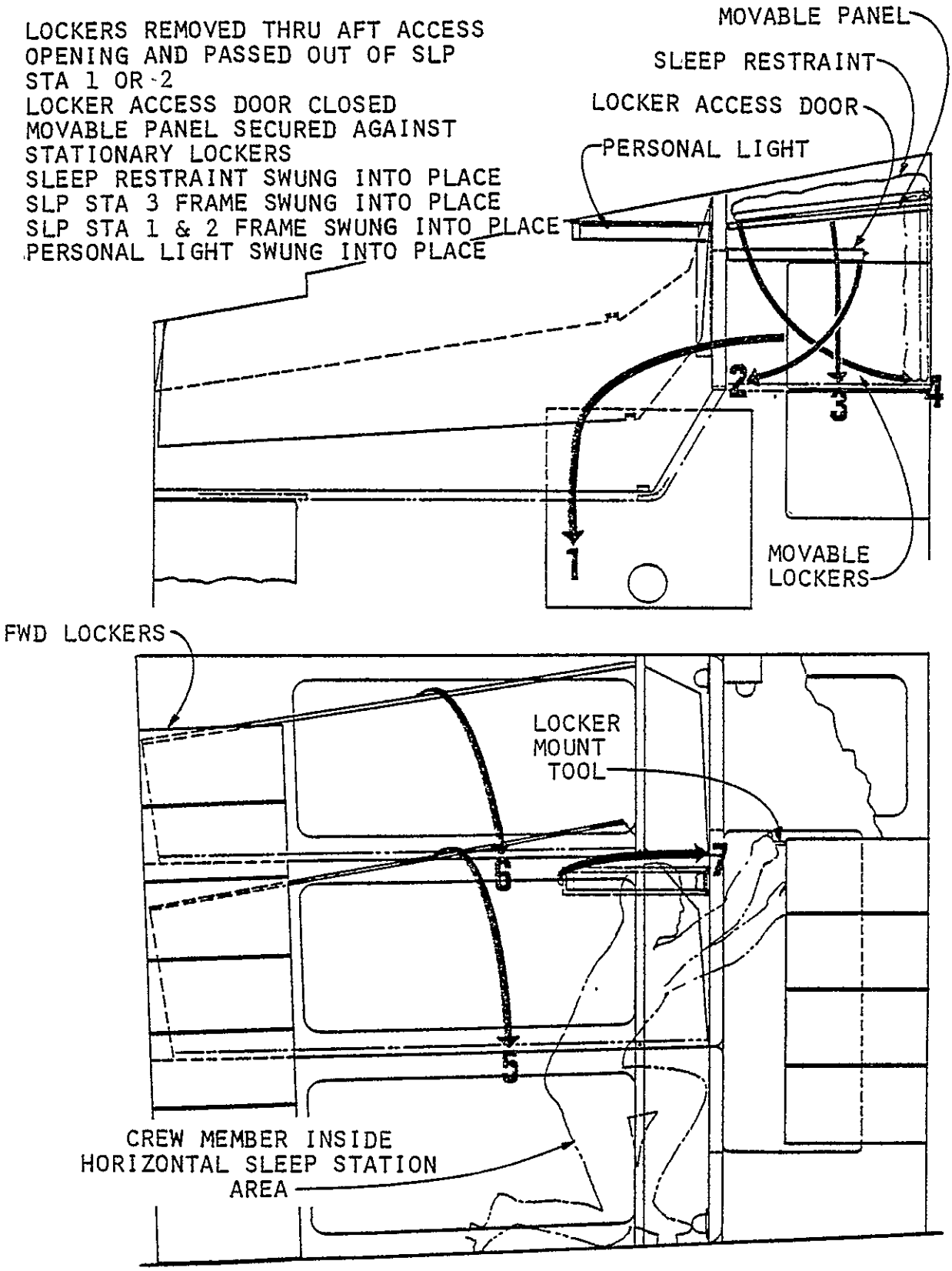


FIGURE 67 ILLUSTRATED PROCEDURE FOR REMOVAL OF LOCKERS IN SLEEP STATION AREA

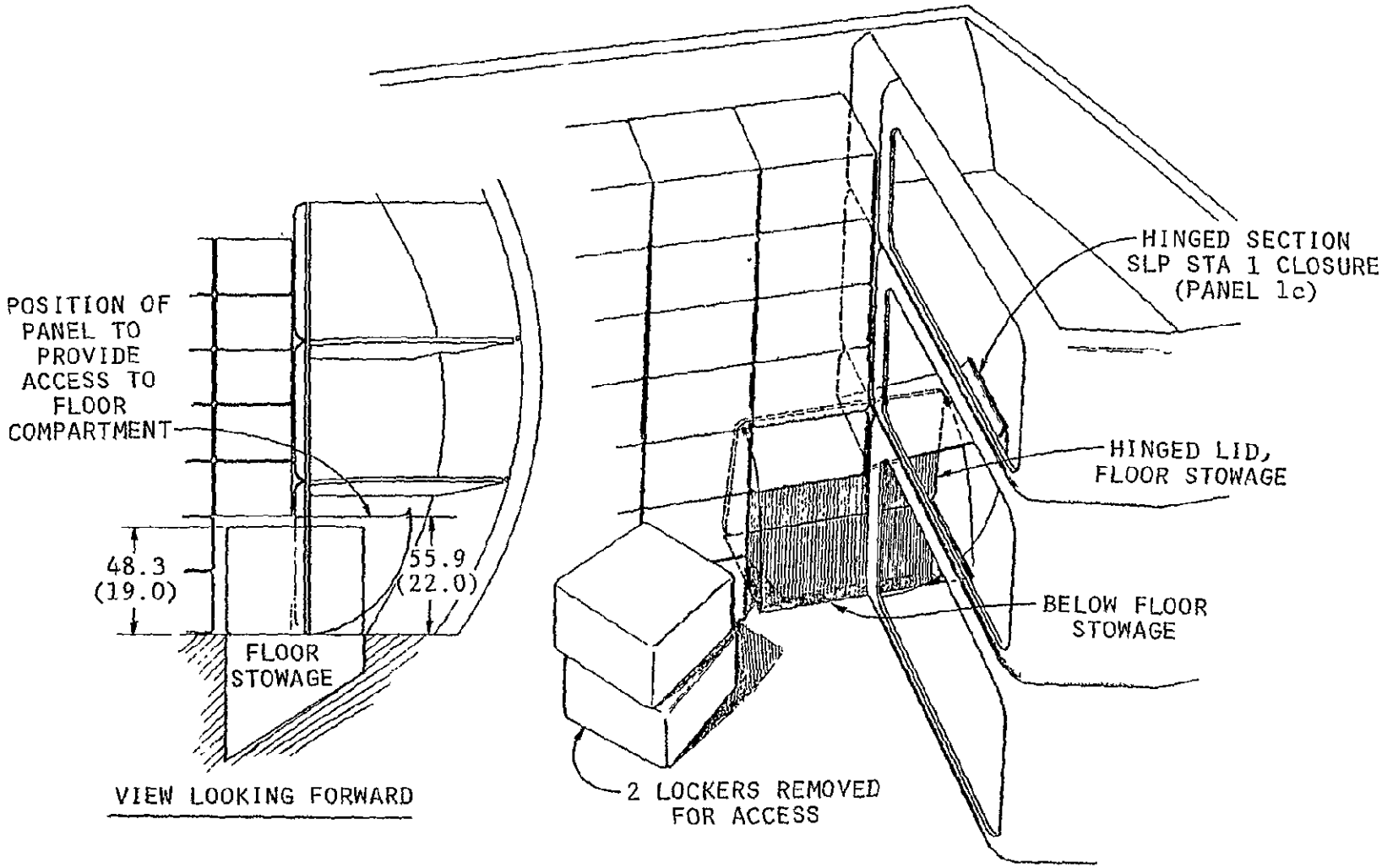


FIGURE 68 FLOOR STOWAGE COMPARTMENT ACCESS PROVISIONS

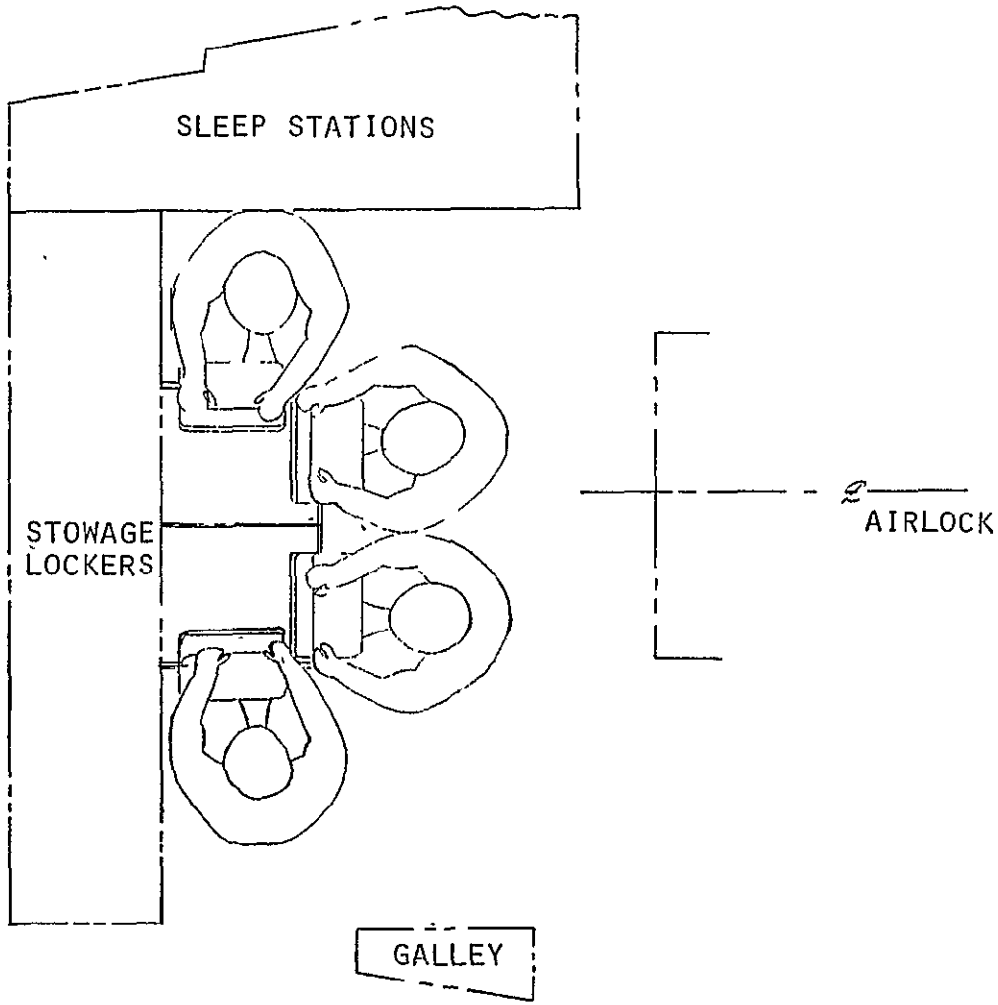
percentile male was found to be required. Use of a single table surface to accommodate four crew members of various heights would require a mutually acceptable average table height. Of several alternate concepts considered, it was found that the concept featuring individual tilted surfaces would allow the crew members to be grouped closer around the four modular stowage lockers that have to be stowed under the table and present the least impact on traffic flow when table positions are occupied. The individual table surfaces permit height adjustment for the required range of crew sizes and the tilt feature positions the food tray in a closer tray-to-mouth location for zero-g eating. Figure 69 presents this table concept and shows that the four positions are similar to the baseline such that dining crew members will be in a face-to-face arrangement. Figure 70 illustrates the supporting framework and the four individual table surfaces. The framework is supported at the forward locker tier in a manner similar to the baseline table. The individual table surfaces can be positioned as shown in Figure 71 for a horizontal orientation when not in use. The entire assembly can be swung up as shown in Figure 72 to permit access to the lockers behind the frame assembly. The entire frame and table surfaces can be collapsed as shown in Figure 73 for the launch/return position.

Of the various table utility features evaluated, a retractable bungee cord concept was considered as the most feasible method to accommodate both retention of the food tray and to permit use of the table surface for desk duties, i.e. paper retention or a work surface to retain small items. Figure 74 illustrates the multiple, retractable bungee cord concept. The food tray will be required to have side slots so that the outer cords can be utilized to hold the tray to the surface. Each cord is fitted with a plug that can be inserted into any hole around the periphery of the table edge. This concept allows a variety of cord positions to help hold papers, books, pencils, etc.

The review of the full-scale table assembly mockup resulted in the following change considerations.

a. The retractable bungee restraint concept in the table surface assembly should be reversed so that the bungee probes are pulled out from the lower edge and inserted at the top edge so that the hole location can be easily seen.

b. The two end positions at the table place the arms of larger personnel against the locker surfaces. By making the table frame wider by 2.54 centimeters (1.0 inch) should alleviate this



PLAN VIEW

FIGURE 69 EATING/WORK TABLE RECOMMENDED CONCEPT - PLAN VIEW (USE POSITION)

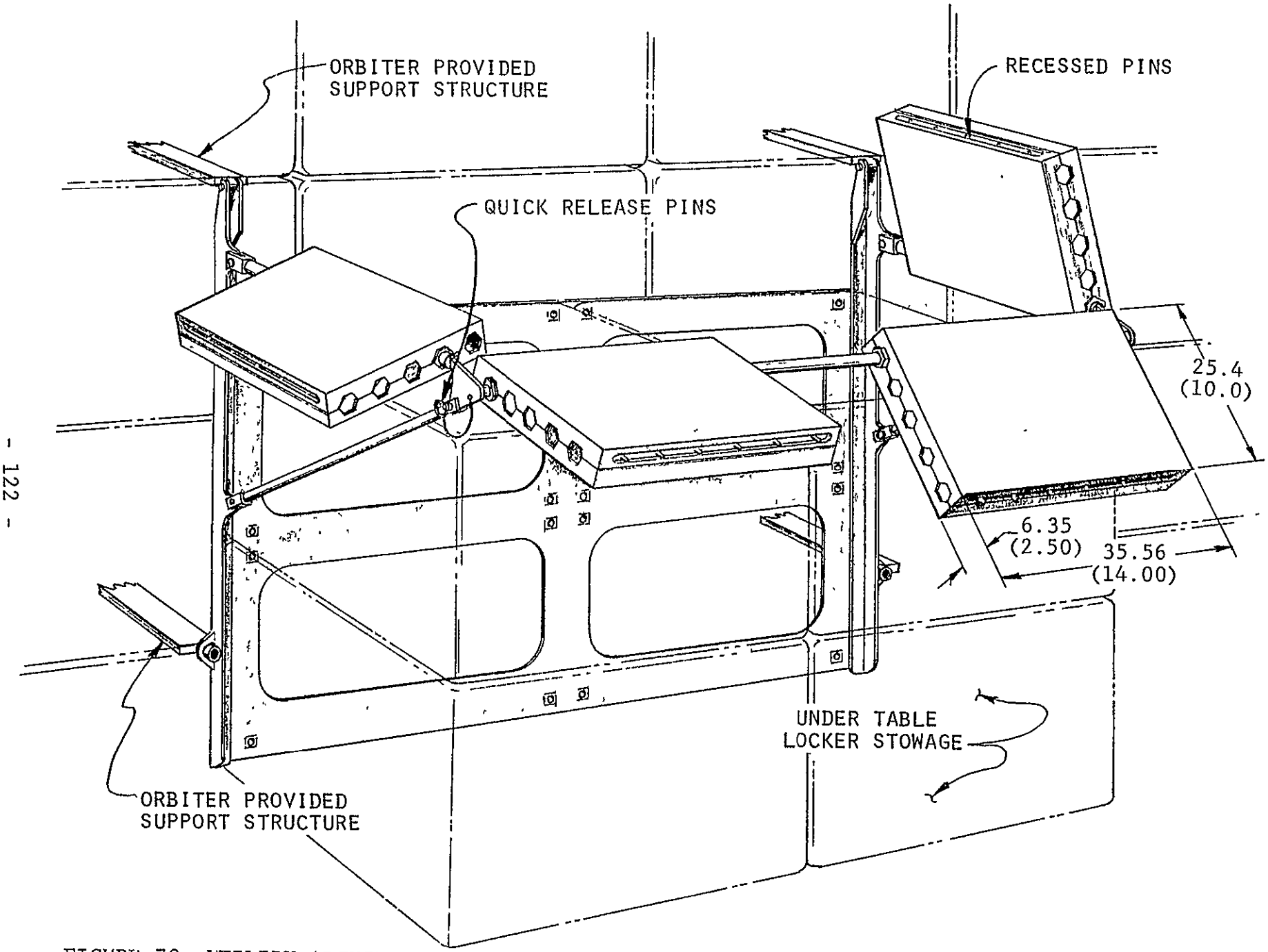


FIGURE 70 UTILITY ADJUSTMENT AND MOUNTING CONCEPT FEATURES FOR EATING/WORK TABLE

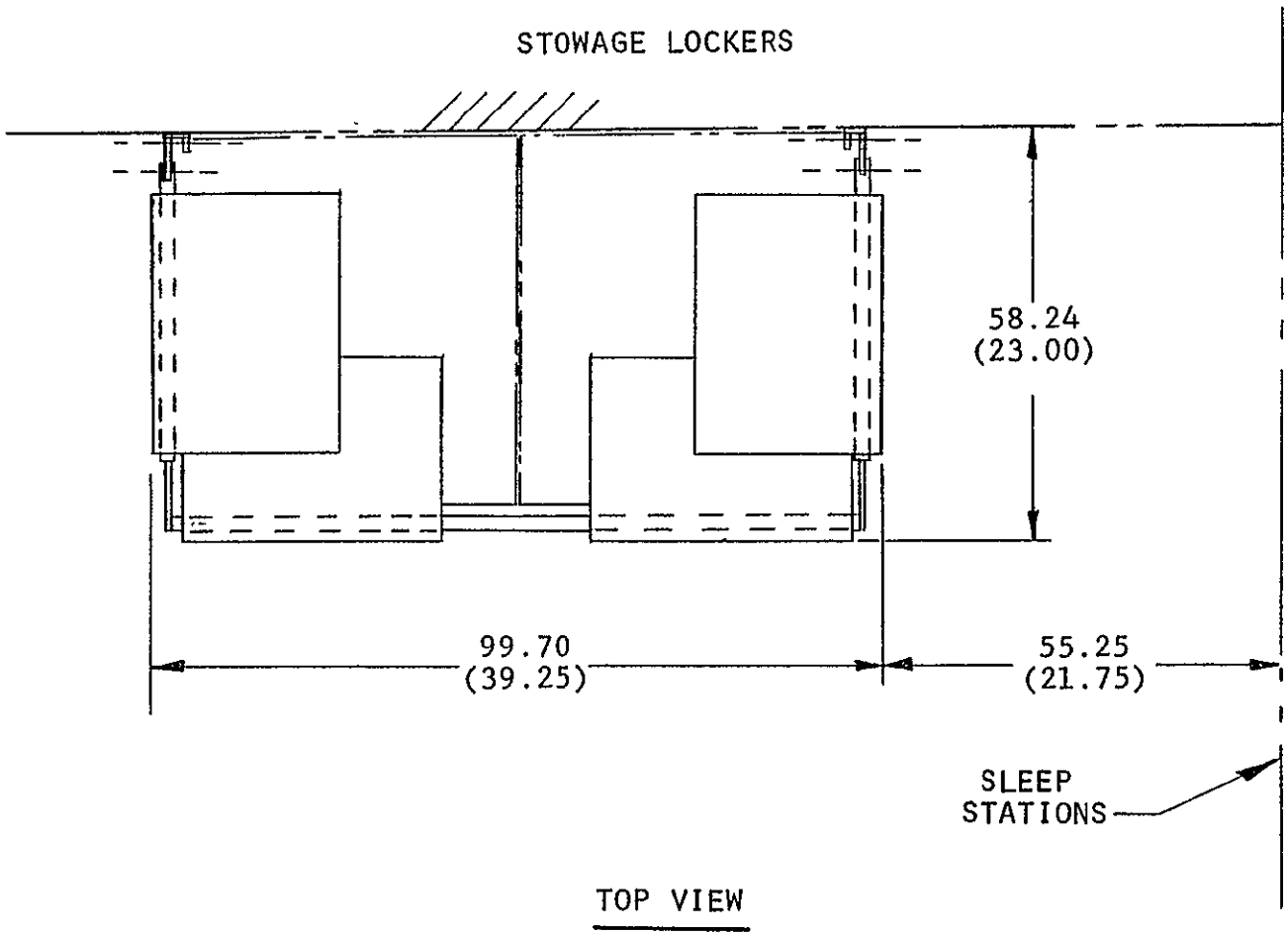


FIGURE 71 EATING/WORK TABLE RECOMMENDED CONCEPT - TOP VIEW (NON-USE POSITION)

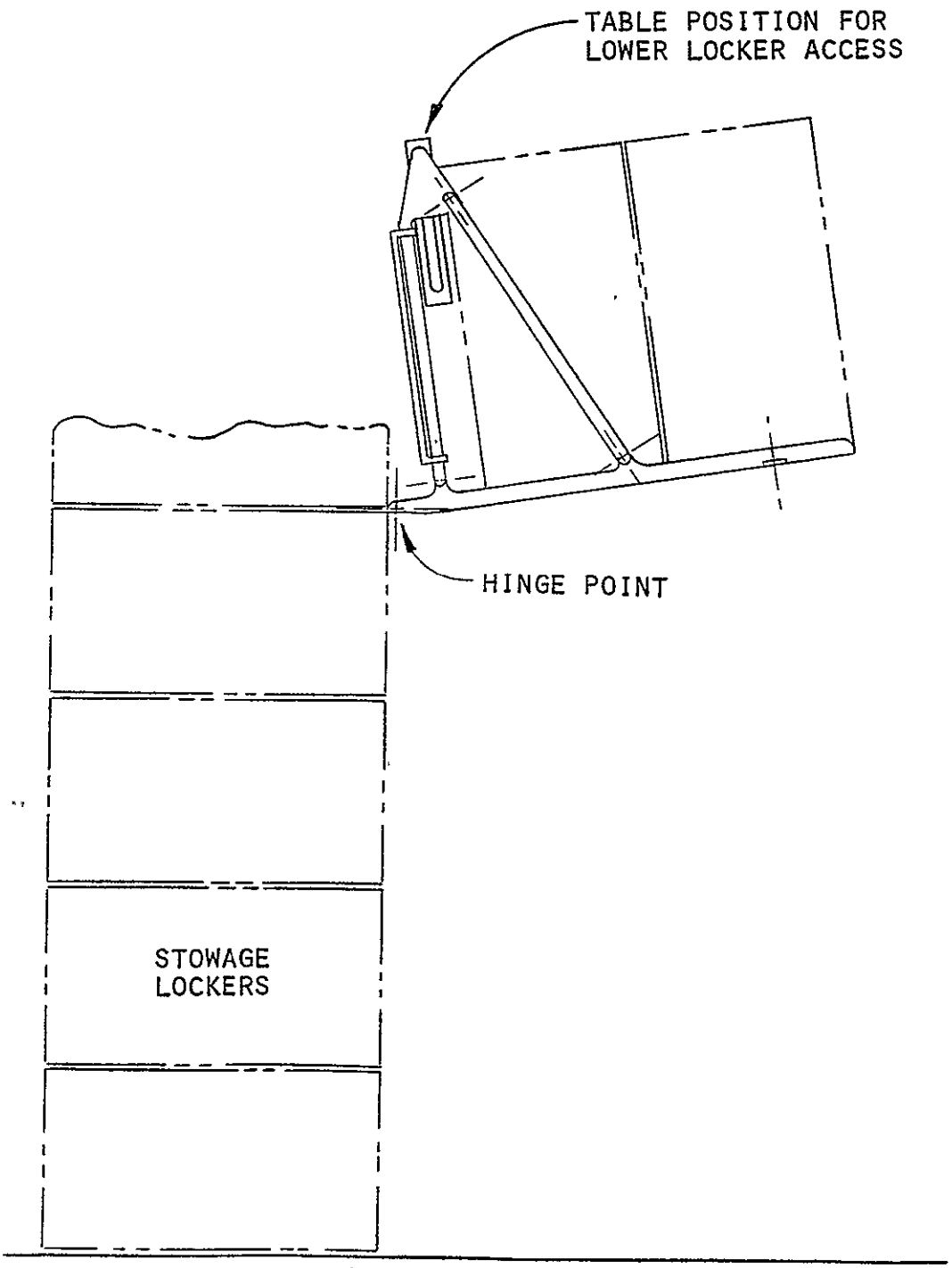


FIGURE 72 EATING/WORK TABLE RECOMMENDED CONCEPT - SIDE VIEW FOR TEMPORARY STOWAGE

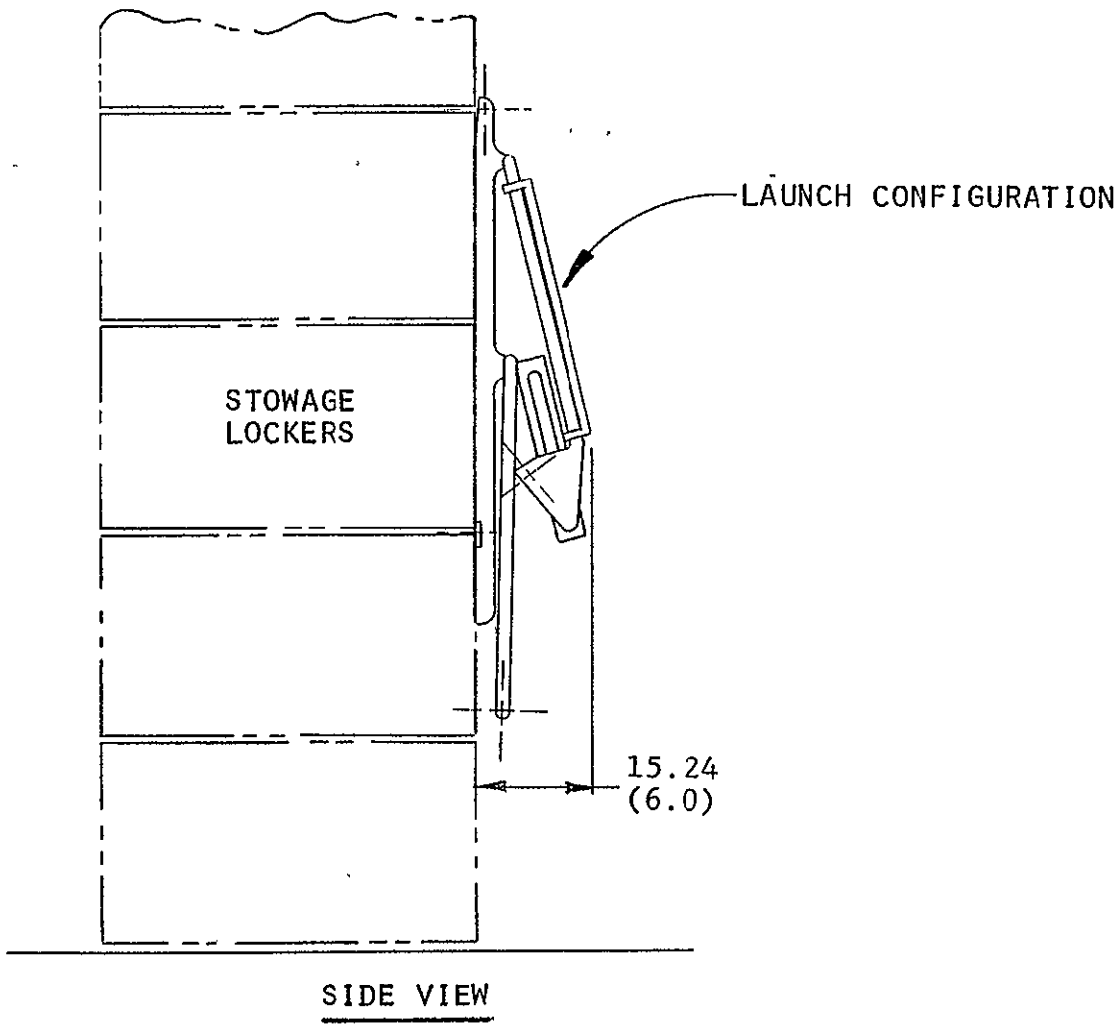


FIGURE 73 EATING/WORK TABLE RECOMMENDED CONCEPT - SIDE VIEW FOR LAUNCH STOWAGE

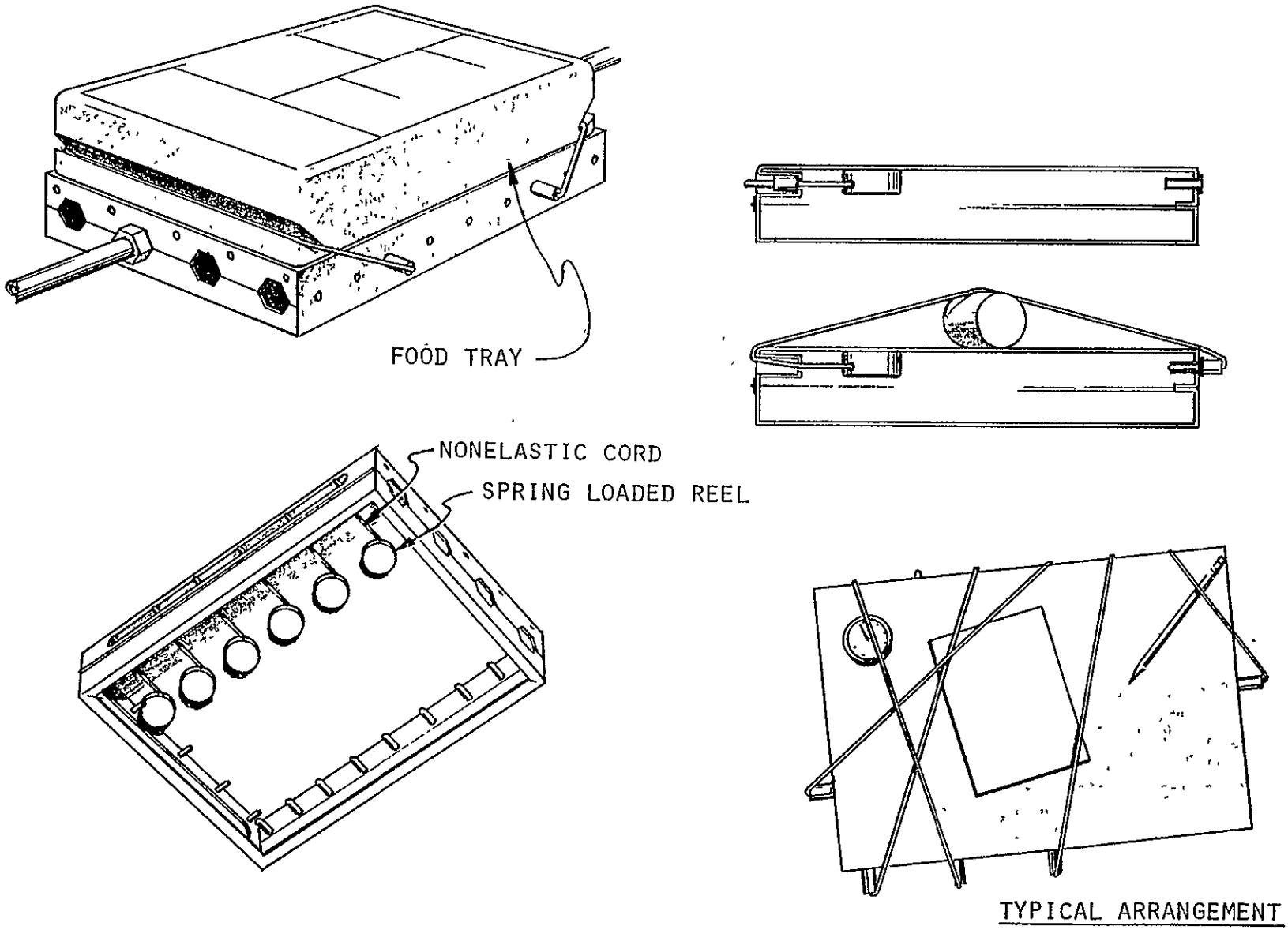


FIGURE 74 UTILITY RESTRAINT FEATURE CONCEPT FOR EATING/WORK TABLE

situation and maintain the four positions in a face-to-face type grouping.

4.4 Personal Hygiene Station and Waste Management Compartment - The evaluation results presented in Reference 13 are summarized in the following sections.

4.4.1 PHS/WMC Area with Camera Installed - As shown on Figures 75 and 76, the use of a large camera at the side hatch window will severely restrict accessibility to the PHS washer and ingress/egress to the WMC.

4.4.2 PHS Area - The personal hygiene washer height position on the aft side of the galley has been determined to be 86.4 centimeters (34 inches) above the floor as shown on Figure 77. The opening height and width dimensions should be at least 43.2 and 35.6 centimeters (17 and 14 inches), respectively. These dimensions are considered compatible with the range of crew sizes and PHS activities presented earlier in Section 2.4.

The PHS activities require a length of 106.7 centimeters (42 inches) aft of the galley, a width of 66 centimeters (26 inches) at waist height for elbow room, and a height of 180 centimeters (71 inches). The baseline distance between the galley and the WMC opening is 111.8 centimeters (44 inches) and is fully adequate for the body bathing activity. Also, the floor-to-ceiling height in this area will provide a head clearance of 28 centimeters (11 inches). The width available with the WMC door in its baseline open position was found to provide exactly enough space for elbow/arm movement of the largest size crew member as shown in Figure 78. A marginal floor width was found to exist, however, unless the space between side frames out to the side wall can be utilized for foot positions. Use of a relocated door with its hinge point 15.2 centimeters (6 inches) outboard of the baseline location, as proposed by the prime contractor, will significantly reduce the activity widths as shown on Figure 79.

Use of a curtain from the WMC door edge to the galley also will present a width problem directly at the aft side of the galley for use of the washer. In this regard, a sliding door extension to the WMC door that moves in the same plane as the WMC door was found to alleviate this situation and will increase the width by at least 5.1 centimeters (2 inches). It will, however, require a closeout extension from the galley aft side surface. Figure 80 illustrates the sliding door concept. One of the main concerns of the baseline door is the interference created by the upper edge and the primary interdeck hatch. It was found that by

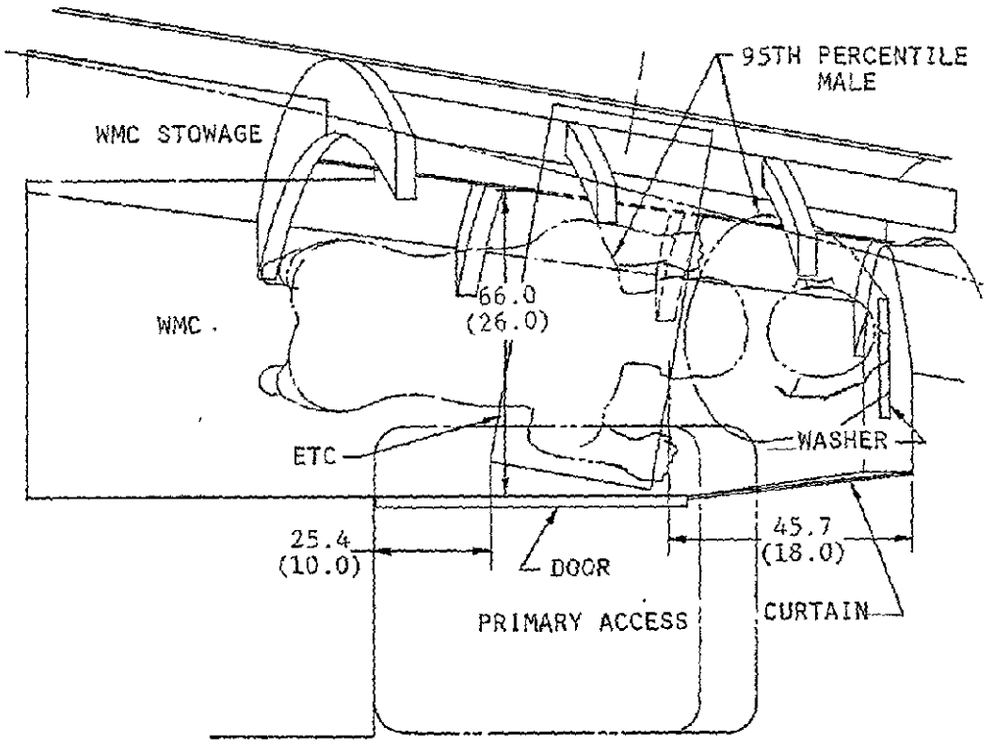


FIGURE 75 PHS/WMC AREA ACCESSIBILITY WITH ETC INSTALLATION (BASELINE CONFIGURATION, TOP VIEW)

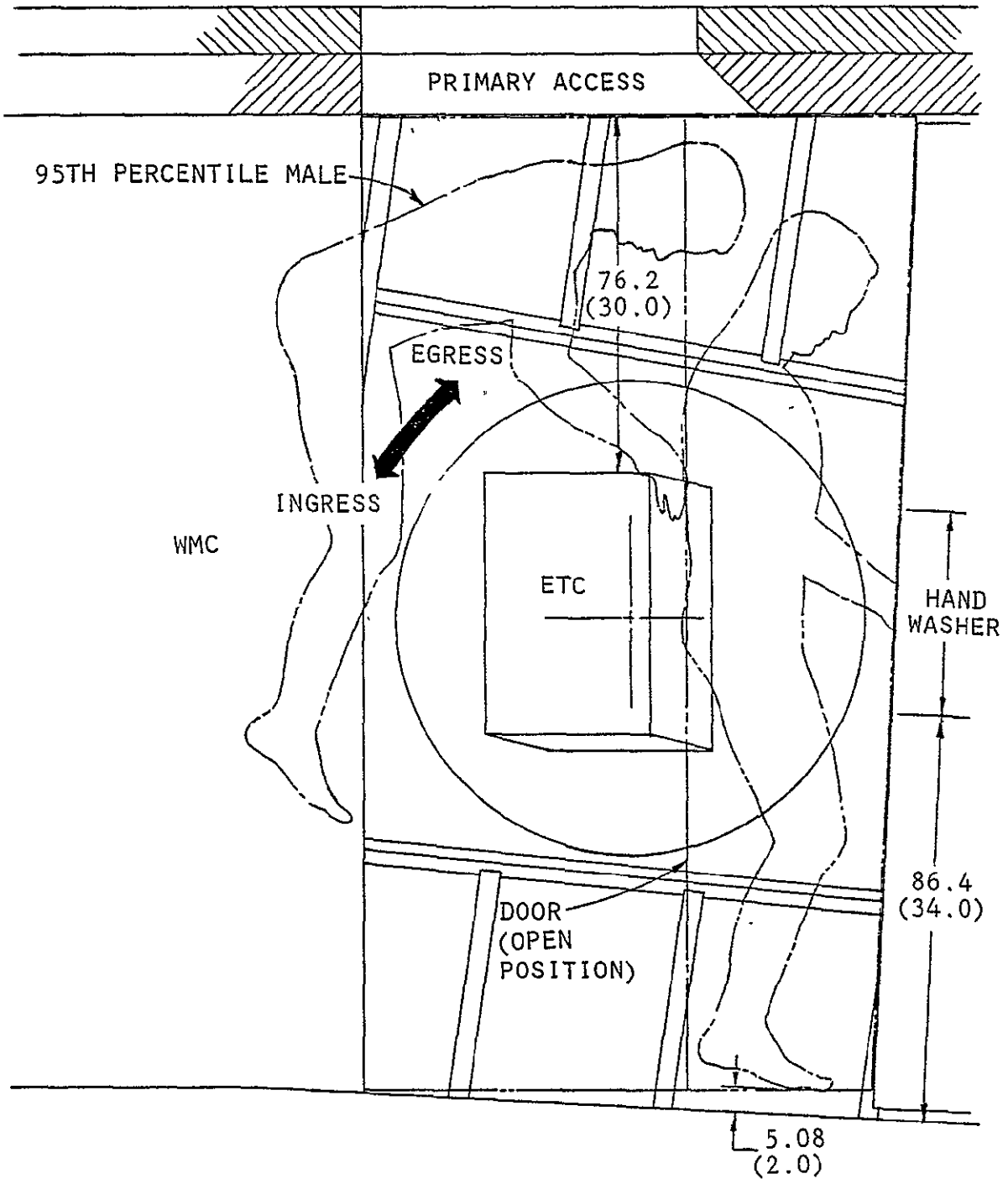


FIGURE 76 PHS/WMC AREA ACCESSIBILITY WITH ETC INSTALLATION (BASELINE CONFIGURATION, SIDE VIEW)

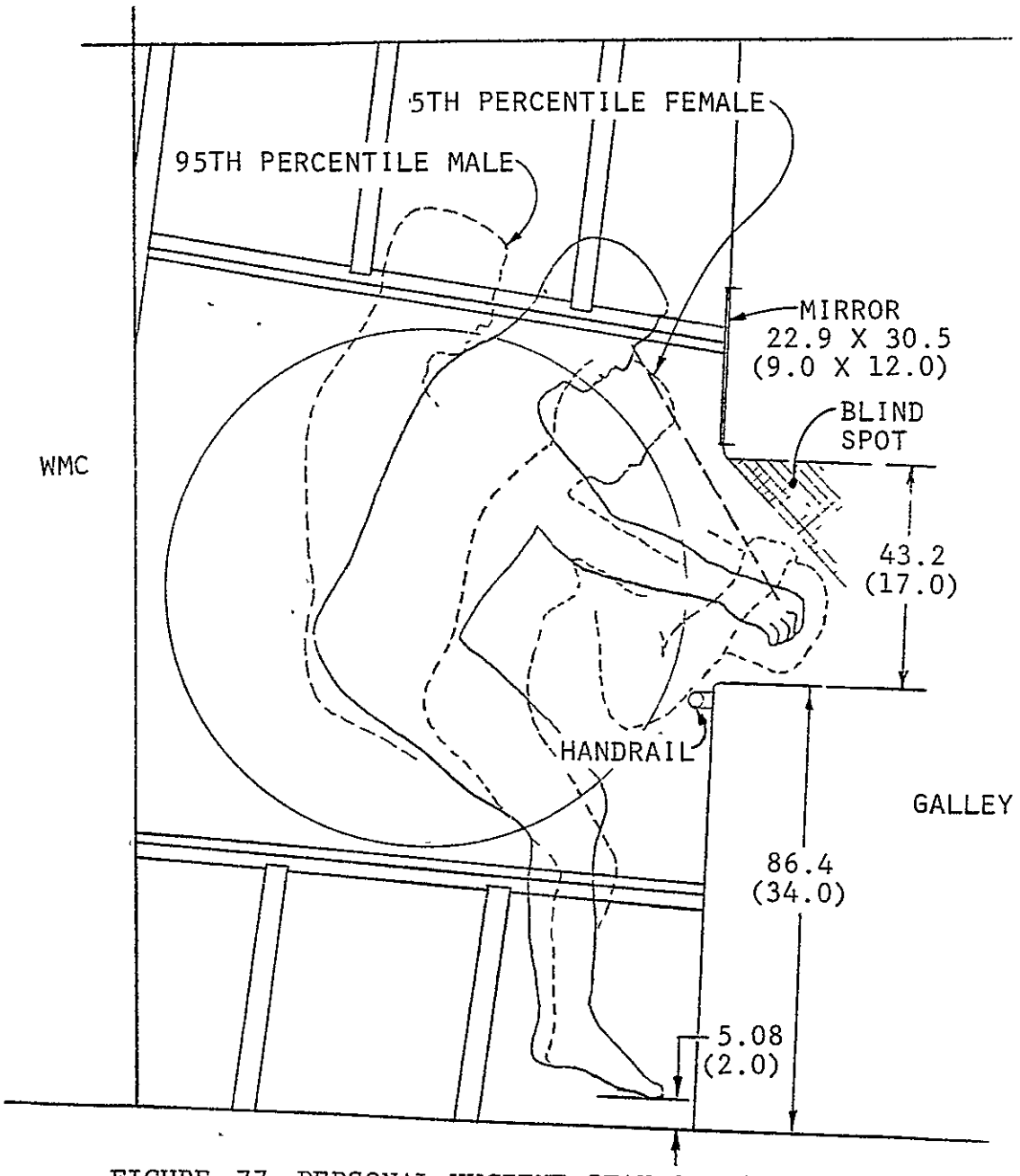


FIGURE 77 PERSONAL HYGIENE STATION HANDWASHER HEIGHT AND SIZE RECOMMENDATION (SIDE VIEW) - (RECOMMENDED CONCEPT)

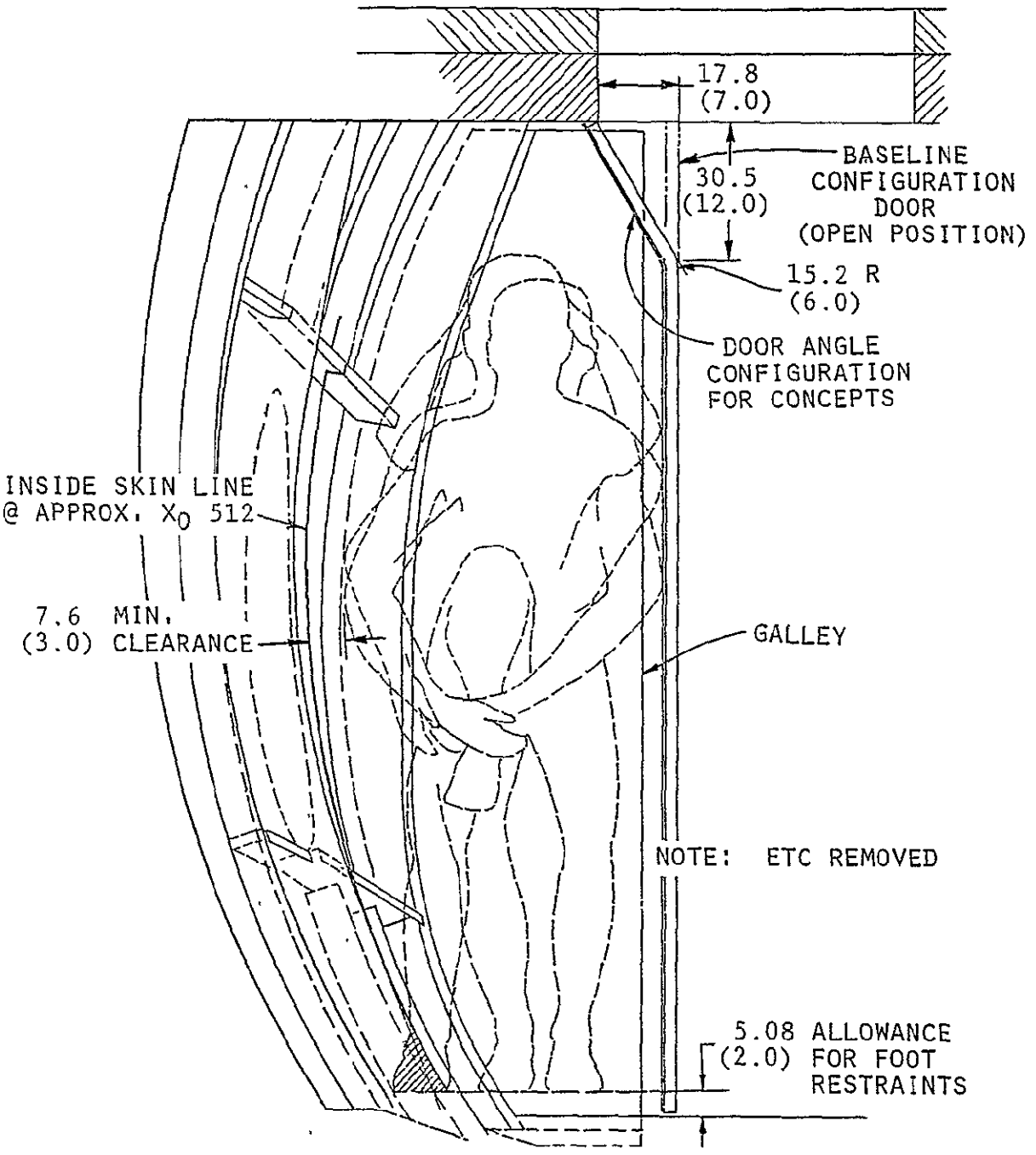


FIGURE 78 95TH PERCENTILE MALE PERSONAL HYGIENE ACTIVITY ENVELOPE IN PHS AREA (BASELINE CONFIGURATION, LOOKING FORWARD)

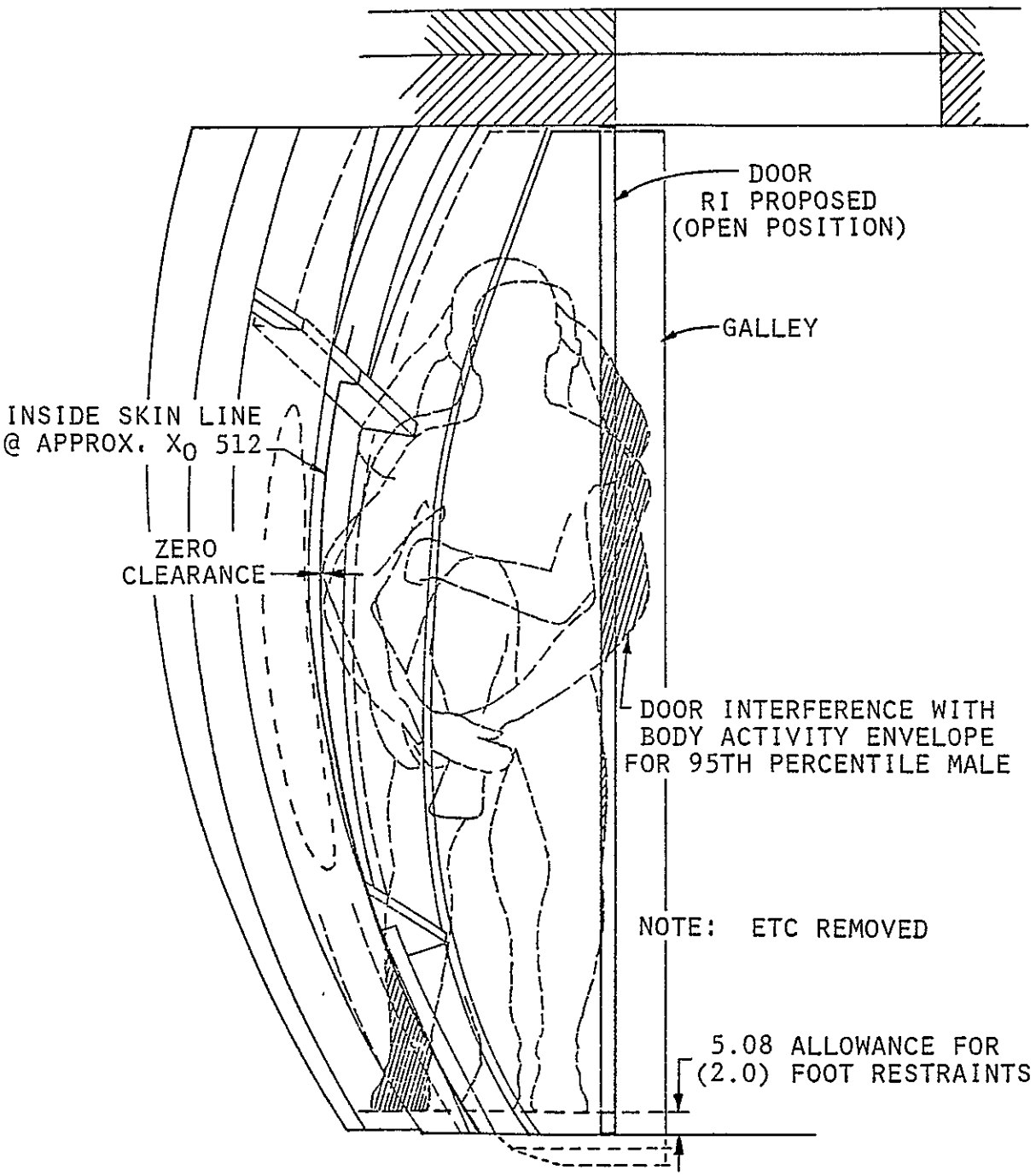


FIGURE 79 95TH PERCENTILE MALE PERSONAL HYGIENE ACTIVITY ENVELOPE IN PHS AREA (RI PROPOSED CHANGE, LOOKING FORWARD)

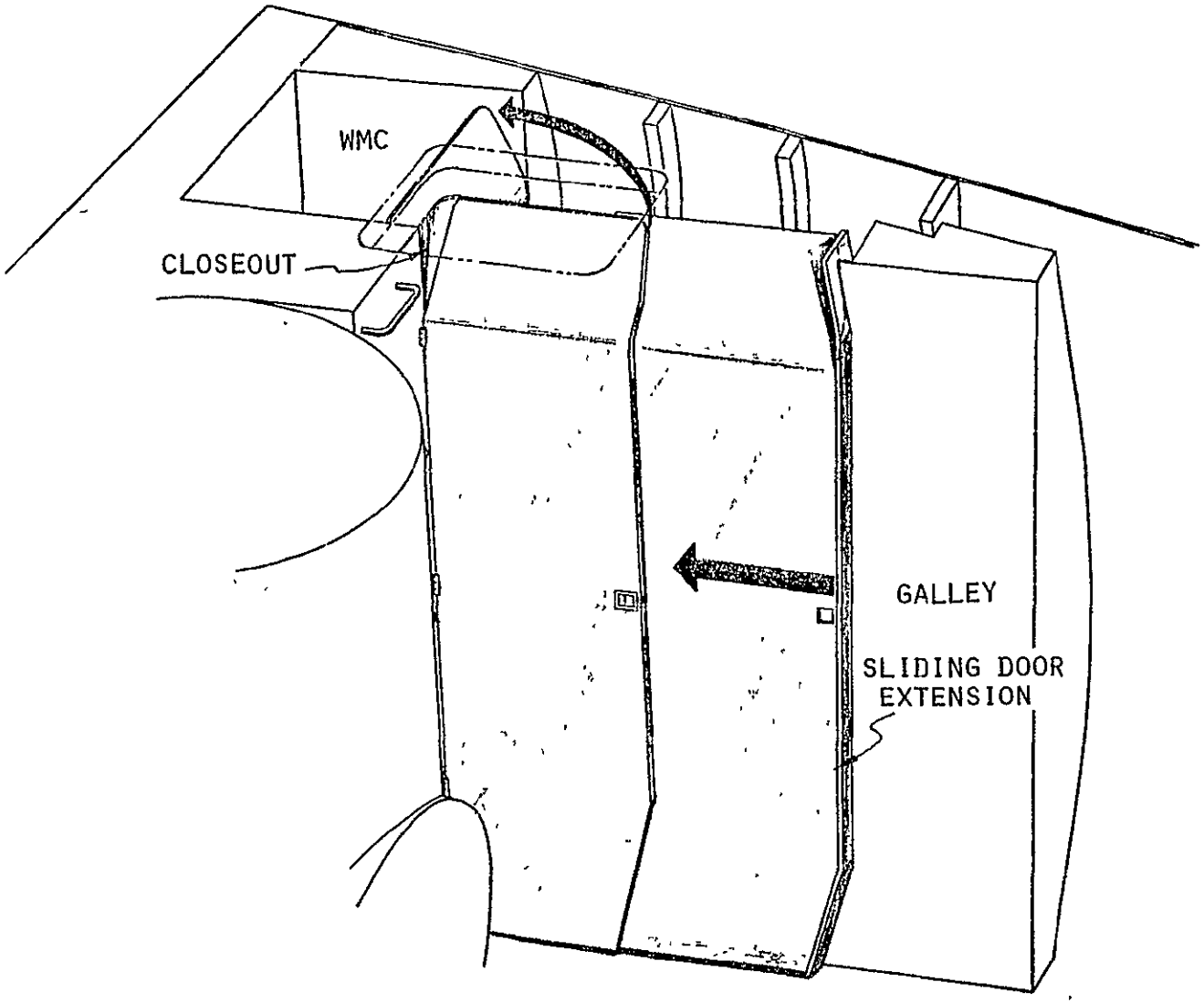


FIGURE 80 PHS/WMC AREA CLOSEOUT RECOMMENDED CONCEPT

using an angled door top as shown in Figure 81, that the interference can be minimized and privacy maintained for the PHS/WMC area.

The location of the airflow control switch for the waste collection equipment on the aft wall of WMC is considered inaccessible to anyone using the washer. A more accessible location for this control is at the front of the WMC.

4.4.3 WMC Area - For WMC equipment use, the baseline and the prime contractor proposed change require a 90-degree conventional seated position. As shown in Figure 82, the baseline compartment width provides adequate space for the largest size crew member. The corner partition created by the prime contractor proposed change, however, will create a marginal width situation as shown by Figure 83. In either case, the legs of the larger size crew members will protrude through the door opening which will preclude separate use of the WMC and PHS since closure of the WMC door will be prevented by this situation. The alternate WMC arrangement using a tilted seat is shown in Figure 84 and is based on accommodating a 68.6-centimeter (27-inch) equipment diameter under the seat. This arrangement is considered to provide a more comfortable weightless body posture for use of the fecal collector equipment. Side handholds and a lap strap should also be provided. This tilted seat arrangement appears to be more compatible for independent urinal use by male crew members than the conventional horizontal seat installation.

4.4.4 Temporary Stowage and Restraint Provisions - A temporary restraint concept utilizing a double bungee spring installation on the side wall area between the frames was proposed. Figures 85 through 87 illustrate this concept. In order to handle towels and washcloths for up to seven crew members, a temporary stowage concept illustrated by Figures 88 through 91 was devised. It appears that the stowage container can be located in the upper WMC area.

4.5 Airlock Out Arrangement - As presented in Reference 14, it was determined that nine stowage lockers can be positioned above the airlock hatch on the aft bulkhead when the airlock is located behind this bulkhead, see Figure 92. These nine lockers can be the ones located at the fourth sleep station in the baseline arrangement. It was also determined that a pedestal supported table assembly away from the forward locker tier could also be accomplished. This type of arrangement as shown in Figure 93 will remove the access obstacle presented by the five stowage lockers at the fourth sleep station as well as permit free access to all the lockers in the forward tier since the table

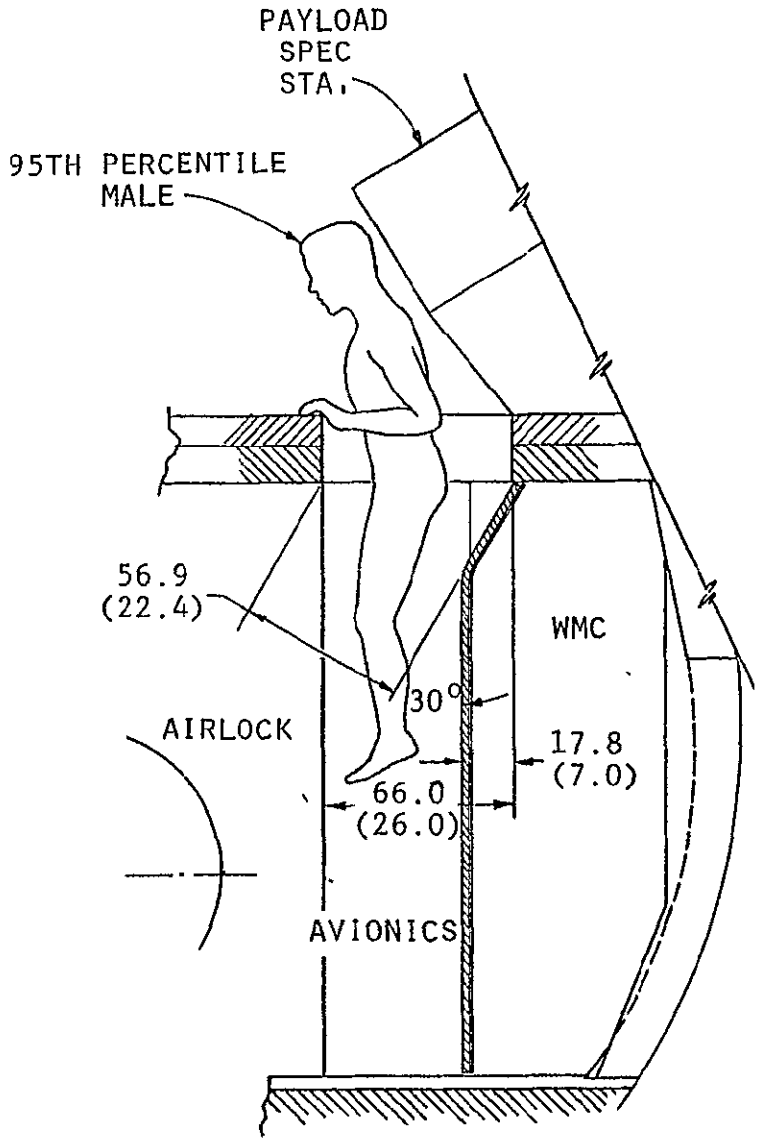


FIGURE 81 CREW MEMBER PASSAGE THROUGH PRIMARY INTERDECK ACCESS HATCH WITH ANGLED WMC DOOR

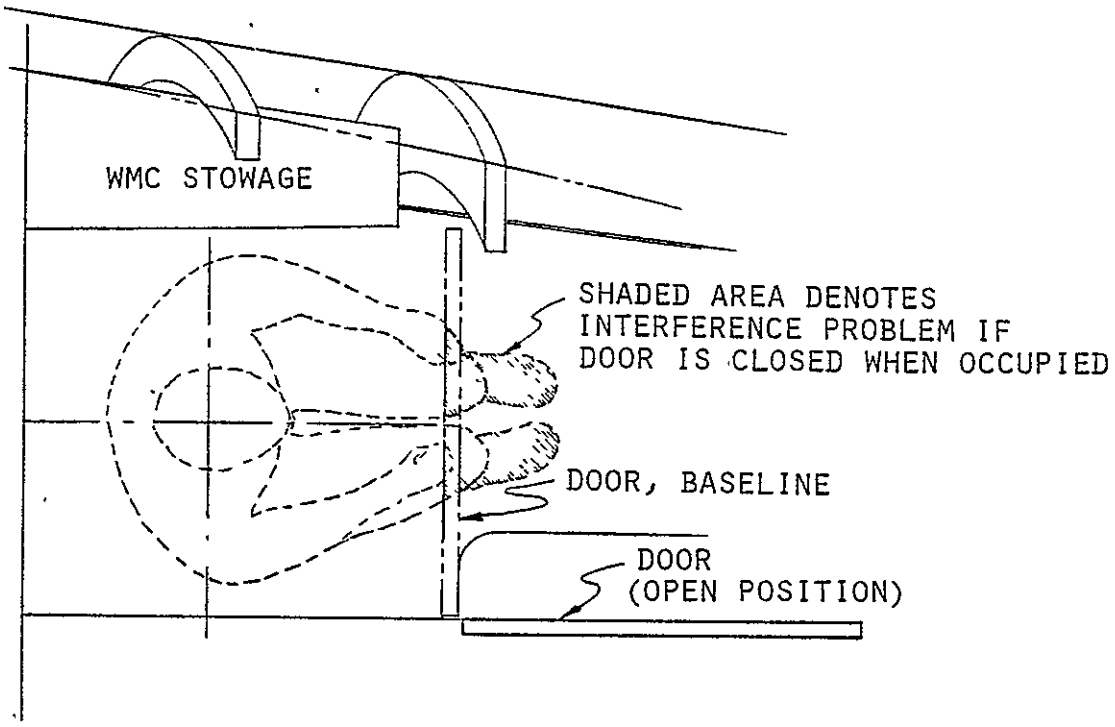


FIGURE 82 95TH PERCENTILE MALE IN WMC
(BASELINE CONFIGURATION, TOP VIEW)

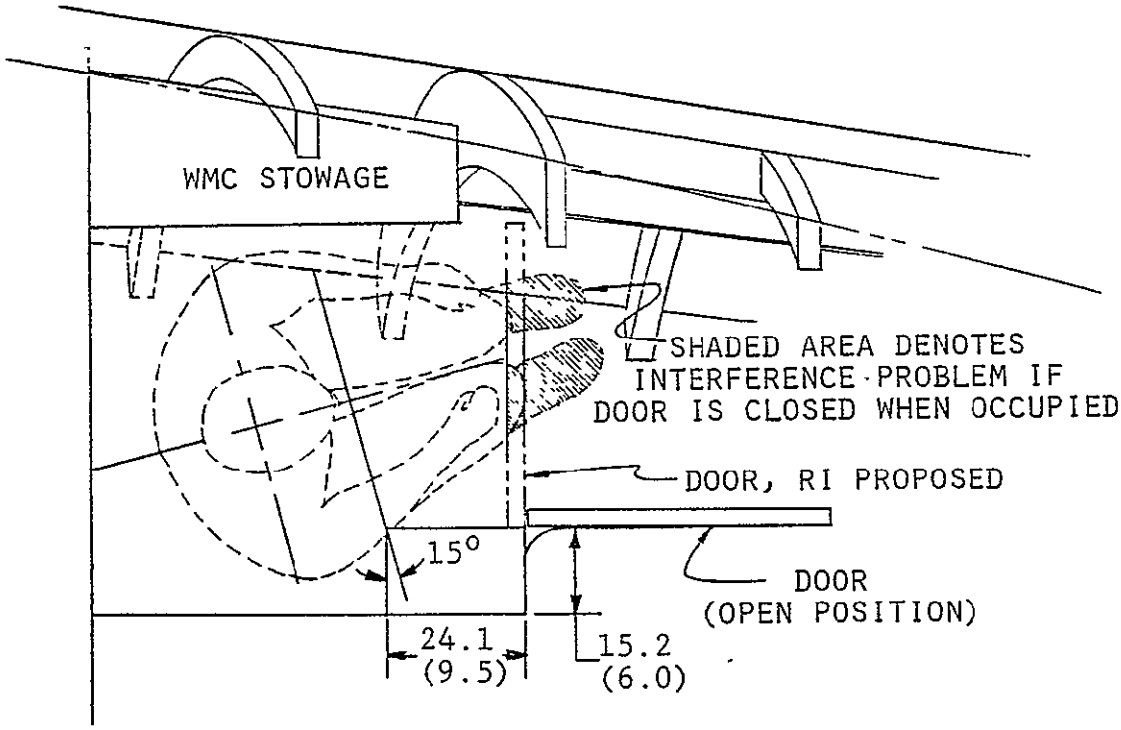


FIGURE 83 95TH PERCENTILE MALE IN WMC
(RI PROPOSED CHANGE, TOP VIEW)

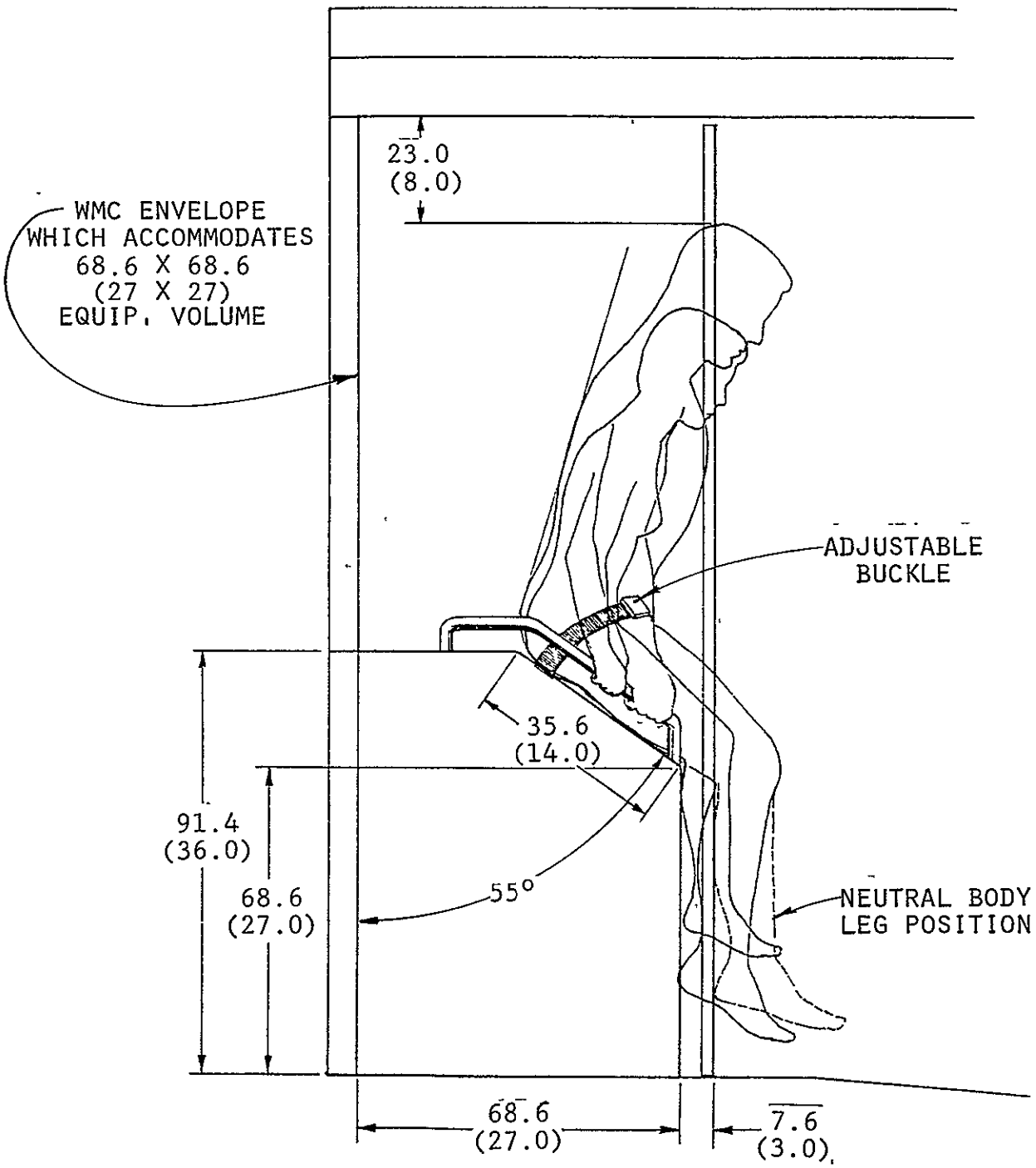


FIGURE 84 TILTED SEAT CONCEPT FOR WMC (RECOMMENDED CONCEPT)

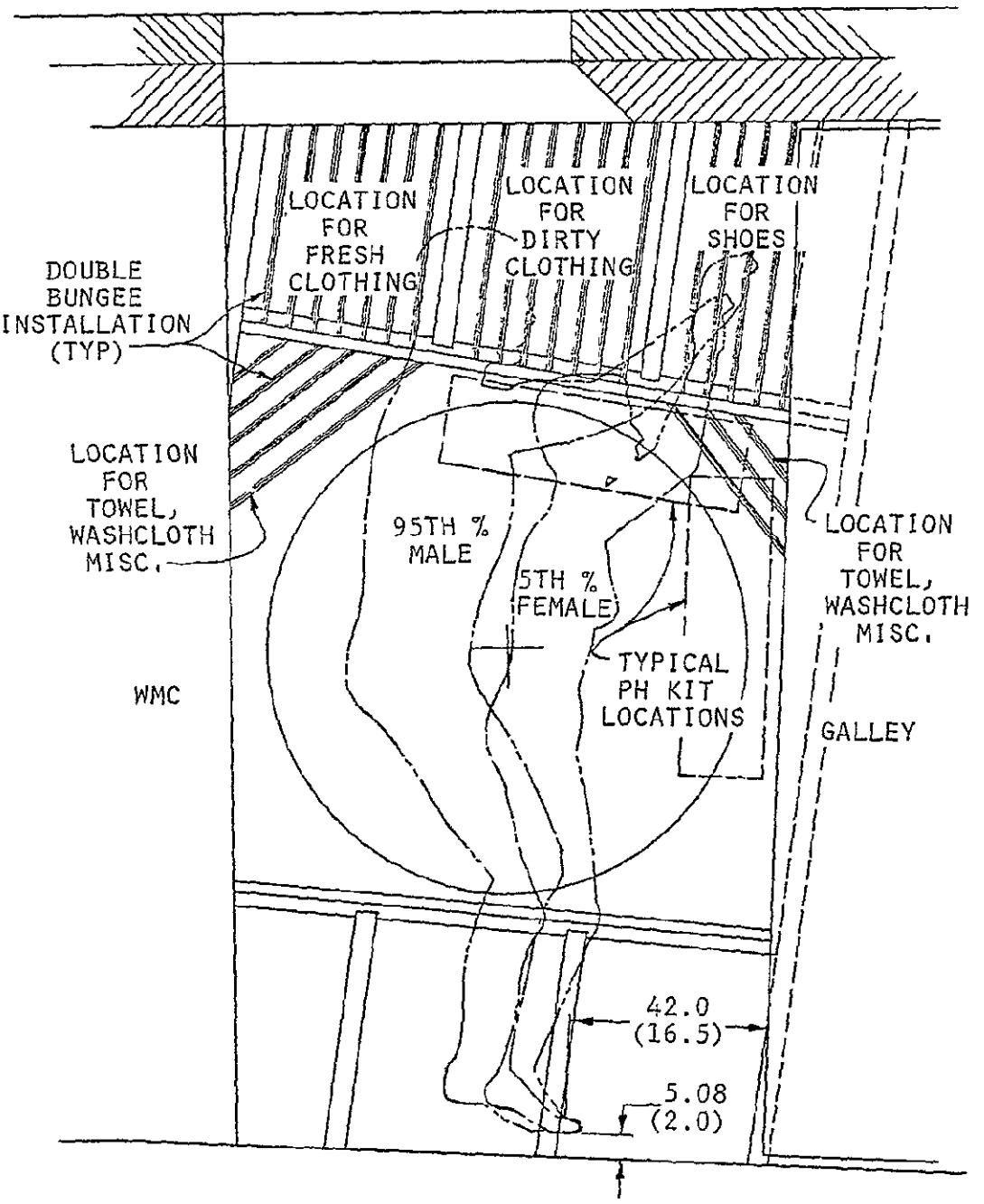


FIGURE 85 TYPICAL TEMPORARY STOWAGE/RESTRAINT PROVISIONS FOR PHS

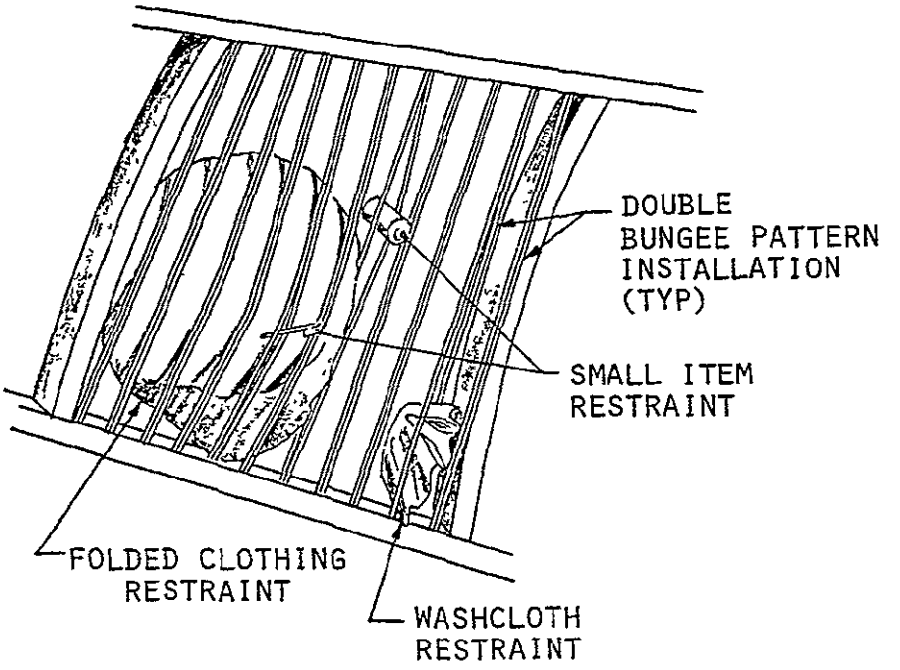


FIGURE 86 TYPICAL UTILIZATION OF DOUBLE BUNGEE RESTRAINT PATTERN FOR TEMPORARY STOWAGE IN PHS

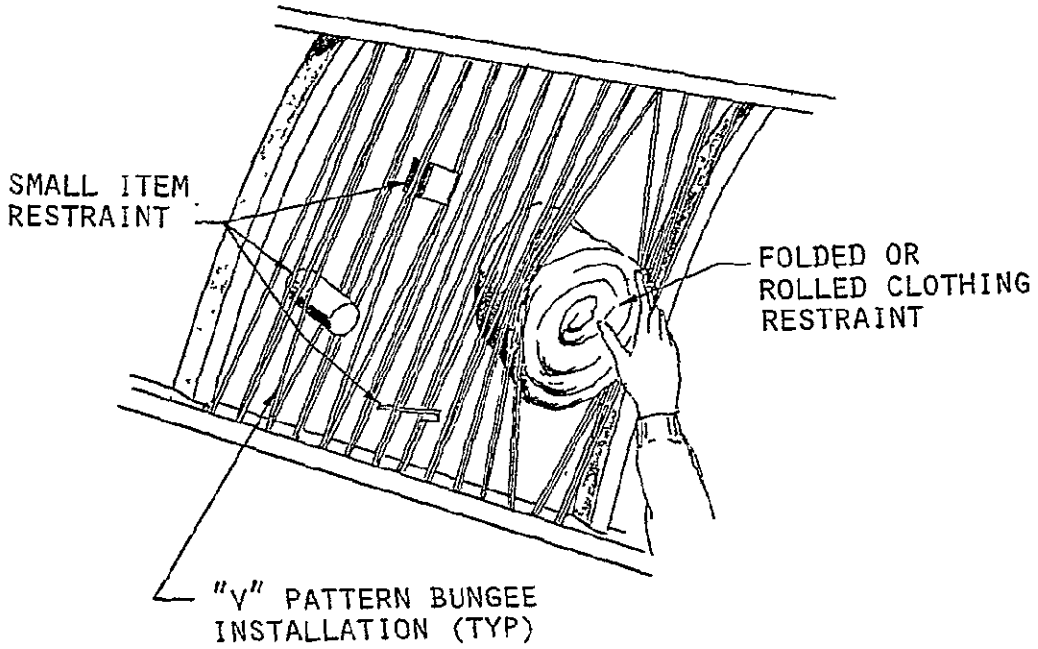


FIGURE 87 ALTERNATE "V" PATTERN BUNGEE INSTALLATION FOR TEMPORARY STOWAGE IN PHS

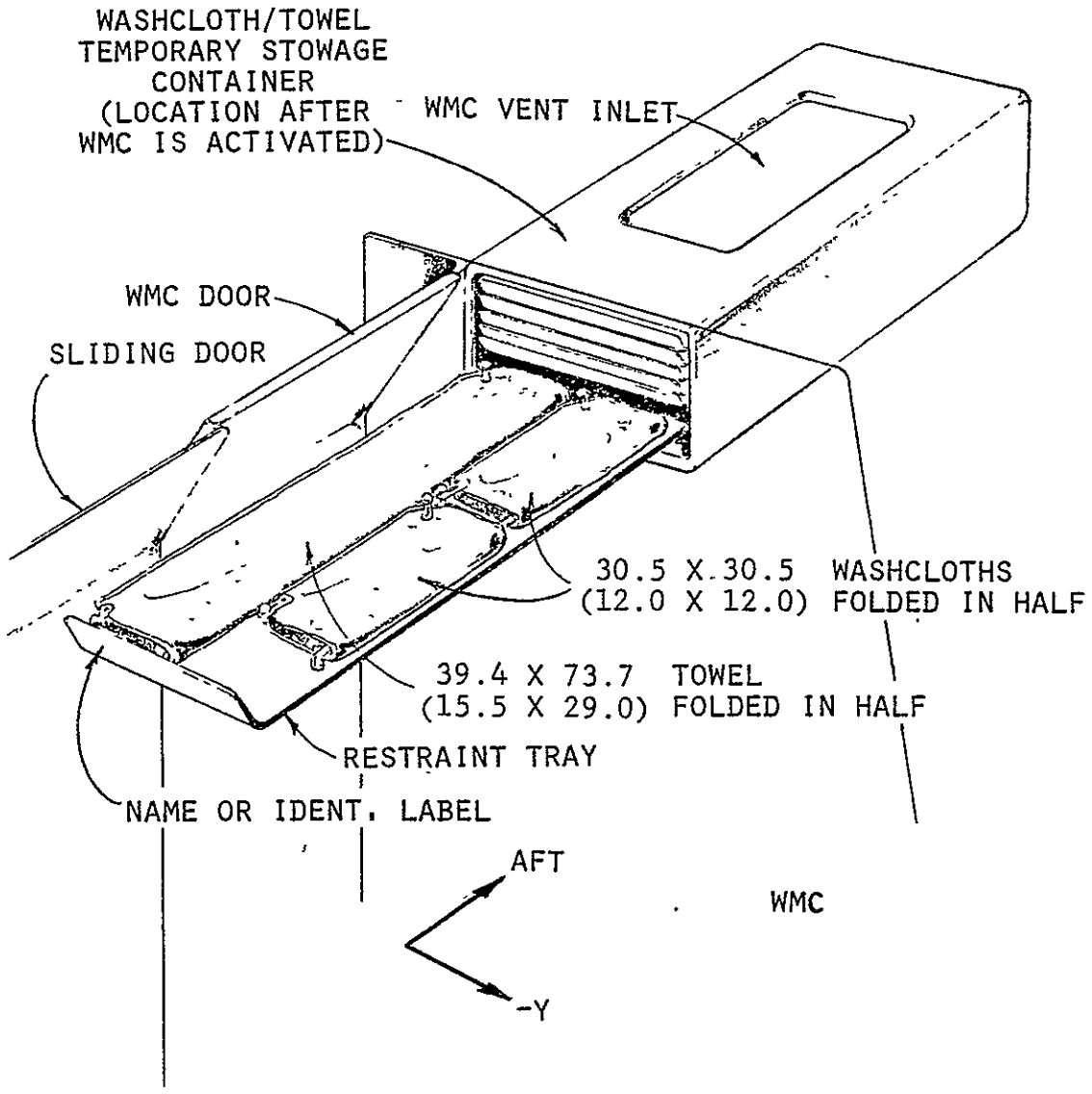


FIGURE 88 TEMPORARY STOWAGE CONCEPT FOR WASHCLOTHS AND TOWELS

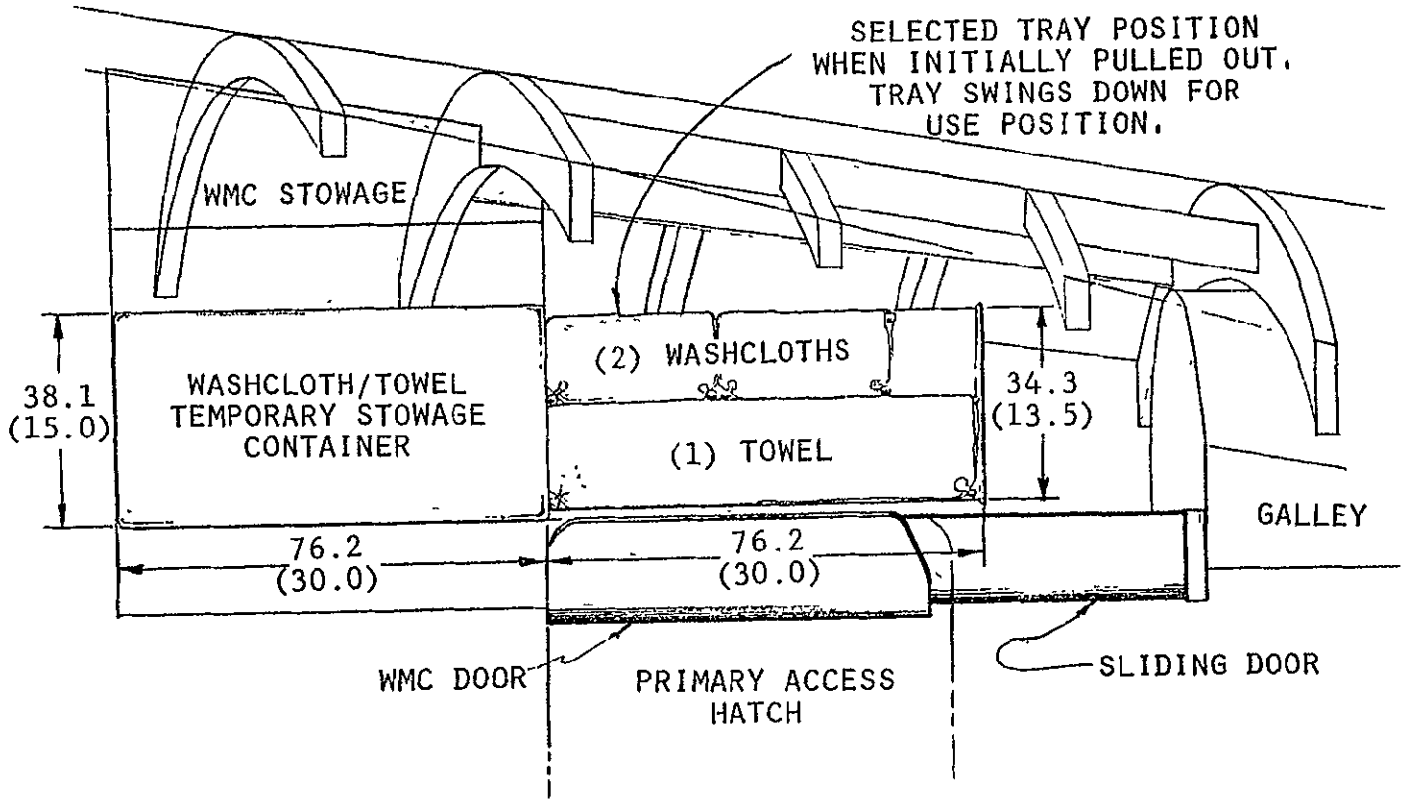


FIGURE 89 WASHCLOTH/TOWEL TEMPORARY STOWAGE CONCEPT - TOP VIEW

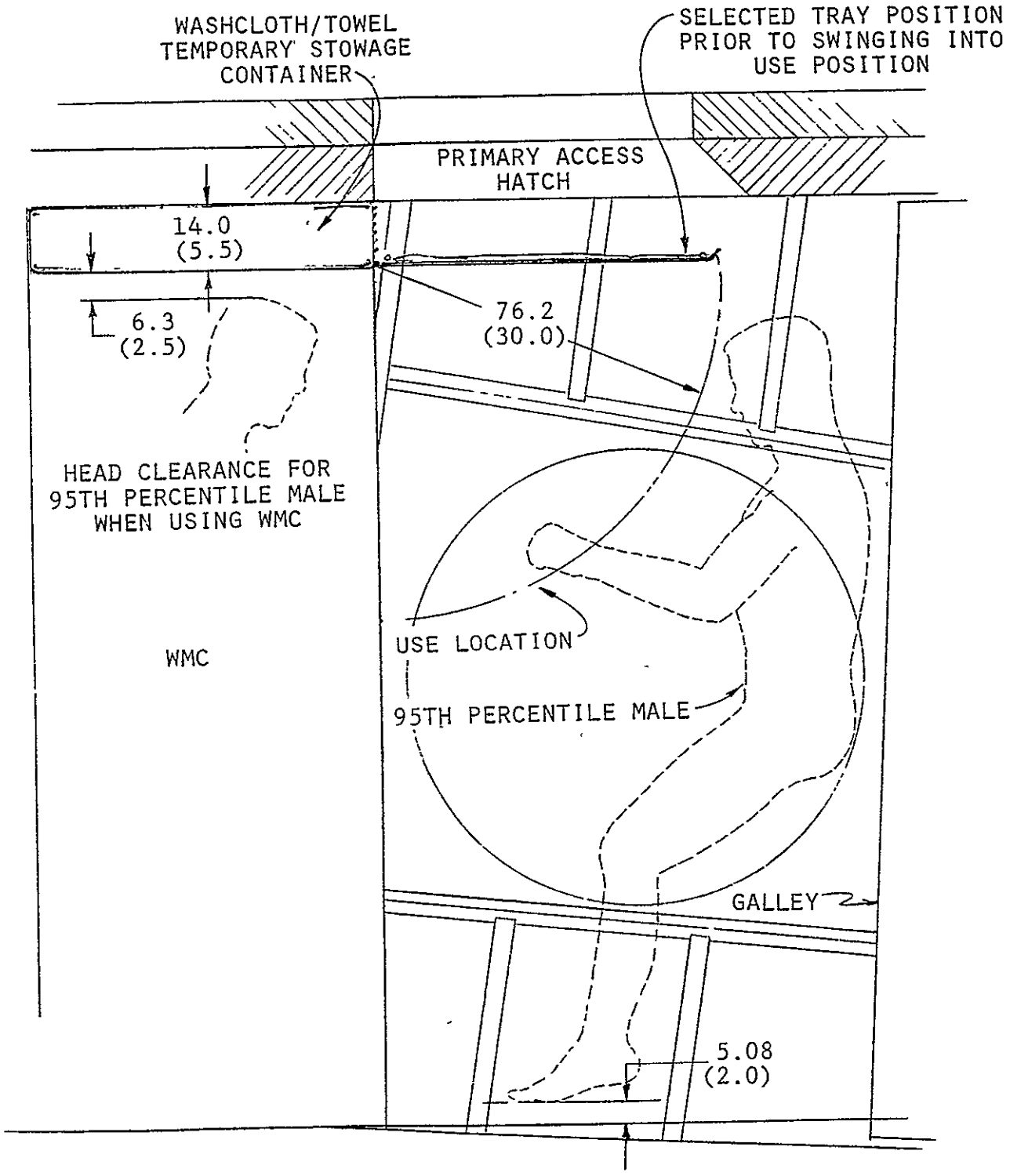


FIGURE 90 WASHCLOTH/TOWEL TEMPORARY STOWAGE CONCEPT - SIDE VIEW

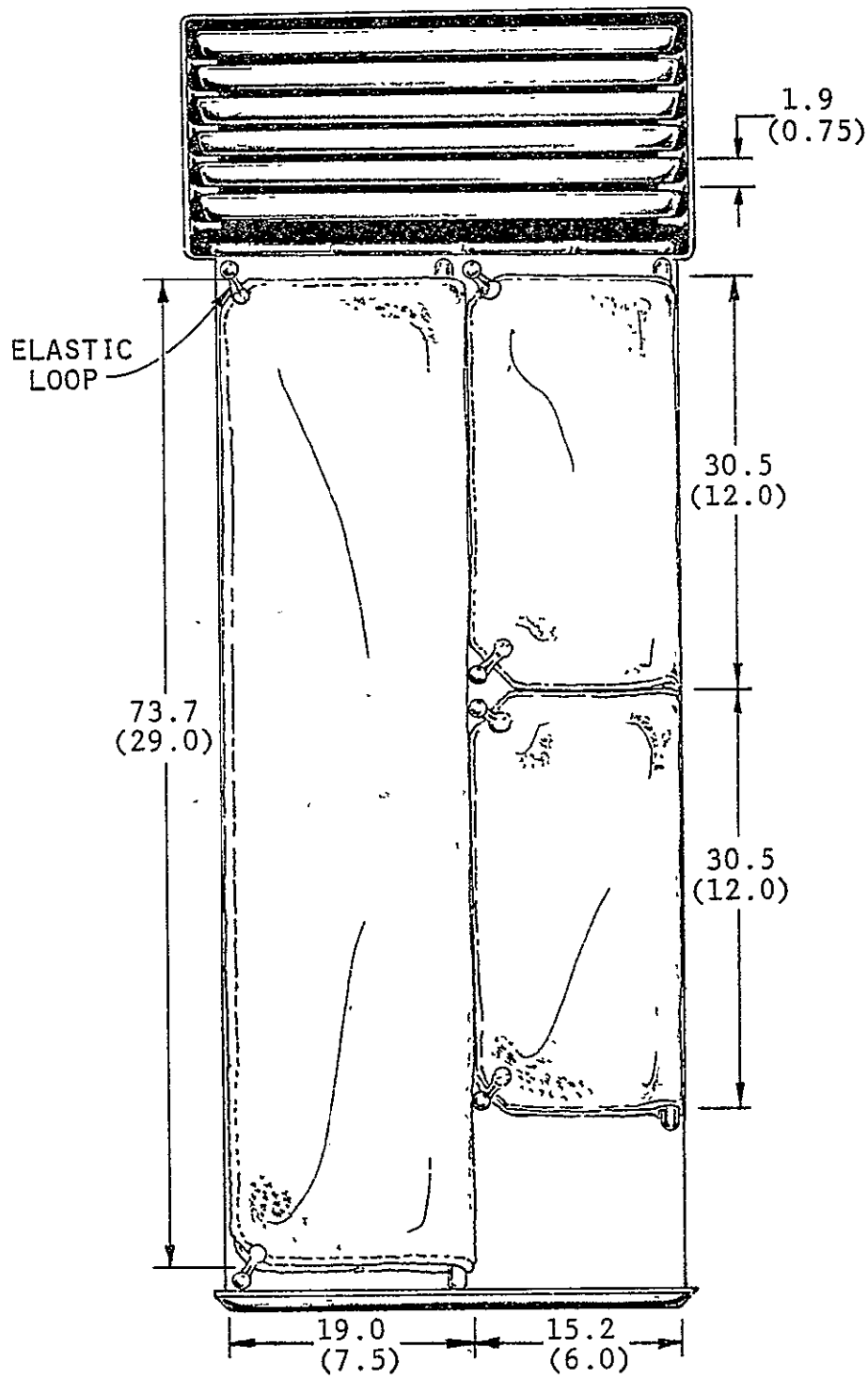


FIGURE 91 WASHCLOTH/TOWEL TEMPORARY STOWAGE CONCEPT - USE POSITION LOOKING AFT

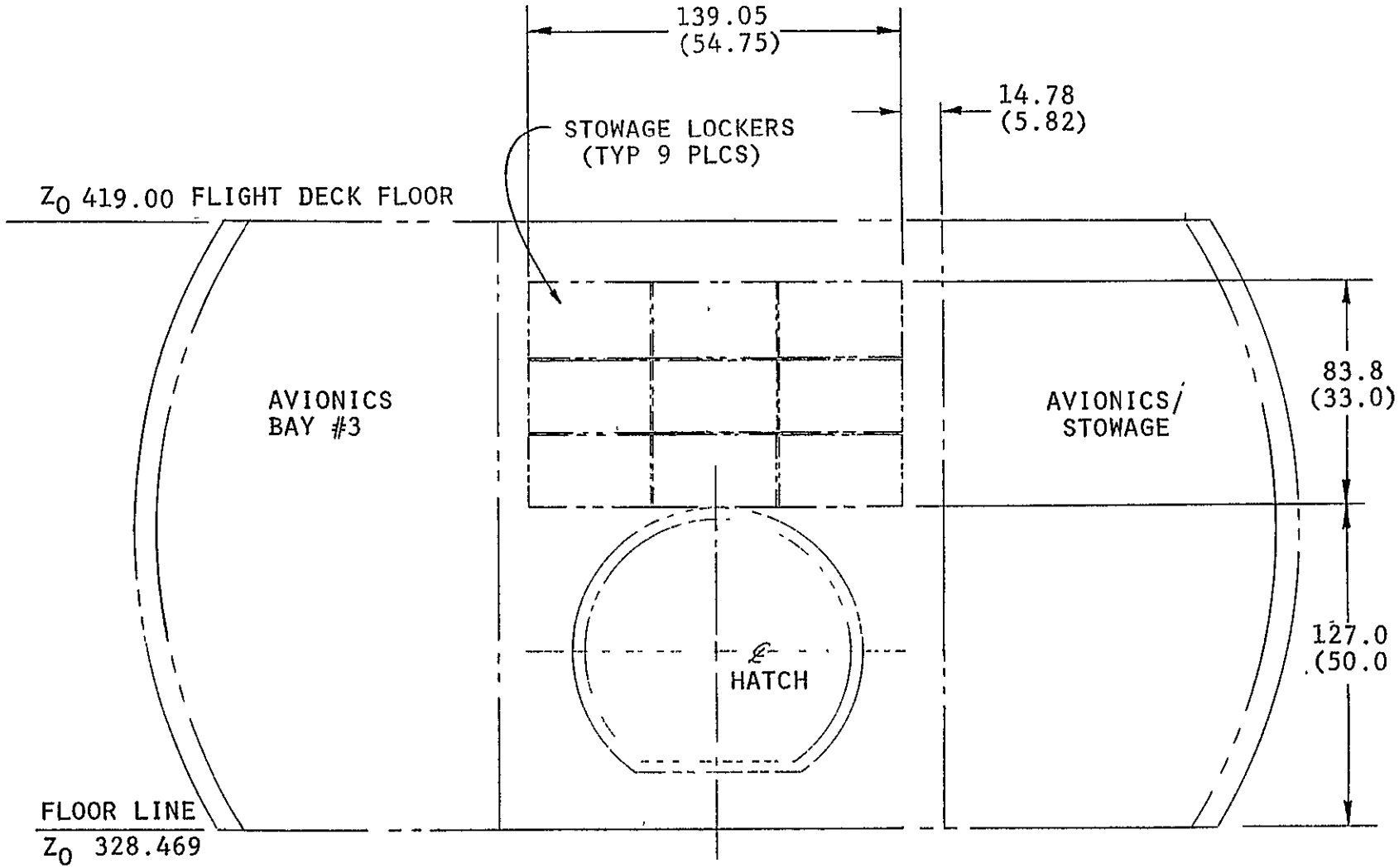
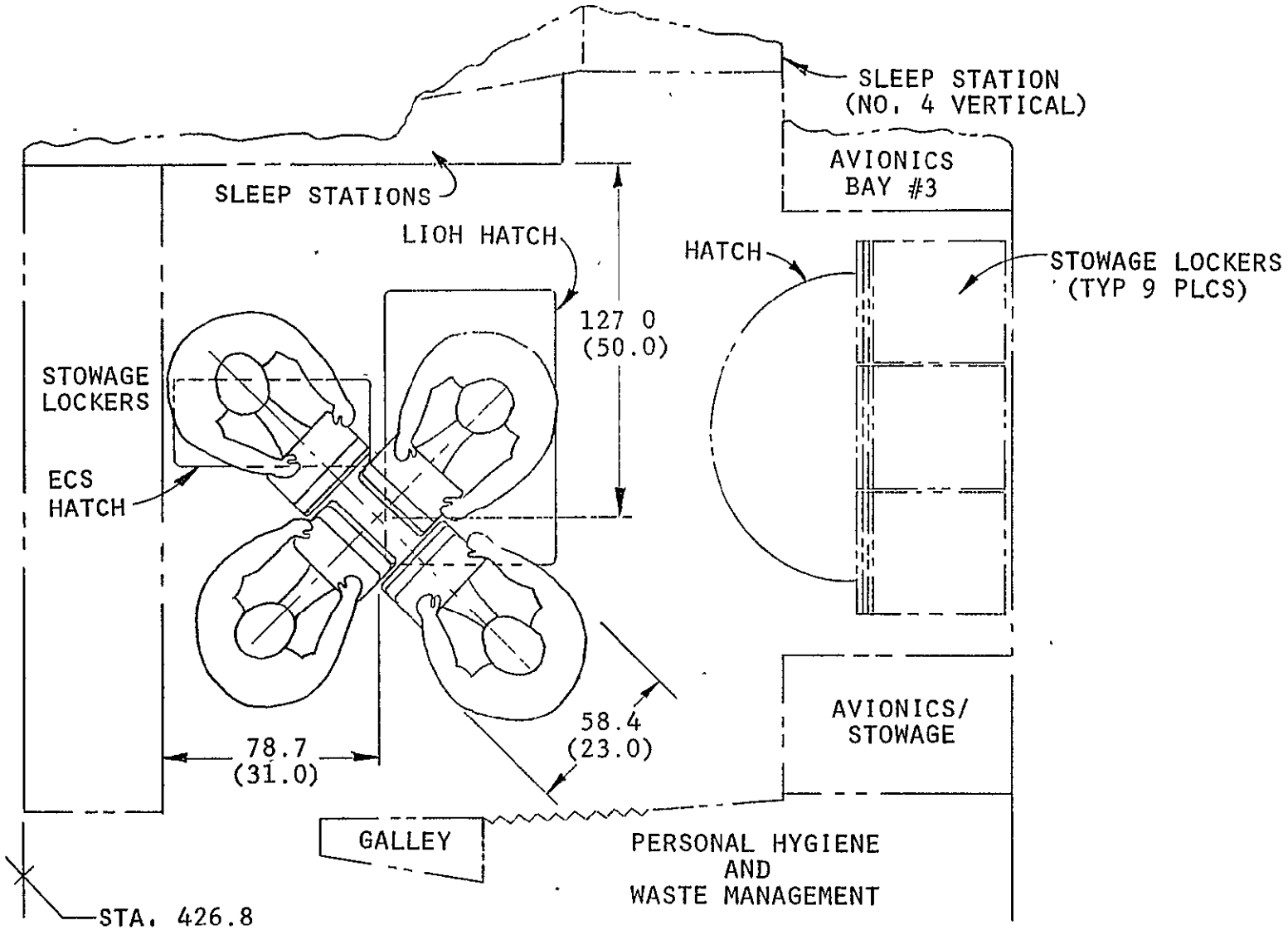


FIGURE 92 RECOMMENDED STOWAGE LOCKER LOCATION - FOR AIRLOCK OUT ARRANGEMENT



PLAN VIEW

(MID-DECK LOOKING DOWN)

FIGURE 93 EATING/WORK TABLE RECOMMENDED LOCATION FOR AIRLOCK OUT ARRANGEMENT

assembly no longer has to be supported directly at the locker door face.

4.6 Mobility/Stability Aids - The results of the evaluation presented in Reference 15 found the Mid-Deck area lacking in mobility/stability aids to support crew activities in a zero-g environment. Only the primary interdeck hatch has a baseline handrail. Review of traffic pattern and activity locations indicated that additional handrails were required. Utilization of the reach envelopes presented previously in Section 2.2 led to the identification of handrail locations as defined in Tables XXI and XXII and illustrated by Figures 94 through 99.

4.7 Sleep Restraint - It was concluded during the sleep restraint evaluation as presented in Reference 16 that the restraint assembly should retain certain desirable features of the Skylab sleep restraint but, of necessity, conform to the shape dictated by the Mid-Deck sleep compartments. Figure 100 presents this concept and features a two-piece sleep liner. Each half has a full length frontal zipper for easier ingress/egress. In order to provide an easier method of overblanket handling under zero-g conditions and within the confines of a small compartment, a spring loaded frame support which retains the blanket was devised as shown in Figure 101. To accommodate the variation in crew member size as presented previously in Section 2.12 (Figure 43), a quick-release adjustable buckle concept was devised as presented in Figure 102. This concept will permit alternate use of the restraint straps by two different sized crew members who desire individual tension adjustment. After an initial adjustment, it will not be necessary to always readjust the strap length. In this regard, the simplest approach to permit alternate use of a sleep compartment by two different crew members was found to be by changeout of the sleep liners only. A carrier belt concept, Figures 103 and 104, was conceived to avoid liner removal and reinstallation. The two liners are attached to the belt so that the liner for use is brought into position by pulling the belt. The alternate liner is simultaneously moved to beneath the sleep restraint frame for temporary stowage without having to remove it. A reversible pillow concept as illustrated in Figure 105 will also simplify the procedures needed to change the sleep restraint for alternate crew member use. Figures 106 and 107 provide additional data as to dimensions for sleep liner halves and the blanket, respectively.

During the review of the sleep restraint mockup, a major discussion developed concerning the weight aspects of a frame mounted assembly. The alternative to use of a frame

TABLE XXI

RECOMMENDED MOBILITY/STABILITY
AIDS FOR MID-DECK WITH AIRLOCK

HANDRAIL LOCATION	FIGURE NO.	PURPOSE
Along the periphery of the airlock access opening	94, 97	a. Mobility aid for travel through airlock access opening. b. Mobility aid within reach of interdeck hatches for control of body position and direction to and from hatches. c. Mobility aid for controlled travel across Mid-Deck d. Stability aid for access to wet trash floor hatch. e. Stability aid for airlock hatch stowage or closure.
At aft inboard corner of galley	94, 96	a. Mobility aid within reach of primary interdeck hatch. b. Stability aid for opening PHS access door. c. Stability aid for galley operations.
At forward inboard corner of galley	94, 96	a. Stability aid for galley operations. b. Stability aid for stowage/unstowage of passenger seats at area forward of galley. c. Stability aid for controlled access to left end stowage lockers.
On edge of sleep stations	94, 95	a. Mobility aids for sleep station ingress/egress. b. Mobility aids for travel along right side of Mid-Deck. c. Stability aid for access to lockers within reach. d. Stability aid (lower handrail) for access to wet trash floor hatch.

TABLE XXI (CONTINUED)

HANDRAIL LOCATION	FIGURE NO.	PURPOSE
At lower edge of PHS washer	94	a. Stability aid for washer activity. b. Mobility aid for PHS ingress/egress.
On either side of seat in WMC	94	a. Stability aid for maintaining seat position until lap strap engaged. b. Stability aid for urinal use by males. c. Stability aid for WMC housekeeping chores. d Stability aid for access to PH stowage area.

TABLE XXII

RECOMMENDED MOBILITY/STABILITY
AIDS FOR MID-DECK WITHOUT AIRLOCK

HANDRAIL LOCATION	FIGURE NO.	PURPOSE
Along the periphery of the airlock access opening at aft bulkhead	98, 99	a. Mobility aid for travel through airlock access opening.
At either corner of the aft avionics bay walls	98, 99	a. Mobility aids for travel across Mid-Deck. b. Mobility aids within reach of interdeck hatches.
At aft inboard corner of galley	98, 96	Same as for airlock in Mid-Deck (Table XXI)
At forward inboard corner of galley	98, 96	Same as for airlock in Mid-Deck (Table XXI)
On edges of sleep stations	98, 95	Same as for airlock in Mid-Deck (Table XXI)
At lower edge of PHS washer	98	Same as for airlock in Mid-Deck (Table XXI)
On either side of seat in WMC	98	Same as for airlock in Mid-Deck (Table XXI)

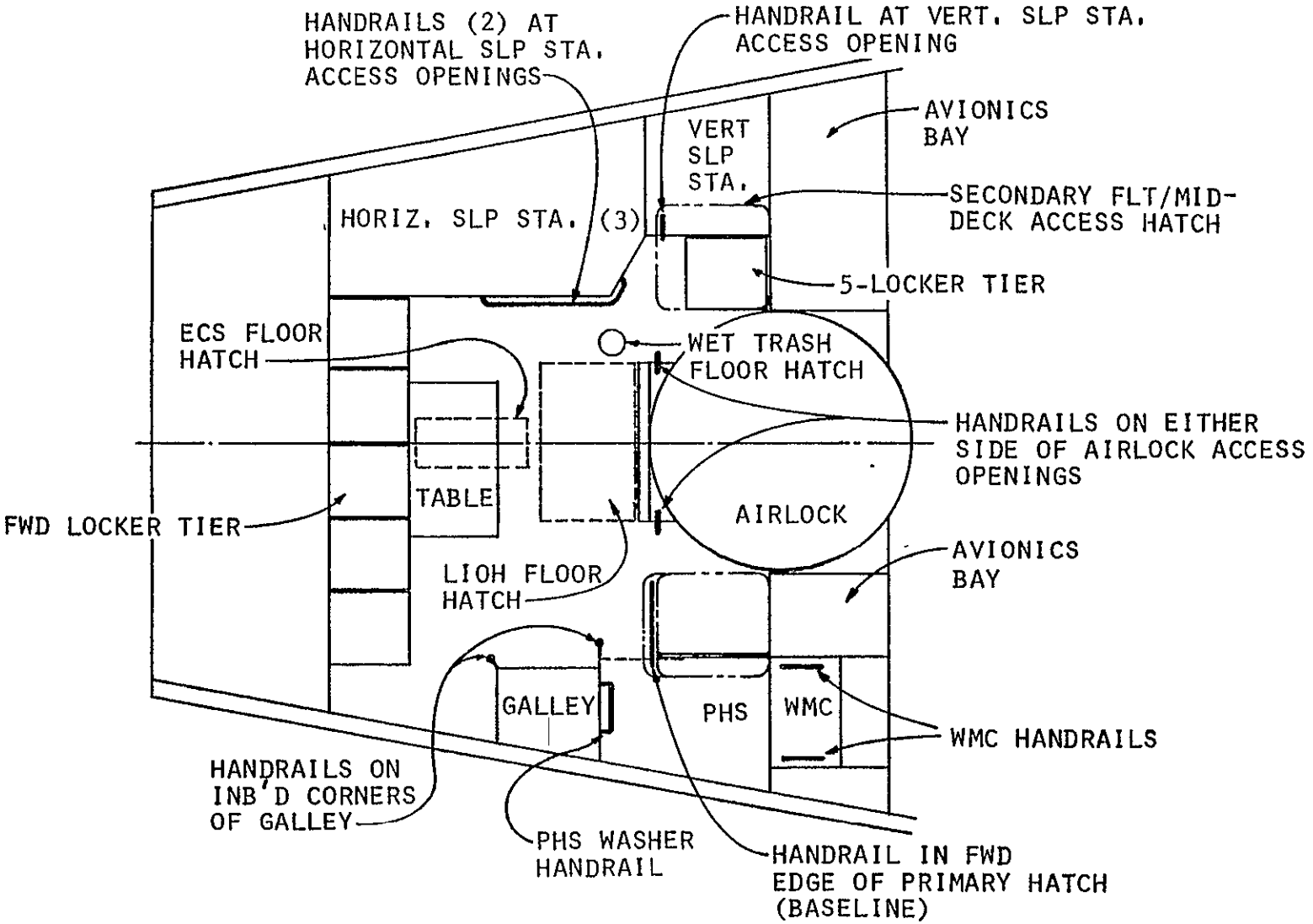


FIGURE 94 RECOMMENDED HANDRAIL LOCATIONS FOR MID-DECK WITH AIRLOCK - PLAN VIEW

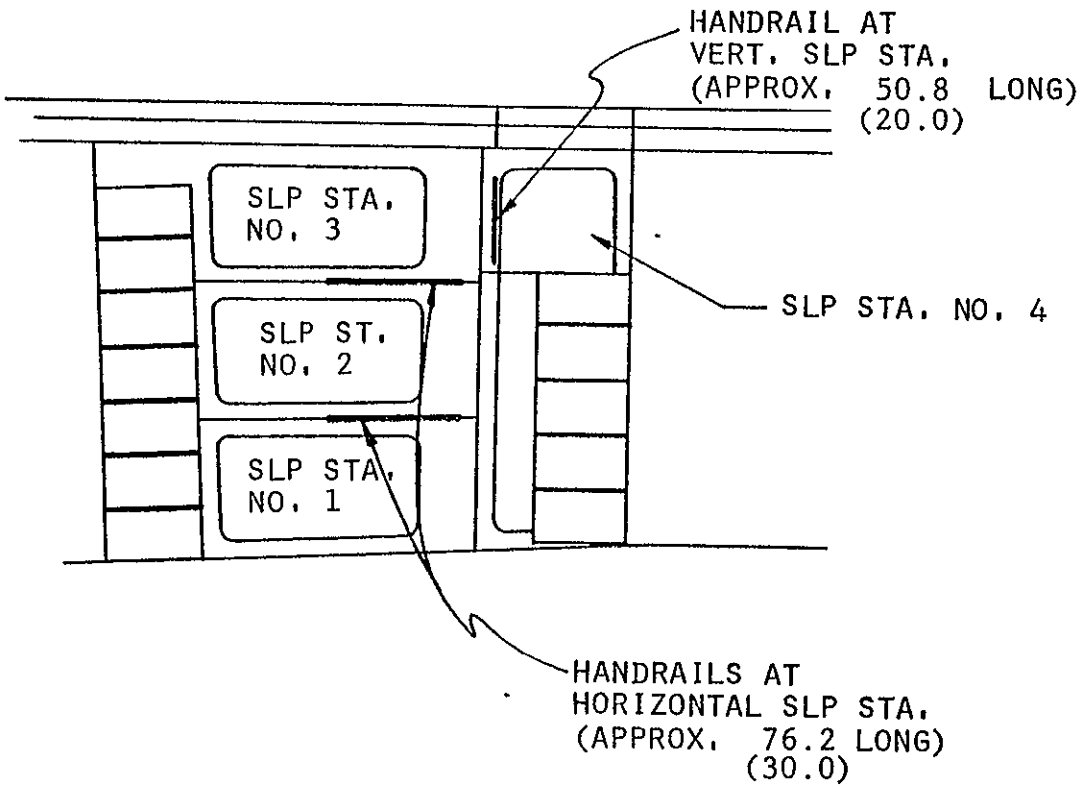


FIGURE 95 RECOMMENDED HANDRAIL LOCATIONS FOR MID-DECK WITH AIRLOCK - RIGHT SIDE VIEW

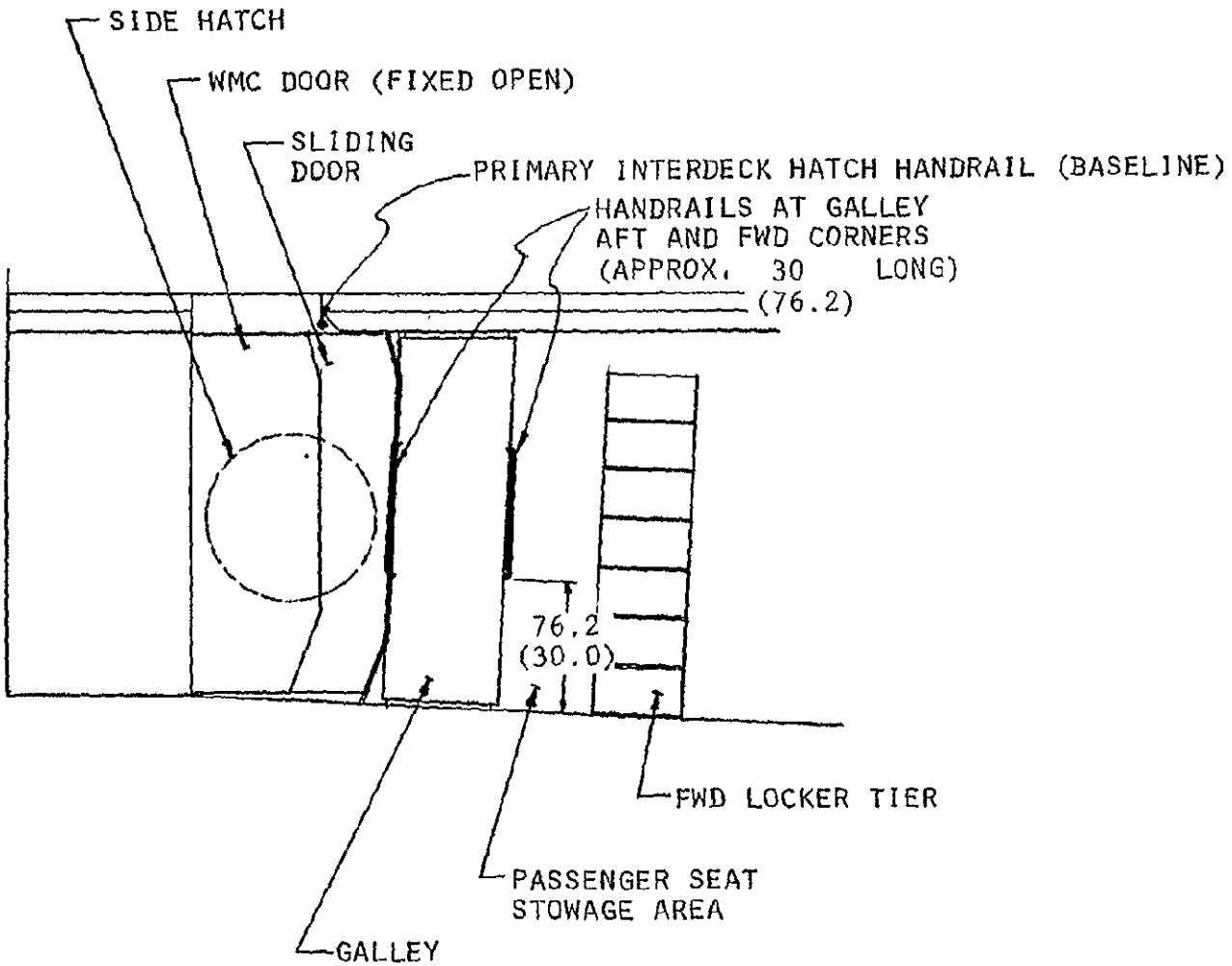


FIGURE 96 RECOMMENDED HANDRAIL LOCATIONS FOR MID-DECK WITH AIRLOCK - LEFT SIDE VIEW

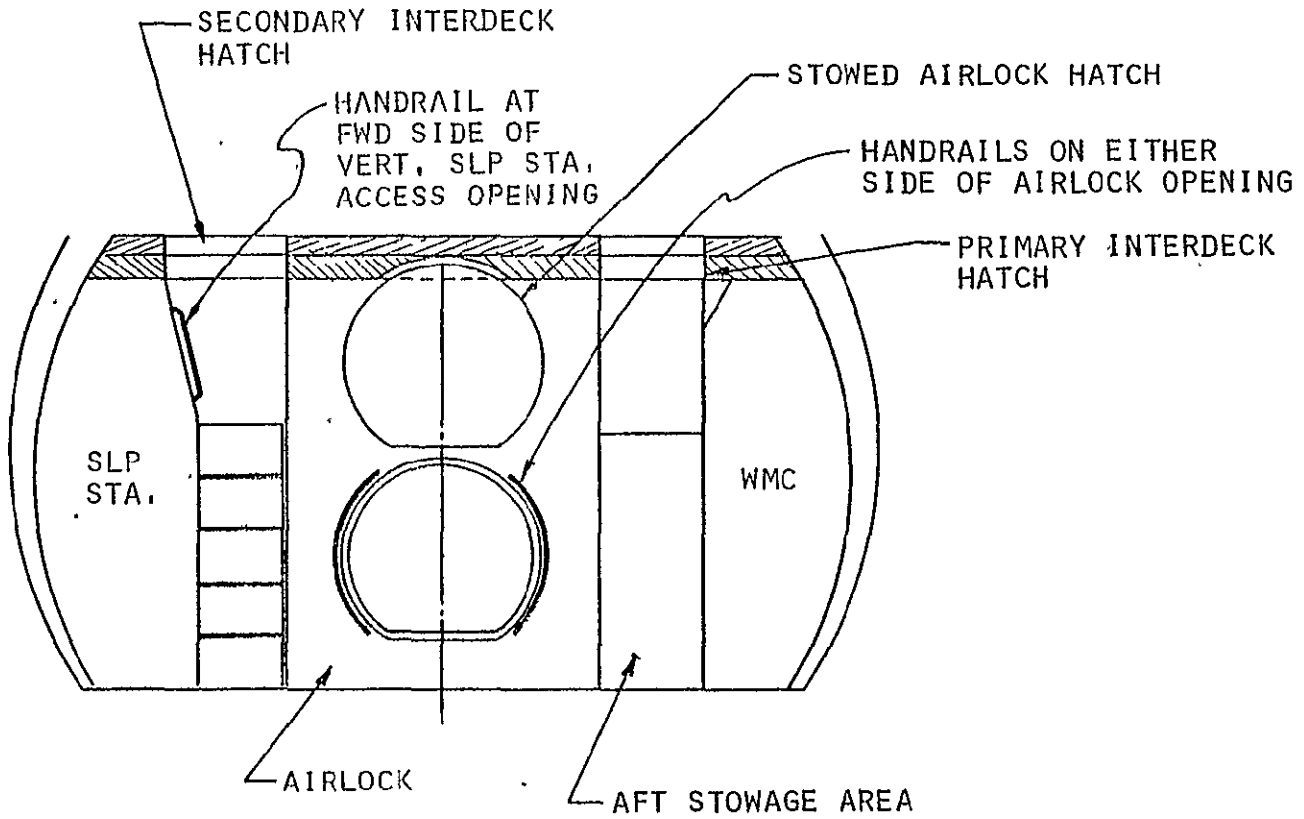


FIGURE 97 RECOMMENDED HANDRAIL LOCATIONS FOR MID-DECK WITH AIRLOCK - AFT VIEW

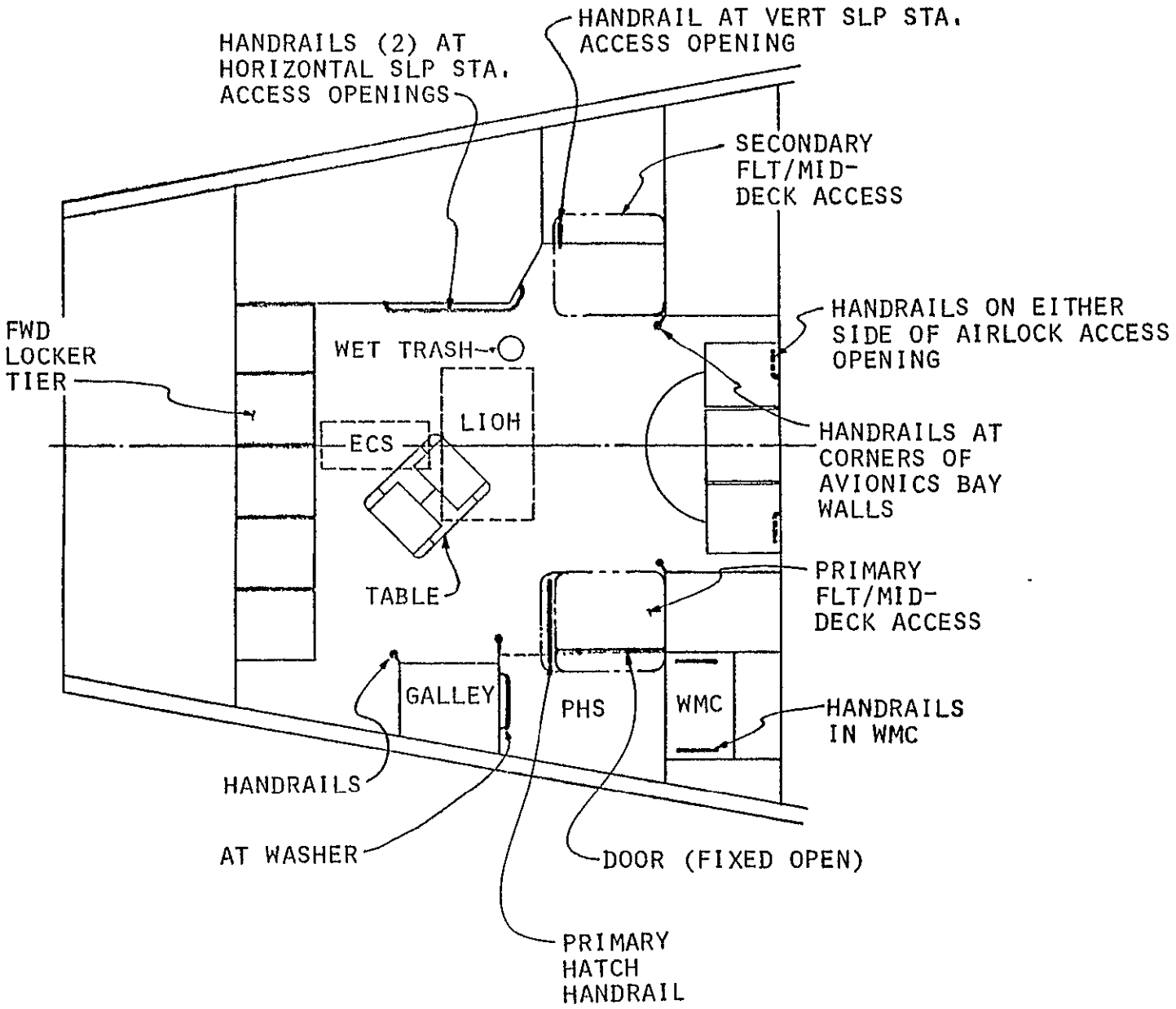


FIGURE 98 RECOMMENDED HANDRAIL LOCATIONS FOR MID-DECK WITHOUT AIRLOCK - PLAN VIEW

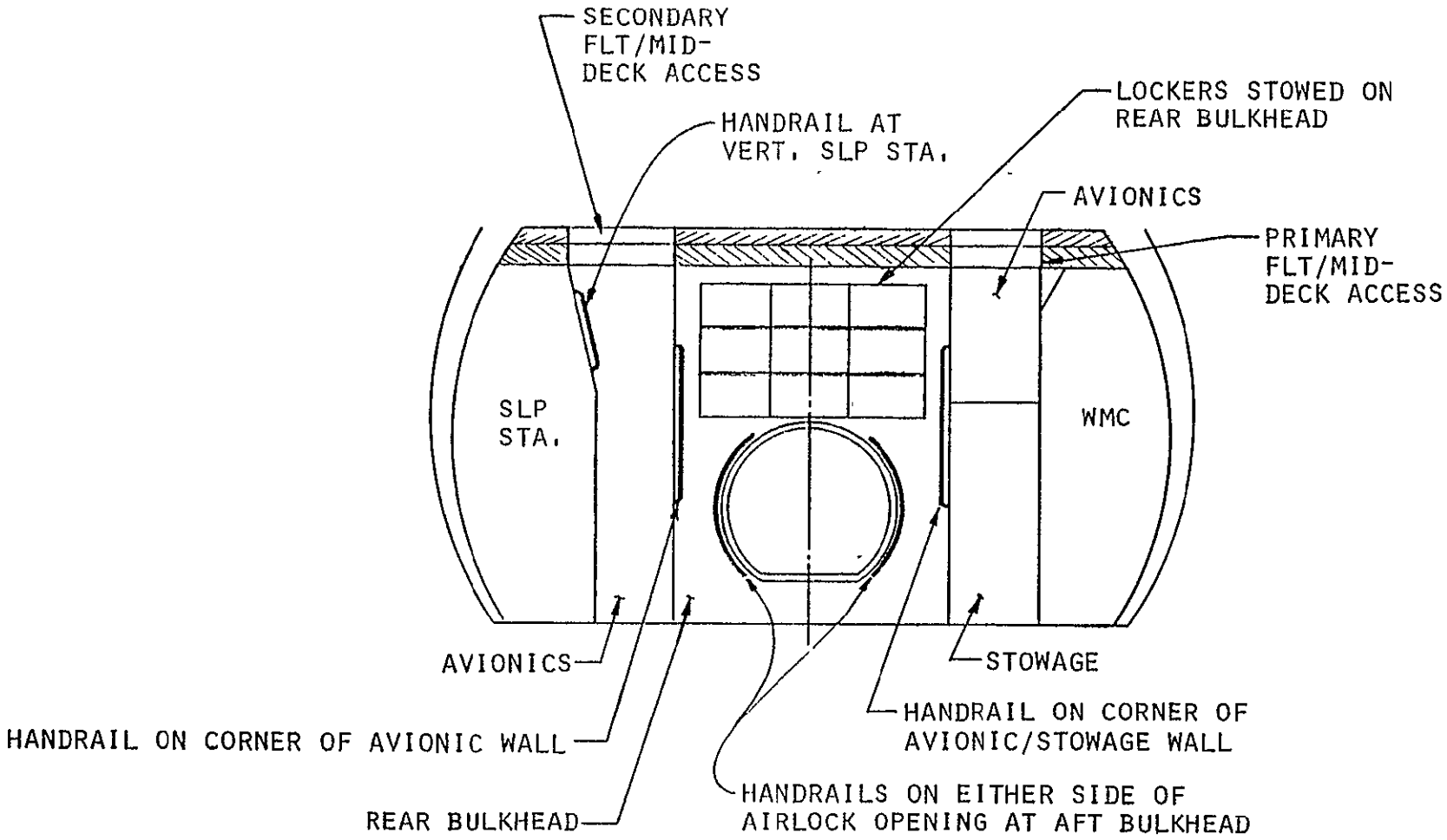


FIGURE 99 RECOMMENDED HANDRAIL LOCATIONS FOR MID-DECK WITHOUT AIRLOCK - AFT VIEW

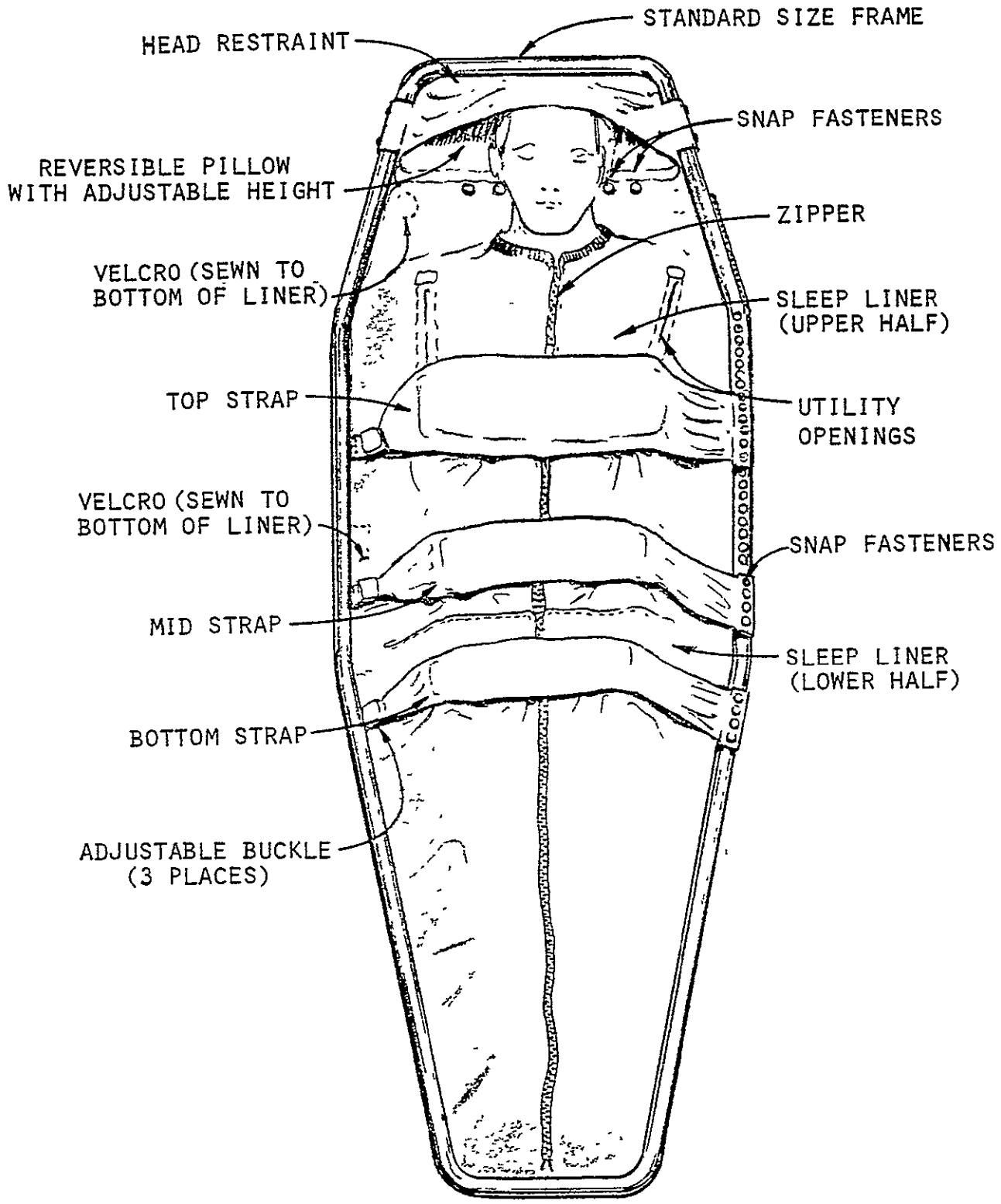
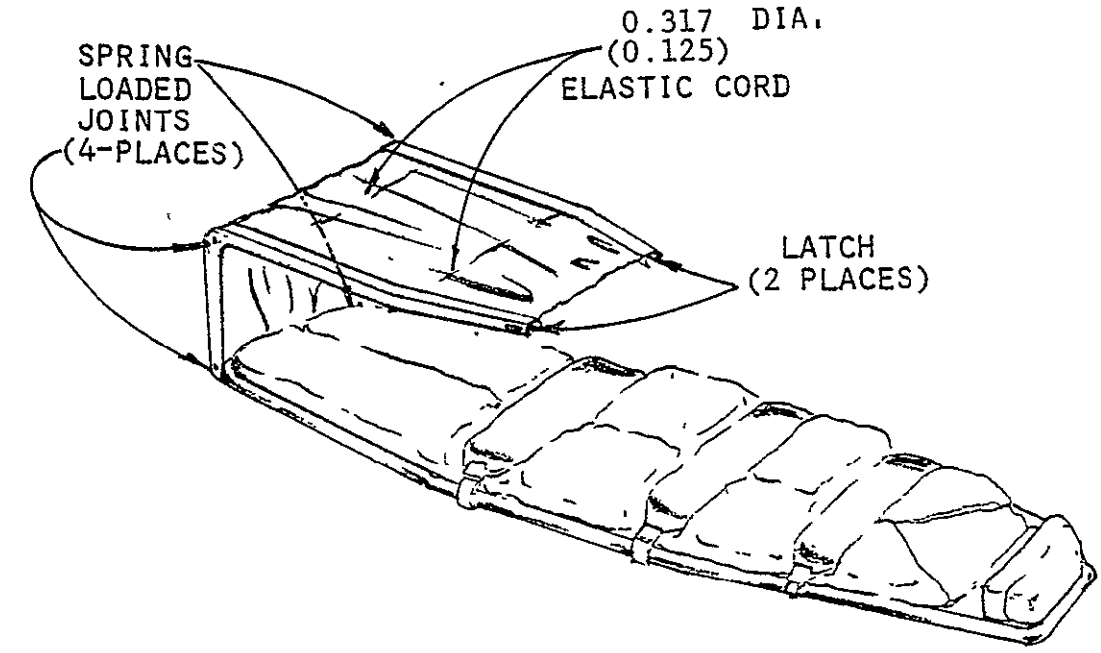


FIGURE 100 MODIFIED SKYLAB-TYPE SLEEP RESTRAINT RECOMMENDED CONCEPT



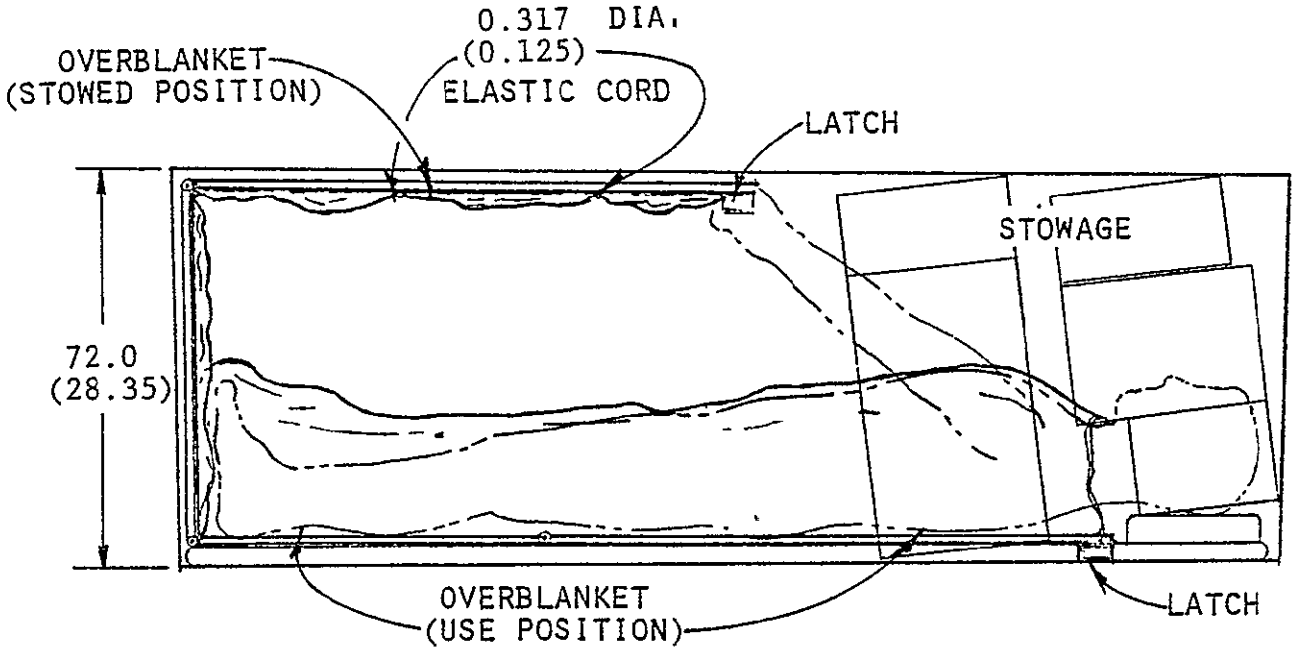


FIGURE 101 OVERBLANKET FOR SLEEP RESTRAINT - RECOMMENDED CONCEPT

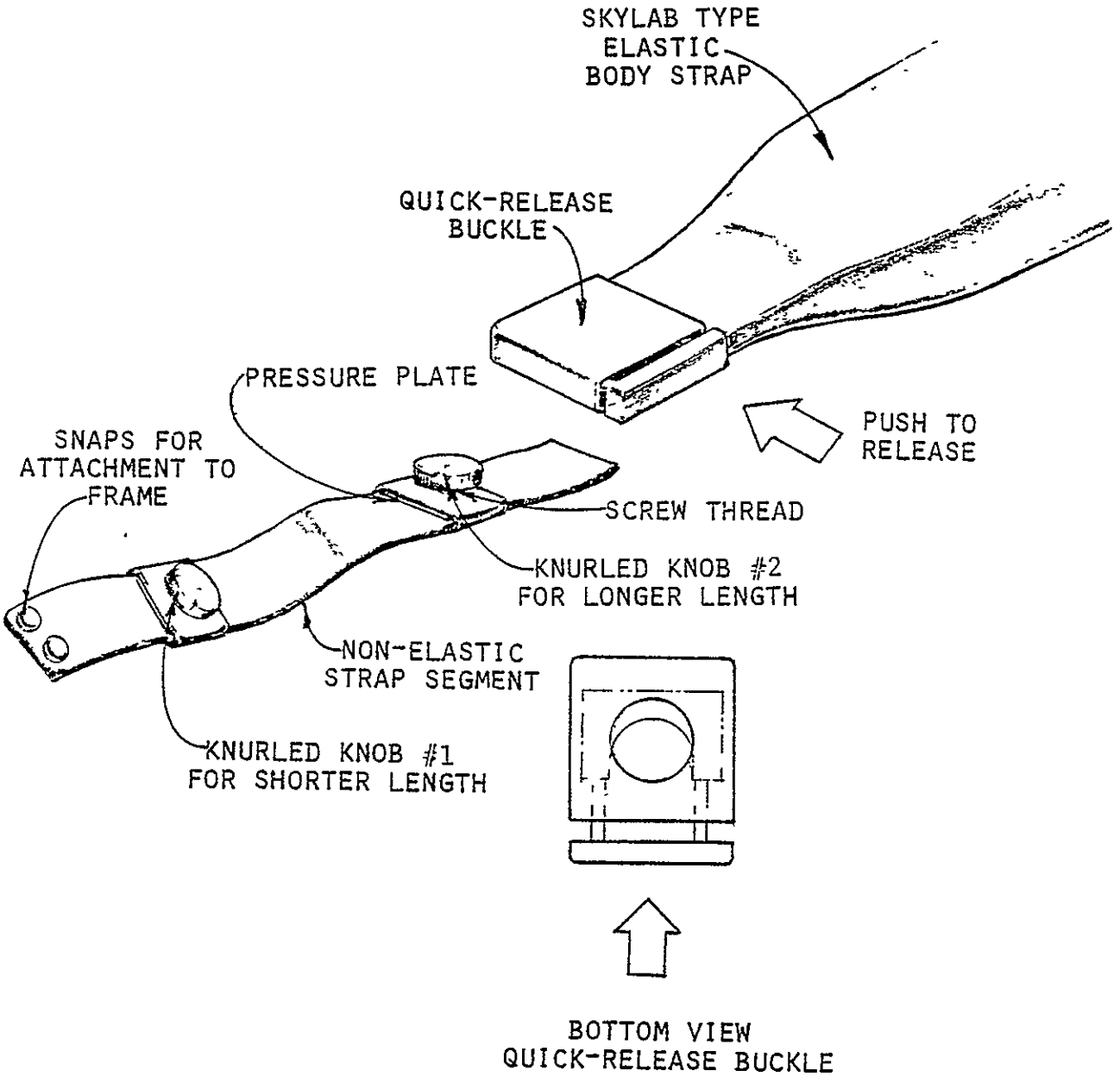


FIGURE 102 QUICK-RELEASE ADJUSTABLE STRAPS FOR SLEEP RESTRAINT - RECOMMENDED CONCEPT

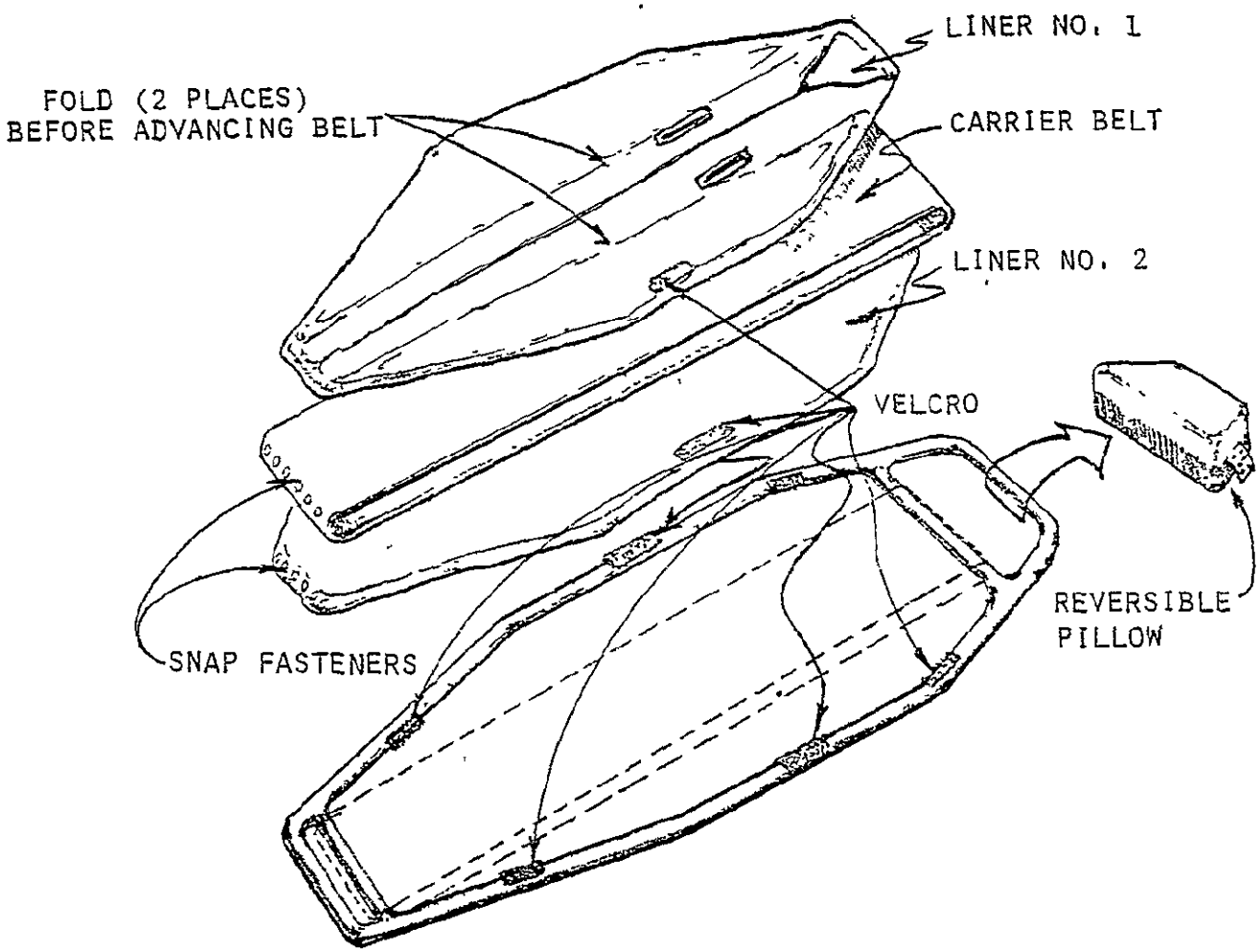


FIGURE 103 SLEEP RESTRAINT WITH BELT MOUNTED LINERS - ASSEMBLY VIEW - RECOMMENDED CONCEPT

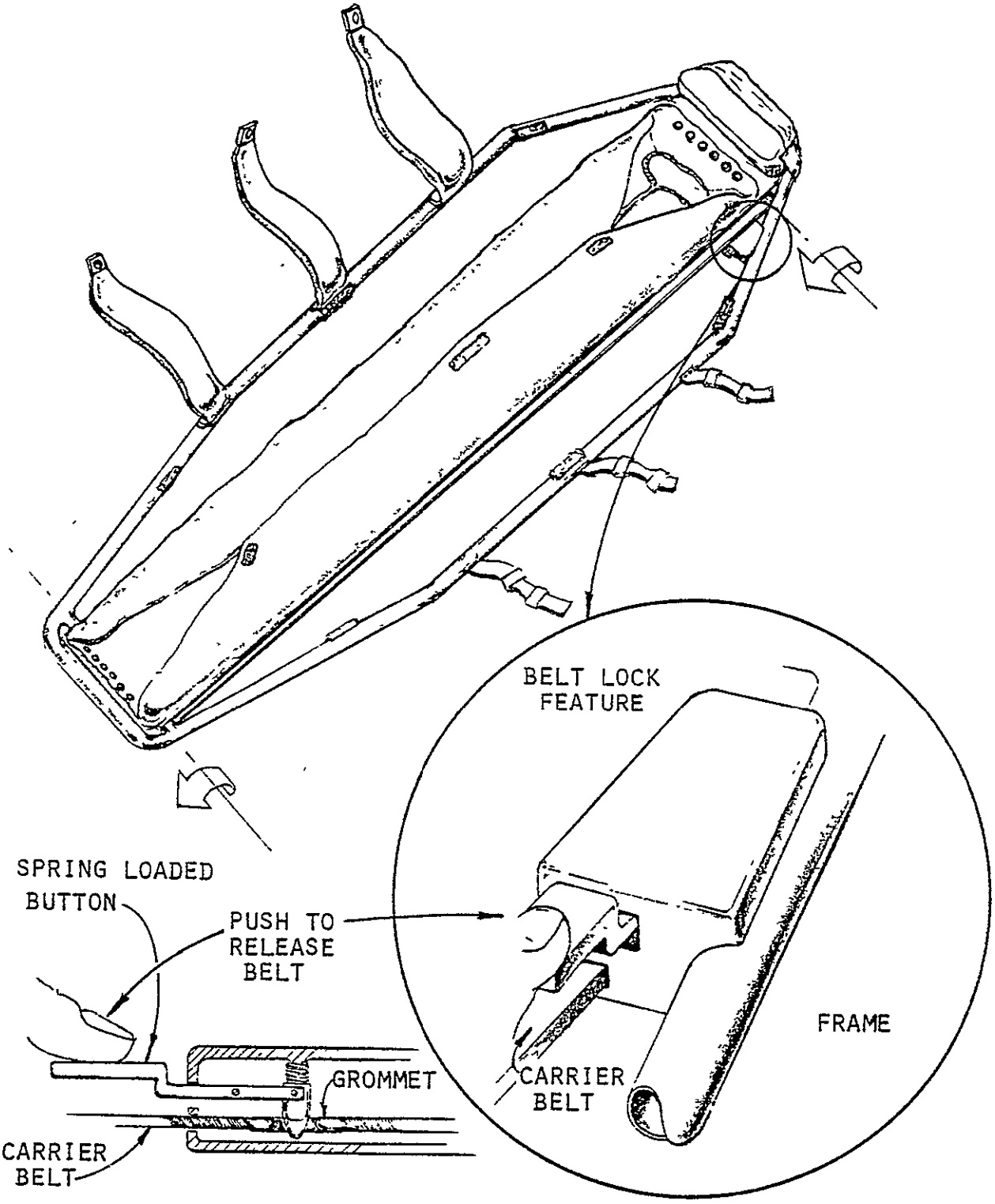


FIGURE 104 SLEEP RESTRAINT WITH BELT MOUNTED LINERS - RECOMMENDED CONCEPT

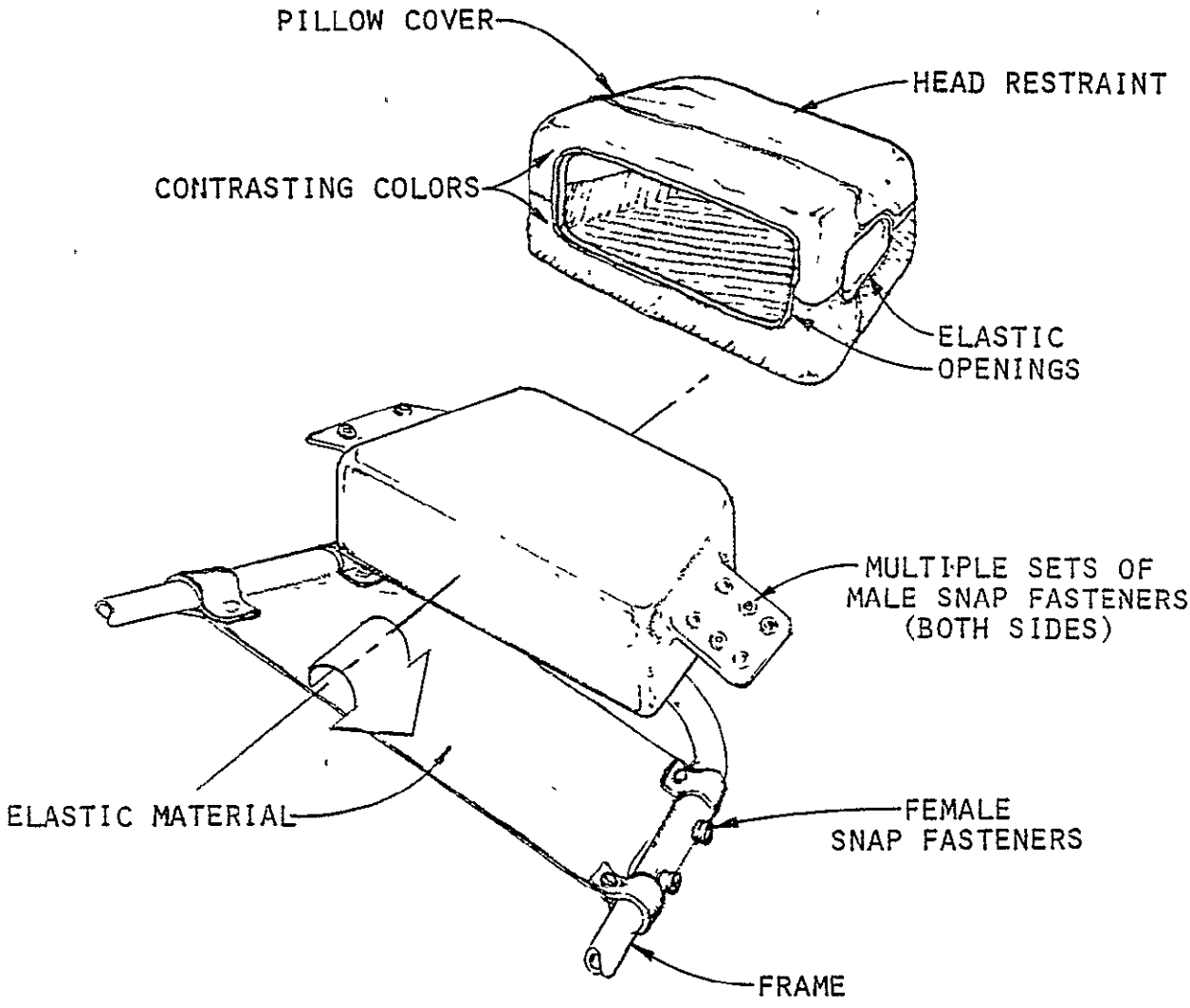


FIGURE 105 REVERSIBLE PILLOW FOR SLEEP RESTRAINT - RECOMMENDED CONCEPT

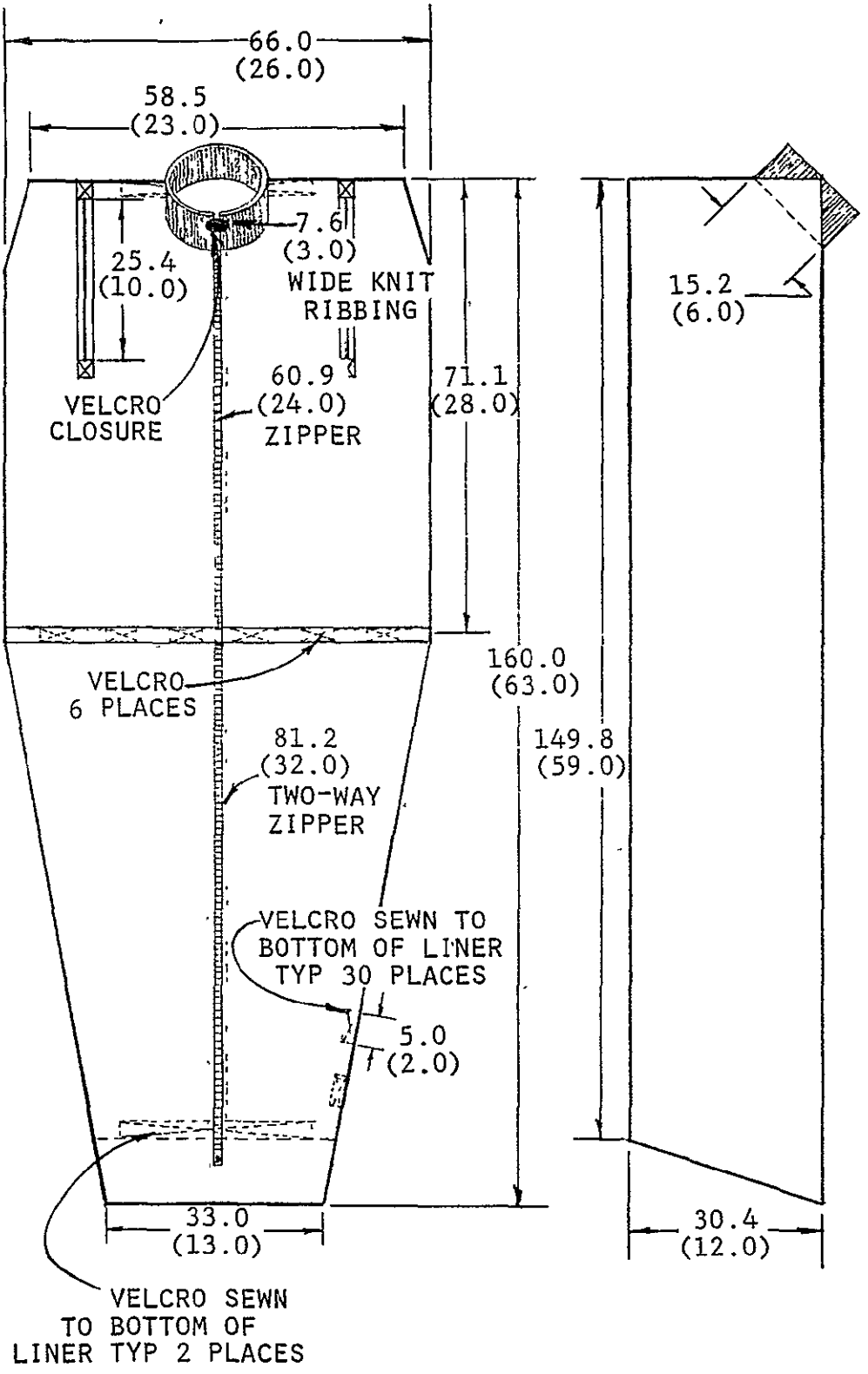


FIGURE 106 SLEEP LINER PATTERN DIMENSIONS

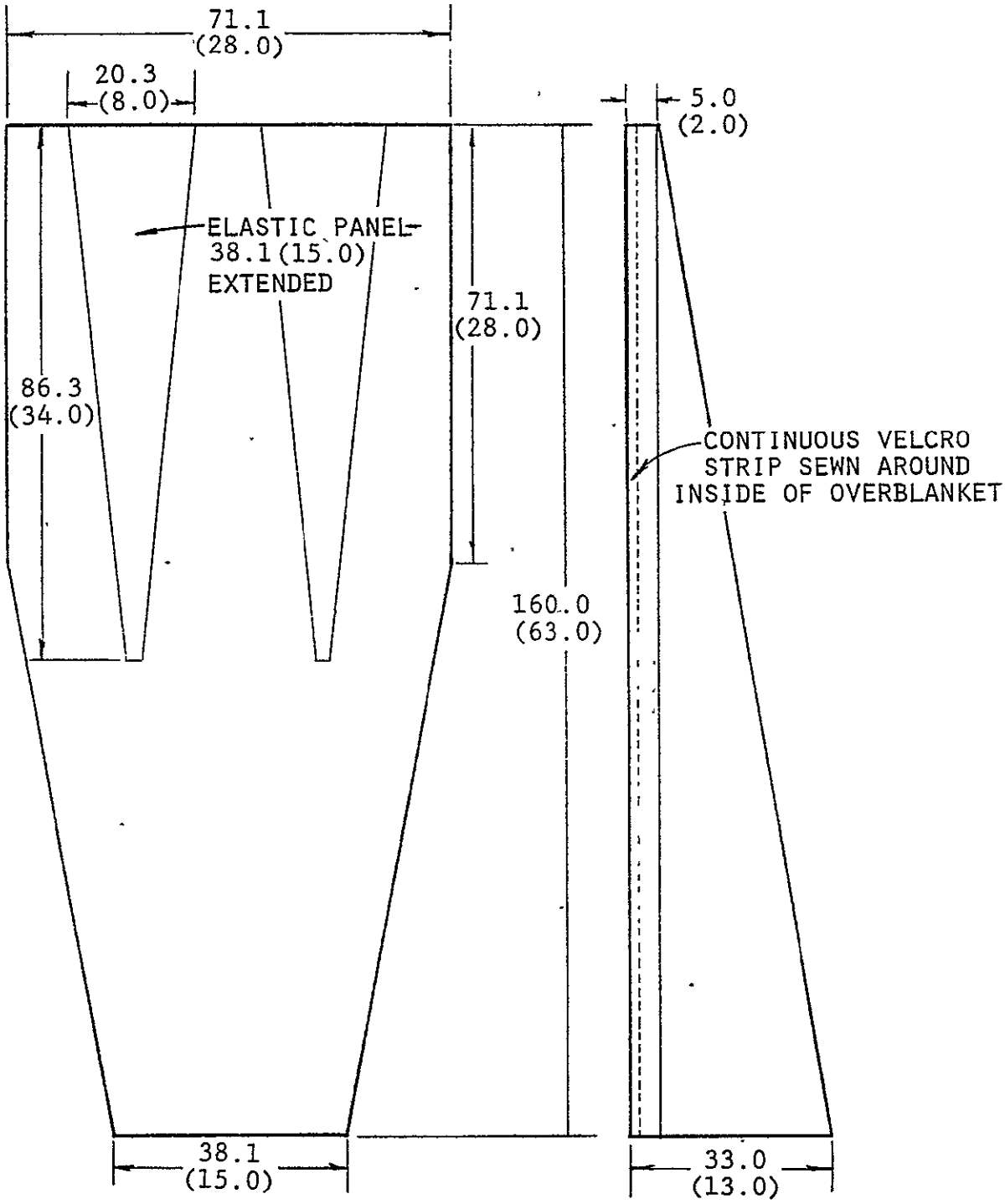


FIGURE 107 BLANKET PATTERN DIMENSIONS

would be to have the sleep liners attach to a pallet panel but the panel would have to be of a material that would not present any thermal effects as a result of body contact. The panel would also have to be capable of passing through the side hatch to enable installation, reconfiguration, or removal of the sleep stations as discussed in Section 4.2.

4.8 Wet Trash Management - The evaluation of wet trash management as presented in Reference 17, concluded that the available wet trash stowage volume available in the floor compartment was inadequate to handle bulk trash volume beyond 17 man-days of operation. A Skylab type can crusher with a trash bag liner concept to collect crushed empty food cans would enable up to 21 man-days of trash stowage in this floor compartment. However, the can crusher concept would require considerable crew time after each meal to accomplish the can crushing operation. It was determined that a larger trash compactor capable of handling all of the wet trash items from meals would be the proper device to enable a full 42 man-days of operation without having to allocate additional wet trash stowage volume. The compactor would be required to reduce the trash items to a volume which is on the order of one-third of the original bulk volume. The compactor liner bag can be of sufficient size to serve as a temporary wet trash collector and would require that only one crew member accomplish the trash compaction and disposal. Three compactor operations a day were determined as being feasible based on the trash compactor outside envelope being identical to that for a standard stowage container. The concept requires that the compacted trash package be tied so that it will maintain its reduced volume shape when removed from the compactor. Figures 108, 109, and 110 illustrate the trash compactor design concept. Figures 111 and 112 illustrate the operational aspects of the compactor by a single crew member. A larger size wet trash compartment access hatch will be required. The baseline hatch diameter of 15.2 centimeters (6 inches) will have to be increased to 25.4 centimeters (10 inches) in order to accommodate the trash package size of approximately 13 8 by 22.8 by 44.0 centimeters (5.45 by 9.0 by 17.3 inches).

The review of the full-scale trash compactor mockup indicated that the ratchet handle socket interface holes should be located so that they can be easily seen to facilitate insertion of the handle ends.

After the review at JSC of the trash compactor mockup, it was learned that items such as towels/washcloths and clothing were planned for reuse and therefore, would have to be kept separate from trash stowage. Since this study considered disposal of damp towels and washcloths as trash, the

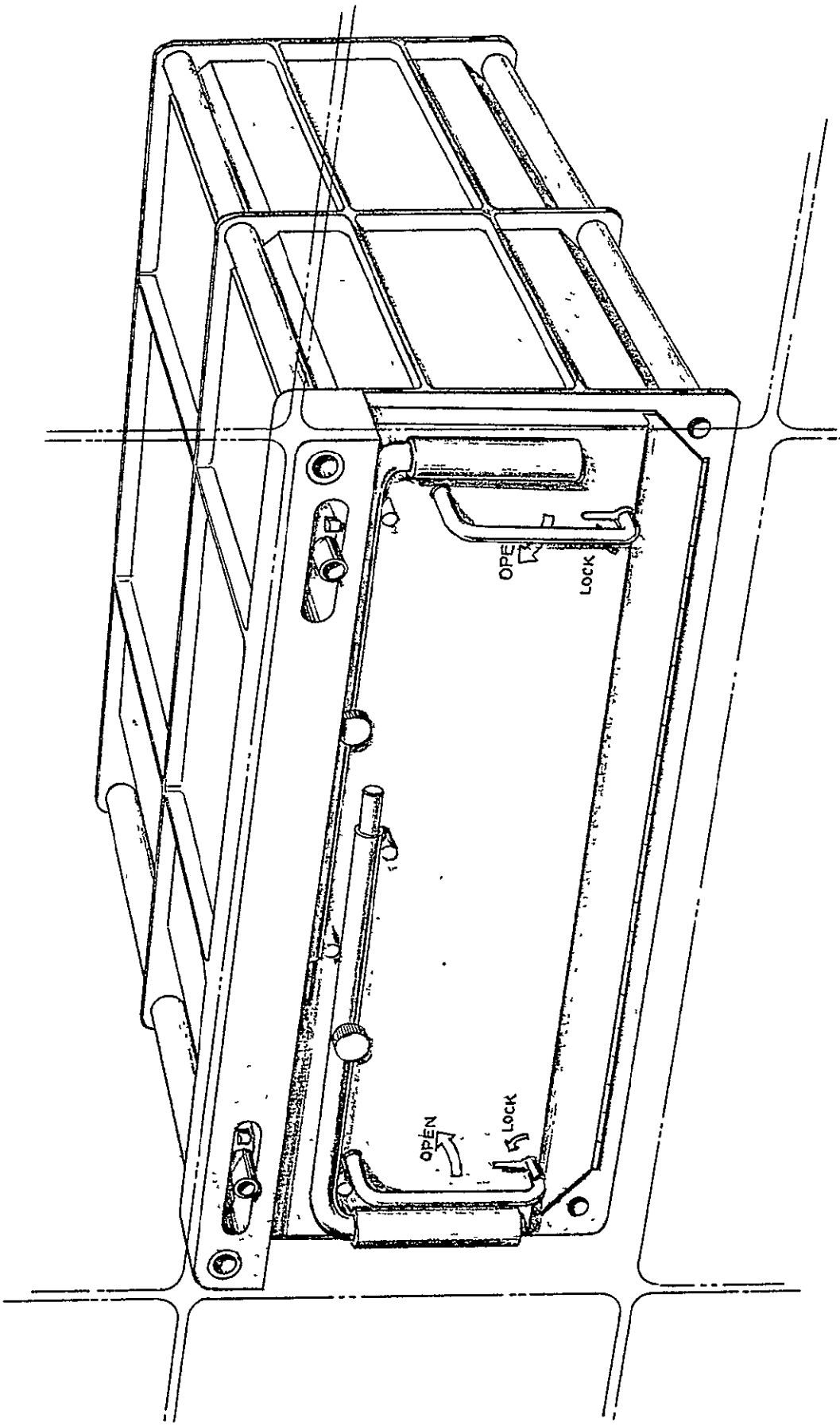
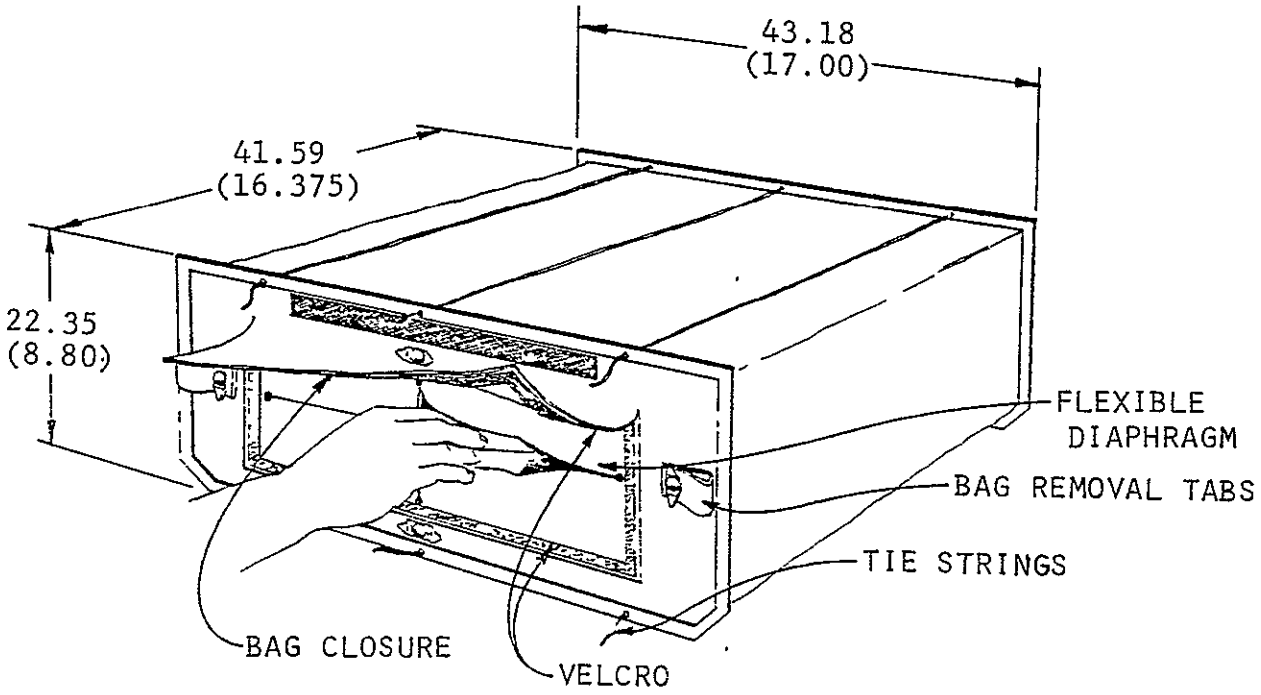
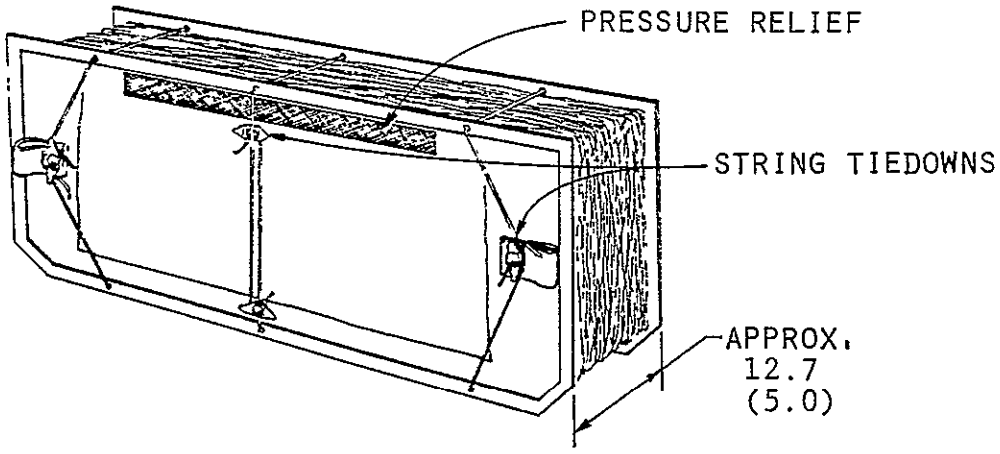


FIGURE 108 TRASH COMPACTOR CONCEPT - EXTERIOR VIEW



COMPACTOR LINER BAG IN USE



COMPACTED TRASH READY FOR STOWAGE

FIGURE 109 TRASH COMPACTOR BAG CONCEPT

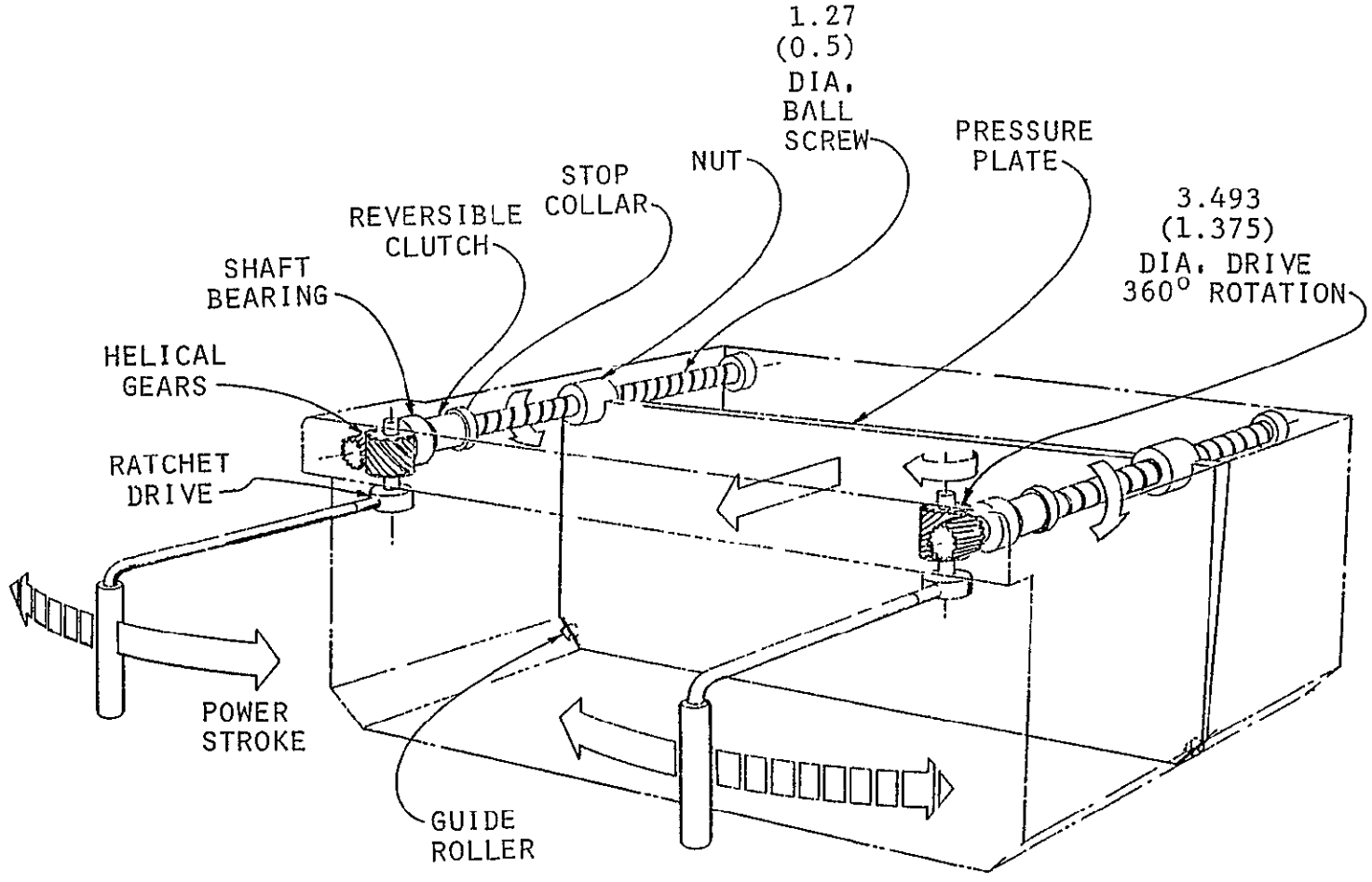


FIGURE 110 TRASH COMPACTOR COMPONENT PARTS

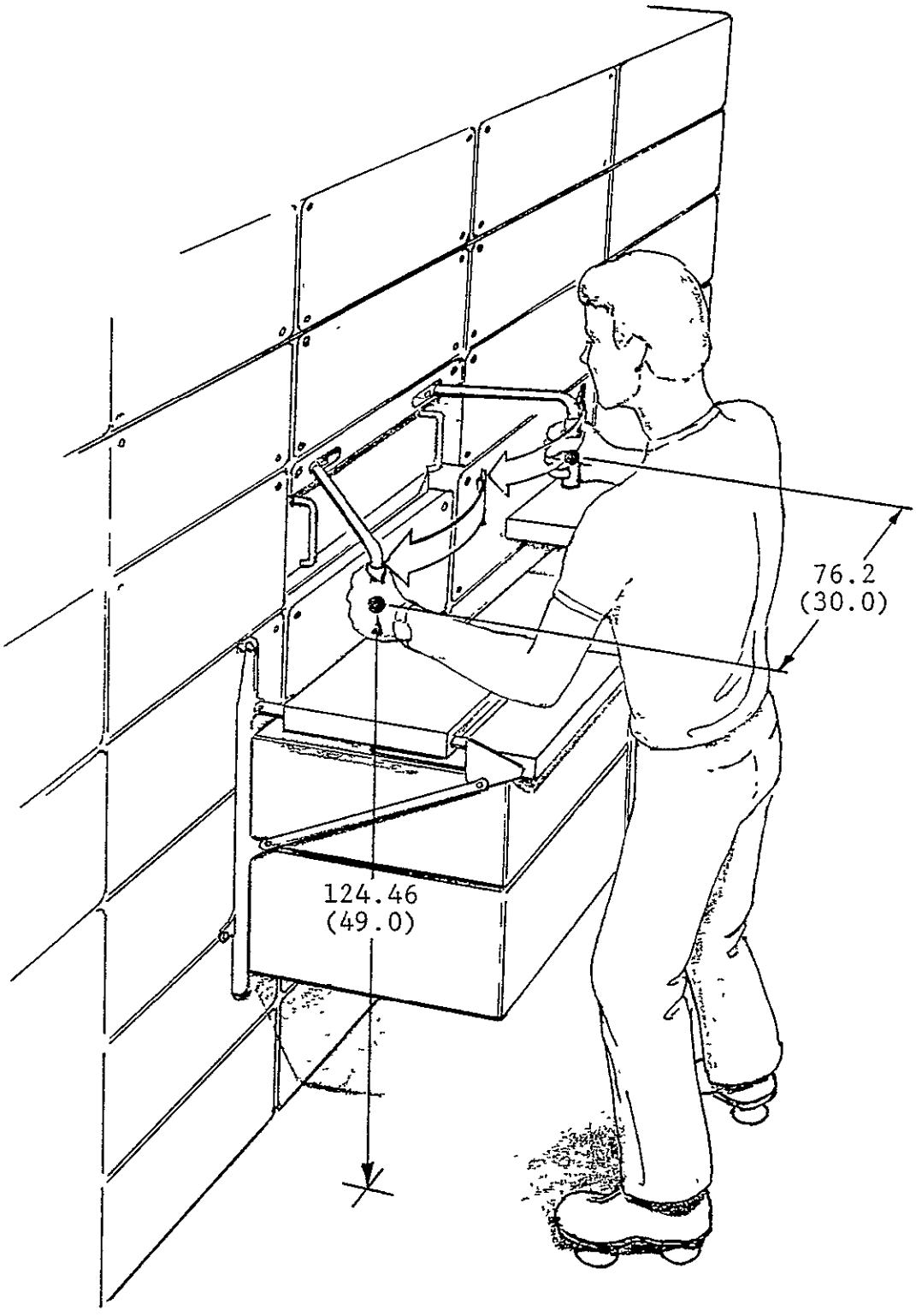


FIGURE 111 TRASH COMPACTOR OPERATION

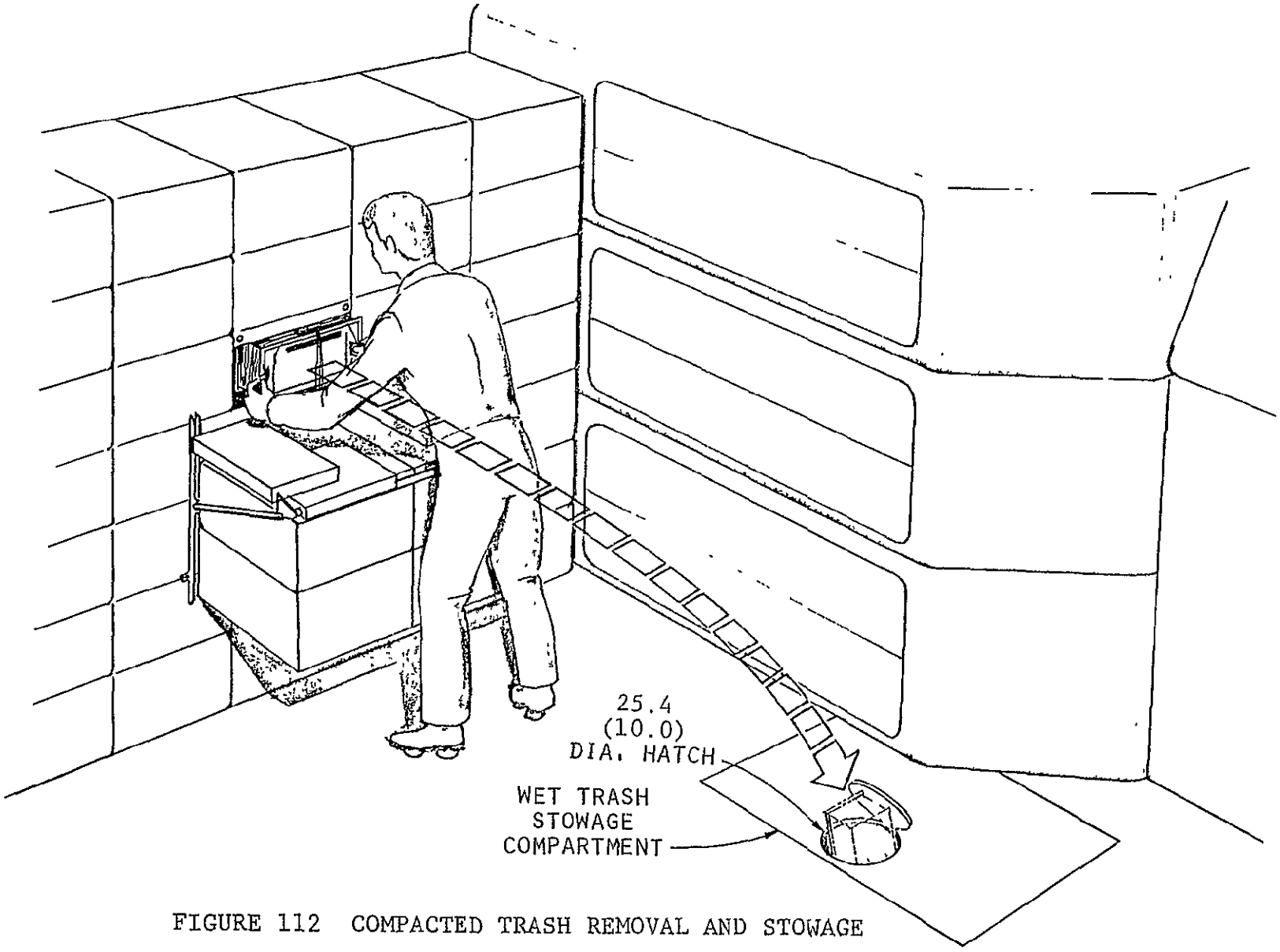


FIGURE 112 COMPACTED TRASH REMOVAL AND STOWAGE

volume handling capability of the wet trash compartment will be more in line with the apparent food item bulk trash. However, the use of a centrally located wet trash collection bag in the compactor and compaction operations should help to minimize crew handling of wet trash items.

4.9 Lighting - Light locations at the head end of the sleep stations were determined as illustrated in Figure 63, see Section 4.2. These locations were selected to place the light assembly control within reach of the crew member that is in the sleep restraint and to avoid any direct eye glare.

The light located outboard of the secondary interdeck hatch could serve the vertical sleep station but it is identified as a Mid-Deck emergency light. The only light shown for the personal hygiene area forward of the waste management compartment is the emergency light outboard of the primary interdeck hatch.

These emergency lights could provide illumination for the indicated areas, but with the respective compartment close-outs for privacy, their function as a Mid-Deck emergency light will be negated. It appears that a light should be located at the aft side of the galley to provide illumination at the washer/mirror location to enable personal grooming tasks.

The forward, right ceiling light location was identified as presenting an interference with the upper sleep station. Subsequently, a change to relocate this particular light was indicated by the prime contractor.

4.10 Color Schemes - The evaluation of color schemes as presented in Reference 18 concluded that the baseline light gray and light green was unacceptable from the standpoint of aesthetic appropriateness and contemporary usage. These two colors are almost identical in value and intensity and differ only slightly in hue. This creates a cold monotonous environment and deprives the senses of any visual interest. Light green and particularly gray colors are not at the top of current popularity lists as discussed in Reference 18. The alternate color scheme selected to meet harmonious, aesthetic, functional, and contemporary usage considerations was as follows:

- Oyster White - All major Mid-Deck surfaces
- Yellow - Sleep station doors and PHS/WMC main door
- Yellow Ochre (Darker Yellow) - WMC/PHS sliding door

- Brown - Table surface and handrails
- Red Orange - Nomenclature cards on white stowage locker doors
- White - All surfaces within the PHS/WMC area except drying station
- Garnet Red - Towel drying station container in top of WMC
- Light Blue - Sleep compartment walls, restraint liners, and pillow covers
- Dark Blue - Sleep restraint overblanket and trim.

5.0 RECOMMENDATIONS

5.1 Airlock Hatch Stowage - The recommended hatch stowage concept was the unhinged hatch configuration with the hatch stowed immediately above the opening on the front of the airlock, see Figure 61, Section 4.1. Moving the hatch from the closed (use) position to the stowed position or vice versa can be accomplished under weightless conditions by allowing the hatch to float as it is guided into position by a crew member. The alternate recommended concept, Figure 62, Section 4.1, utilizes this same stowage location concept but provides a detachable hinge such that when connected for use, the hatch will swing just as the baseline installation, Figure 60, Section 4.1. Both the recommended concept and the alternate method require a recessed opening in the ceiling in front of the airlock to avoid having the hatch dimension block the upper portion of the airlock opening.

5.2 Sleep Stations - The following recommendations were made as a result of the sleep station evaluations.

a. The width of all horizontal compartments should be maintained as wide as possible with the original baseline floor trace approximately 94 centimeters (Y_o 37 inches) to the right of the Mid-Deck centerline recommended as the inboard closeout limit.

b. The sleep restraint for the lower horizontal compartment should be installed so that the occupant will be facing the floor. The other two upper horizontal sleep positions should be facing up as in the original baseline arrangement.

c. The sleep restraint in the vertical compartment should be installed so that the occupant will be facing forward.

d. Compartment provisions should be based on individual stowage design concept. Further detailed design evaluation will be required before dual stowage aspects can be resolved.

e. A hard closeout design featuring inward folding doors (bi-fold) which swing away from the sleep restraint location should be provided with a modular appearance for the entire sleep station installation. A removable panel concept is recommended to enable reconfiguration and accessibility

to required stowage areas or items that may otherwise be blocked by this concept. These recommendations are illustrated on Figures 64 through 68 as presented in Section 4.2.

It should be noted that recommendations a, b, and c are based on fully meeting the space requirements for a 95th percentile male crew member, see Figure 63 as presented in Section 4.2

5.3 Eating/Work Table - It was recommended that the eating/work table as presented by Figure 70, Section 4.3, be utilized in the Mid-Deck area. It satisfies all desirable features with the exception of blocking direct access to the forward locker tiers. However, this situation will exist for all concepts that are hinged at the forward locker wall. This concept provides a more compact grouping around the four lockers under the table in the same face-to-face position arrangement as the baseline. It provides individual height adjustment at a tilt angle which places the food at a closer mouth-to-tray location for zero-g eating. The baseline table with its conventional horizontal orientation and lack of tilt capability will not provide this feature in a comfortable manner for the range of crew sizes under consideration.

Table utility features that are recommended are as follows:

- Smooth electrically insulated surface with handgrip table edges.
- Multiple retractable bungee cord restraint installation.

5.4 Personal Hygiene Station and Waste Management Compartment - The recommended location for the personal hygiene washer was determined to be at a height of 86.4 centimeters (34 inches) above the floor on the aft side of the galley. An opening height and width of 43.2 and 35.6 centimeters (17 and 14 inches), respectively, was also determined as necessary from the anthropometric data. A handrail at the lower edge of the washer was also recommended as a position stability aid during PHS ingress/egress. A 22.8 by 30.5-centimeter (9 by 12-inch) size mirror should be located above the washer opening.

The baseline door hinge point should be retained but the door configuration recommendations include an angle top portion with a sliding hard door extension as illustrated in Figure 113. This door concept will alleviate the primary interdeck hatch interference as well as provide the

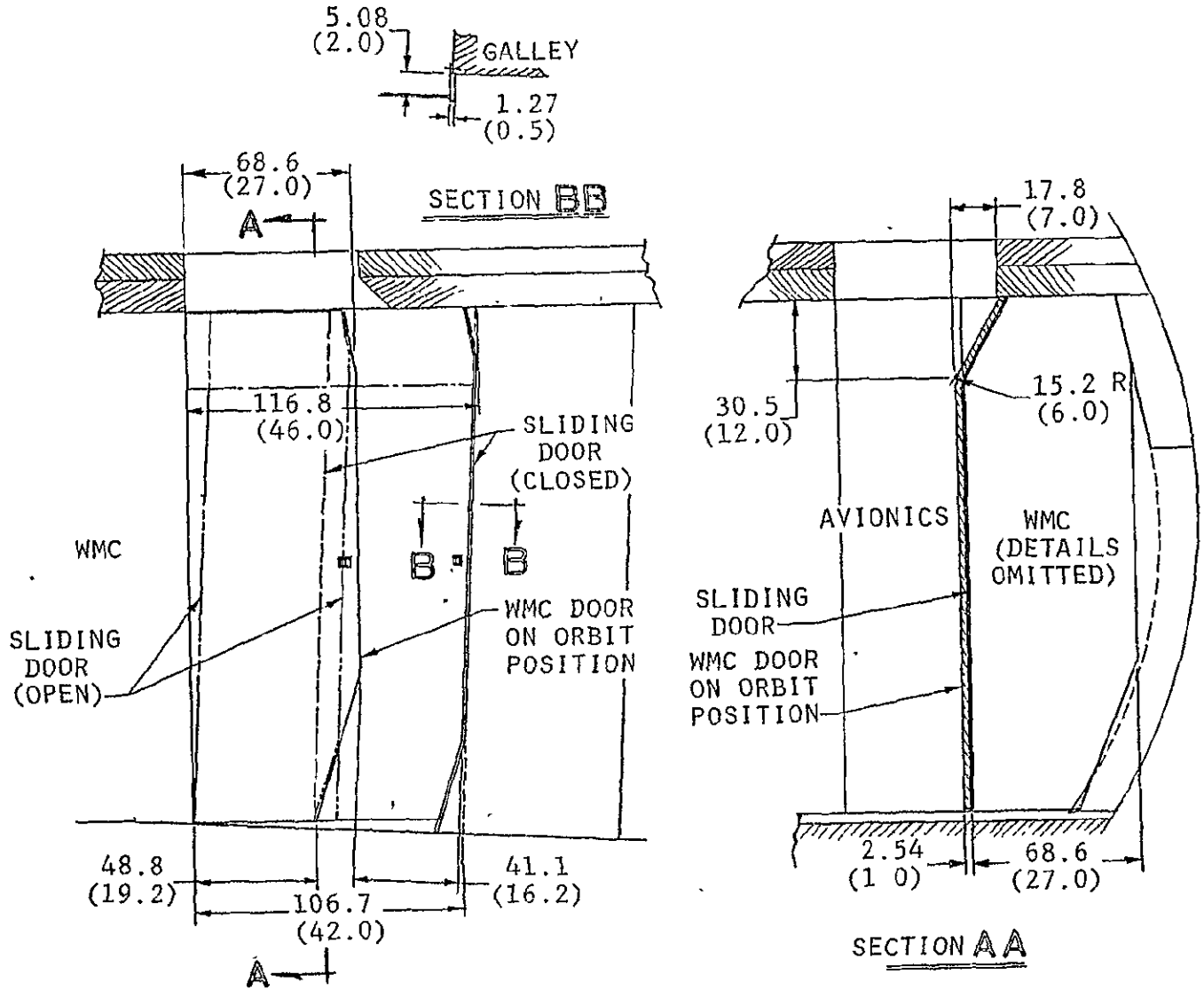


FIGURE 113 PHS/WMC AREA CLOSEOUT - RECOMMENDED CONCEPT DETAILS

required privacy closeout for the PHS/WMC area. It will also provide adequate width space aft of the galley for the largest size crew member to perform all the personal hygiene activities. It was also recommended that the spaces between the side wall frames be left open to permit utilization of the floor surface out to the side wall as foot restraint surface. Otherwise, the available floor width between the frame inboard edges and door will present a marginal width situation for positioning of the feet.

Recommendations for temporary stowage and restraint provisions include use of a double bungee pattern across the open areas between frames as shown in Figures 85 through 87 as presented in Section 4.4. Special handling requirements for towels and washcloths led to the recommendation that a deployable retention tray concept be utilized such as illustrated by Figures 88 through 91 as presented in Section 4.4. For the WMC arrangement, it was recommended that a tilted seat installation as depicted by Figure 84, Section 4.4, be utilized with side handholds and a lap strap. This configuration will provide additional space behind the crew member that might be used as additional stowage space.

The suction airflow control for using the PHS washer or WMC equipment should be moved from its planned location at the aft wall of the WMC to a forward position to make it more accessible for someone using the washer.

It was also recommended that use of the side hatch window as a camera installation should be avoided. A large camera located in this area will severely limit access to the washer and the WMC. An alternate approach would be to limit a camera installation to periods during the day when use of the PHS/WMC facilities would be at a minimum.

5.5 Airlock Out Arrangement - It was recommended that the Mid-Deck arrangement presented by Figure 93 as presented in Section 4.5 be utilized when the airlock is not in the Mid-Deck area. The nine lockers launched in the baseline location at the fourth sleep station can be relocated to a position on the aft bulkhead above the airlock hatch. This location will provide free access to the fourth sleep station. A pedestal supported table away from the forward locker tier will permit free access to all the lockers in this area. The individual table surfaces are identical to those recommended for the eating/work table as shown in Figure 70 as presented in Section 4.3 but are supported by a pedestal as shown in Figure 114.

The table assembly would be collapsible and stowable as shown in Figure 115.

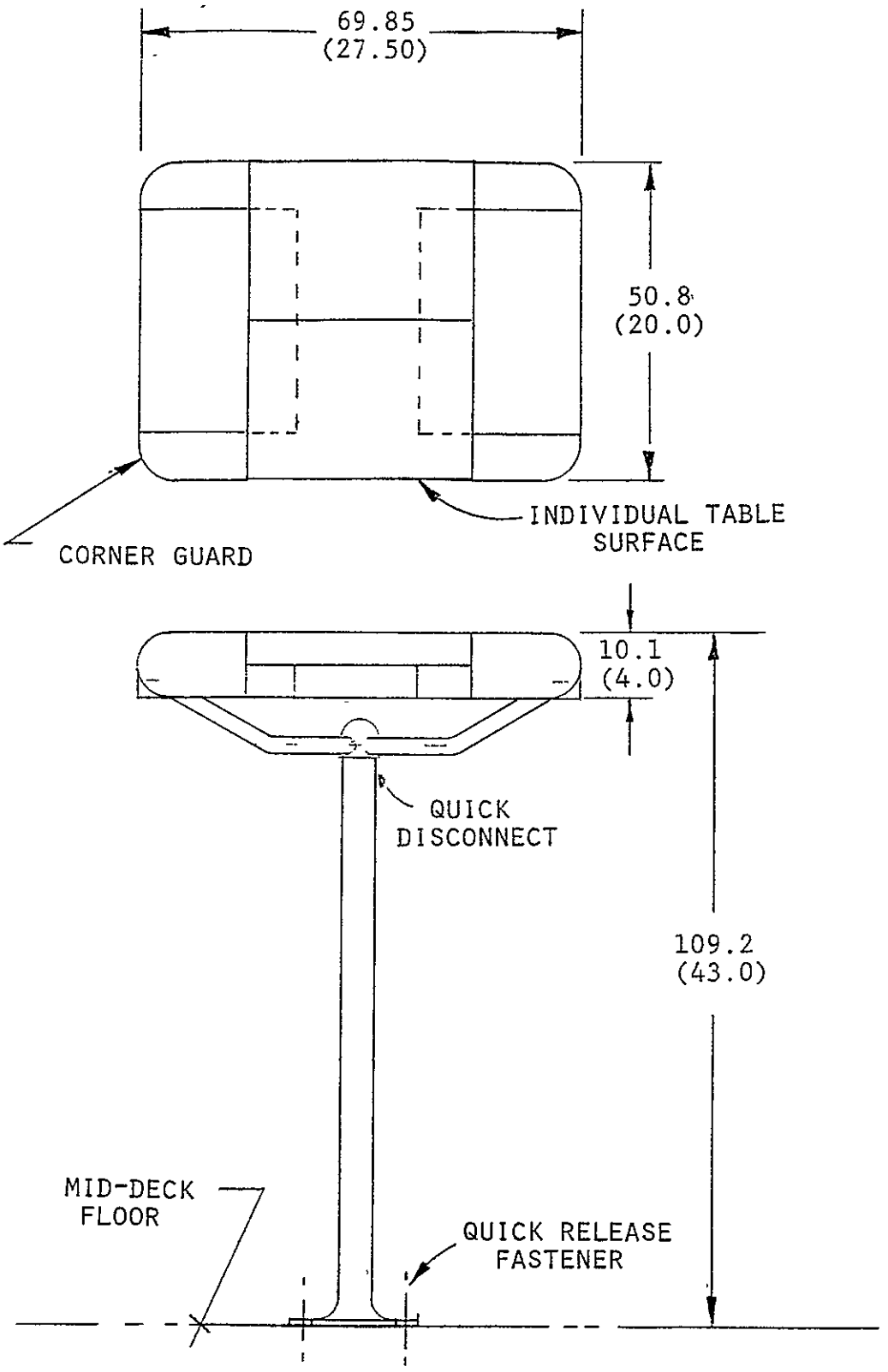


FIGURE 114 EATING/WORK TABLE UNOCCUPIED
DIMENSIONAL DATA - AIRLOCK OUT

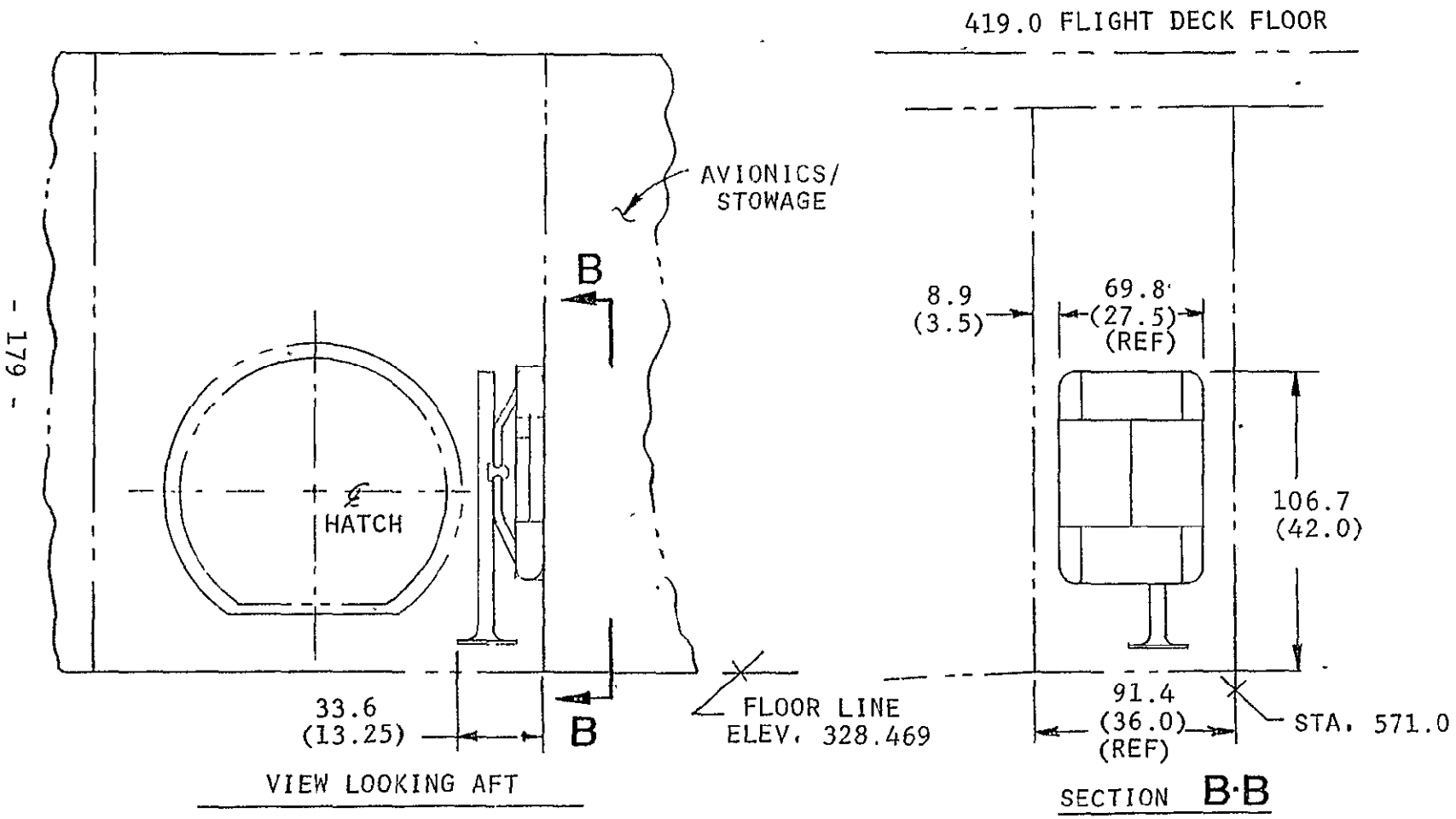


FIGURE 115 EATING/WORK TABLE LAUNCH AND STOWAGE AREA - AIRLOCK OUT

These recommendations will require two different table assemblies to be compatible for the two possible Mid-Deck arrangements, one with an airlock and one without the airlock.

5.6 Mobility/Stability Aids - The handrail locations identified on Figures 94 through 99 as presented in Section 4.6 were recommended as being required to provide crew members with sufficient mobility/stability aids to perform their activities under zero-g conditions.

5.7 Sleep Restraint - The recommended sleep restraint configuration features a two-piece sleep liner with full length zippers for each half. It is based on design and fabrication of standard sleep restraint pieces (i.e., frame, sleep liner, restraint straps, pillow, and overblanket) that will accommodate the variation in crew member sizes from a 5th percentile female to a 95th percentile male. The quick-release adjustable strap length feature will permit individuals to select the desired restraint strap tension for the crew size differences.

To accommodate alternate crew member use of a sleep compartment with a minimum of reconfiguration of the sleep restraint, the movable belt concept with two sleep liners is also recommended. This version of the recommended sleep restraint would only be flown for missions requiring alternate use of the same sleep compartment.

The recommended concept features are presented in Figures 100 through 105, see Section 4.7.

5.8 Wet Trash Management - It was recommended that trash compaction be utilized as part of the trash management operation. A trash compactor having the capabilities of that represented by Figures 108, 109, and 110 (see Section 4.8) was recommended to aid in reducing wet trash volume and provide a compact clean package for disposal in the wet trash floor compartment. Utilization of this concept will require that the baseline floor access opening diameter for this area be increased from 15.2 centimeters (6 inches) to 25.4 centimeters (10 inches) to accommodate the size of the trash package. The trash compactor will require the space of one standard stowage container and should be located in the forward locker tier as illustrated by Figure 111, Section 4.8.

5.9 Lighting - Since deviations to the baseline lighting pattern were being accomplished by the prime contractor, a final evaluation was not possible within the contract time frame of this study. In any event, light locations for the

personal hygiene and waste management area must be compatible with personal hygiene activities at the washer on the aft side of the galley as well as for the waste management compartment activities. For these latter activities, lighting provisions must consider that a crew member will be facing forward for fecal equipment use and male crew members will be facing aft for urinal use. Lighting for accessibility to stowage areas in this area and for equipment cleanup must also be considered.

5.10 Color Schemes - It was recommended that a white (oyster white) color finish be utilized as the basic major color for all major surfaces in the Mid-Deck. To enhance the major activity area appearance, yellow doors at the sleep stations and PHS/WMC were recommended with a brown color for such items as table surfaces and handrails. An all white PHS/WMC area was recommended since it would help to visually enlarge the small compartment and provide a neutral background to reduce visual clutter when personal items are deployed. A light blue color was recommended for sleep station interior surfaces and sleep liner material to provide a cool, restful appearance with good light reflectance. A dark blue overblanket and other trim material provides a monochromatic color scheme conducive to a restful atmosphere.

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APPENDIX A

DESIGN REQUIREMENTS

SHUTTLE ORBITER SLEEP STATION AND RESTRAINT

DESIGN REQUIREMENTS

SHUTTLE ORBITER SLEEP STATION AND RESTRAINT

1.0 OVERALL CONCEPT

Shuttle crew members shall be provided with four individual compartments insulated from the spacecraft's operational light and noise. These compartments shall provide space for the donning and doffing of clothing, storage of the crewman's personal items and clothing, and sleeping facilities for the scheduled rest periods as well as moments of opportunity at crew discretion.

1.1 THE COMPARTMENT

1.1.1 Environment

1.1.1.1 Sound. The sleep compartment shall be capable of being isolated from the sounds of normal ship's operation and personal activity of non-sleeping crew members. Attenuation techniques shall limit ambient in-compartment noise from outside sources to 55 db.

The attenuation techniques shall not prevent a sleeping crewman from hearing the emergency caution and warning signals.

1.1.1.2 Temperature, Airflow, Humidity. The sleep compartment shall be controllable by its inhabitant to maintain a personal comfort box bounded by a temperature range from 20°C to 25.6°C (68°F to 78°F), a flow rate sufficient to change the air every 4 to 8 minutes with the inlet airflow variable but not exceeding 15.24 meters per minute (50 fpm). The direction of airflow shall be controllable to direct the air away from the crew member's nasal area.

1.1.1.3 Light. The sleep compartment shall be capable of being completely darkened. Additionally, a permanent light suitable for reading and controllable to 323 lumen/meter^2 (30 footcandles) by the inhabitant shall be provided within the compartment.

1.1.1.4 Communications. The sleep compartment shall have intercom facilities for the use of the inhabitant. These shall provide, but not be limited to, caution and warning, and inter-spacecraft communications controls operable by crewmen in their sleep restraints.

1.1.2 Architecture

1.1.2.1 Orientation. The four compartments shall be located on the right side of the Mid-Deck providing three horizontal and one vertical oriented arrangements with respect to the Orbiter interior. Crew member sleep position orientation within the upper two horizontal compartments shall be facing up while the position in the lower compartment shall be facing down. The aft end of the three horizontal compartments shall be the head area for each crew member. The vertical sleep station shall provide a sleep position facing forward with the head area toward the ceiling.

1.1.2.2 Volume and Dimensions. Each compartment shall be large enough to accommodate a male crew member of the 95th percentile stature as defined by the USAF flying officer (projected to 1980) anthropometric standards and a sleep restraint assembly to permit donning and doffing of clothing and sleeping positions. The location of items shall be within the functional reach of a 5th percentile female crew member. In addition to the inhabitant and the sleep restraint, space for temporary stowage of clothing and personal items shall be provided.

1.1.2.3 Interference. The compartment shall be constructed such that a structurally rigid closeout or some similar suitable device will separate individual compartments and prevent one crewman from disturbing an adjacent crew member as he moves about within his own enclosure.

1.1.2.4 Temporary Stowage. The compartment shall provide for the overnight stowage of items of personal equipment (pocket-type items) and clothing. Consideration shall be given to expanding these provisions to accommodate both temporary and semipermanent stowage for personal items and clothing to allow the compartment to be used by two crew members on alternate shifts. This shall be treated as a design alternate.

1.1.3 Other Considerations

1.1.3.1 Off-Duty Equipment. Provisions for the individual off-duty tape player system shall be incorporated within the compartment.

1.1.3.2 Closeout and Access Appearance. The closeout of the sleep stations shall provide a modular appearance with each compartment having a bi-fold door access.

1.1.3.3 Stowage Area Accessibility The closeout paneling shall be sectional and removable to permit transport through the Mid-Deck side hatch and to permit ground and inflight access to stowage areas in the vicinity of the sleep stations.

1.2 THE RESTRAINT

1.2.1 Retention. The sleep restraint shall be capable of retaining a sleeping crew member ranging from the 5th percentile female to the 95th percentile male (USAF data extrapolated to 1980) without compromising comfort. Design alternates may be employed to consider a full range of retention mechanisms from a single whole-body sheet-type device to strategically placed straps around various body points. Adjustability must be incorporated to allow for varying body sizes and configurations.

1.2.2 Ingress/Egress. The restraint shall allow unencumbered ingress and egress, with emphasis on the capability for rapid egress in an emergency. Access openings, closure methods, etc., shall be as simple as possible within the confines of the retention and comfort requirements. Design alternatives are acceptable (e.g., snaps, velcro, elastic, ties, etc.).

1.2.3 Utility Openings. The user shall be able to free his arms to accomplish "out-of-restraint" chores while using the device (e.g., reading, operating comm., adjusting ventilation, etc.). Appropriate "through-the-restraint" openings shall be incorporated in the device to accommodate this requirement.

1.2.4 Thermal Flexibility. The restraint shall have an integral capability to be adjusted to suit the personal thermal needs of the user. Deployable layers of covering may be the best approach to meeting this requirement, but design alternatives are acceptable.

1.2.5 User Motion. Sufficient flexibility shall be incorporated into the sleep restraint to allow body and limb flexure and full 360° yaw about the erect body axis without compromising either the comfort of the user or the retention integrity of the restraint.

1.2.6 Mounting Provisions. The sleep restraint shall have integral mounting provisions for attaching the device to the parent compartment. These provisions shall retain the device in a stable condition during ingress, egress, and user stay. Consideration shall also be given to the ease of mounting and demounting the device.

1.2.7 Use. In the event of split-shift operations involving up to seven crew members, the sleep compartment may be sequentially shared with another crew member. The sleep restraint assembly shall be designed to permit alternate crew member to reconfigure the restraint assembly and use his/her sleep liner and pillow cover without having to change out the entire sleep restraint.

1.2.8 Use Rate. For sanitation on missions longer than seven days, the restraint liner and pillow cover should be replaced on a weekly schedule.

1.2.9 Materials. The materials used in constructing the sleep restraint exhibit comfort characteristics similar to those generally associated with cotton fabrics. These materials shall be compatible with specification NHB-8060.1A.

APPENDIX B

DESIGN REQUIREMENTS

SHUTTLE ORBITER EATING/WORK TABLE

DESIGN REQUIREMENTS

SHUTTLE ORBITER EATING/WORK TABLE

1.0 OVERALL CONCEPT

The Shuttle Orbiter shall contain a device consisting of four individual table surfaces suitable for use by crew members to support the following:

a. Restrain and support food trays at mealtime.

b. Serve as an "office desk" to support general paper work and administrative chores.

c. Serve as a basic platform upon which tools, parts, and components can be arrayed and restrained in support of inflight maintenance activities.

d. Serve as a focal point for crew assembly in leisure periods by providing a stable platform for display and retention of small items such as books, cassette recorders, etc.

The table assembly shall be located in the Mid-Deck area of the Orbiter and be conveniently positioned with respect to the galley. It must be capable of being securely stowed for launch and entry; exhibit a minimum infringement upon Mid-Deck volume, traffic patterns, and stowage access; and be completely removable and easily stowed if contingencies or high priority activities (such as EVA pre and post) make demands upon Mid-Deck volume.

The table assembly shall be designed for use by crew members exhibiting the neutral zero-g body posture, a position defined as a semi-crouch with the resultant posture falling between the one-g sitting and standing positions. (For details see JSC-09551, Skylab Experience Bulletin No. 17, "Neutral Body Posture in Zero-g"). The user population will range from the 95th percentile male to the 5th percentile female.

1.1 MEAL SUPPORT

1.1.1 Food Trays. The primary interface for each table surface with respect to meal support will be with the food tray. The tray design has not been finalized yet, but

for planning purposes it can be considered to be 7.62 by 25.40 by 35.56 centimeters (3 by 10 by 14 inches) in external dimension and capable of retaining all food stuffs, beverages, and utensils necessary for a meal. The interface between table surface and tray will be at the attach point, which will be of TBD configuration. No power or plumbing requirements will have to be provided by the table assembly.

1.1.2 Loading and Frequency. No more than four crew members shall be accommodated at a single serving. For crews of more than four members, multiple servings for a single meal may have to be accommodated if single-shift operations are undertaken. For multiple shift operations, no single meal should ever require more than four crew members to be served. Three meals a day for each crew member will be the required meal support for the table, meaning that if 3-shift operations are undertaken, as many as nine separate serving periods per 24 hours could result.

1.1.3 Architecture

1.1.3.1 Location. The table shall be located near the galley for convenience of serving. It should also provide ready access for all users to trash stowage areas. It must not interfere with access to wall-mounted stowage lockers or below-the-floor stowage areas or operational accesses. It must not unduly restrict traffic through the area or impede ingress/egress associated with the airlock hygiene area, sleep restraints, or interdeck hatches.

1.1.3.2 Restraints. The table must accommodate the food tray in a stable manner so as to allow unimpeded eating. No personnel restraints should be considered as integral to the table, they will be part of the vehicle. Retention and stability of the food tray shall be such that both hands are allowed to be free for managing utensils and eating.

1.1.3.3 Lighting. Mid-Deck ceiling lighting will be used to illuminate the table.

1.1.3.4 Stowage. The table must withstand launch and entry loads of 3 g's. As a design option, it may be completely removable and stowable in an unobtrusive location, or it may collapse or fold in some manner so that its use and stowage locations are adjacent and have a common hard mounting or hinge point. It must be capable of complete stowage to clear the Mid-Deck for other activities if contingencies or priorities so dictate.

1.1.3.5 Table Surface Arrangement. The individual table surfaces shall be arranged so as to place the crew members in a face-to-face position arrangement.

1.1.3.6 Height Adjustment and Tilt Requirements. Each table surface unit shall have height adjustment capability to accommodate the user population defined in Section 1.0. The table surface shall have an angle adjustment feature such that it can be positioned at an optimum angle in relation to the user as well as in a horizontal plane.

1.2 OFFICE DESK

1.2.1 Writing. Each table surface shall provide a smooth flat area of at least 25.40 by 35.56 centimeters (10 by 14 inches) to serve as a stable platform for pen and paper type activities.

1.2.2 Accouterments. Ancillary hardware, such as retention devices for paper, pencils, etc., shall not be required as integral to the table. However, designs which accommodate such items without imposing constraints upon the meal support function are desirable.

1.2.3 Adjustments. The writing surface shall be in a tilt position with respect to the user as defined in 1.1.3.6.

1.2.4 Reading. The table shall be capable of accepting documents on its surface (retained by either vehicle provided restraints or integral devices, depending upon design options) for the purpose of providing a stable and well lighted reading support. Lighting will be provided by the Orbiter Mid-Deck ceiling lights, and no power requirements are levied on the table.

1.3 MAINTENANCE BENCH

1.3.1 Work Surface. The table shall provide a stable, electrically insulated surface upon which equipment items may be secured while they are inspected, disassembled, repaired, reassembled, and checked out.

1.3.2 Restraints and Stowage. The table shall not be required to furnish retention mechanisms or stowage facilities for maintenance activities as an integral part of the basic unit. However, unobtrusive devices that do not impose constraints on the meal support and stowage requirements are considered desirable design options.

1.3.3 Flexibility. The basic design of the table shall not preclude its ability to accept independently attached restraint, lighting, or stowage provisions in support of inflight maintenance activities.

1.3.4 Utilities. The table shall not be required to supply power, fluids, or integral lighting in support of maintenance activities.

1.4 OFF DUTY

1.4.1 In the absence of any other operational requirement for the use of the table at a particular time in any mission, it will be available to serve as an off-duty congregation point for crew members and its basic design shall not preclude such unscheduled use. No specific requirements shall be laid on the unit in support of this particular use.

1.5 MISCELLANEOUS CONSIDERATIONS

1.5.1 Vehicle Interface. When the airlock is present in the Mid-Deck, the table assembly shall be mounted at the front of the forward stowage lockers. The mounting framework shall be hinged to permit the assembly to be swung up out-of-the-way of the lower lockers to permit access to these lockers. The mounting framework shall accommodate four of the standard size stowage lockers under the table assembly. When the airlock is not present in the Mid-Deck, a table assembly supported by a pedestal attached to the Mid-Deck floor shall be utilized.

1.5.2 Mass Properties. The table must be constructed from materials that are compatible with the Orbiter environment, as light in weight as possible, and as sturdy as practical considering the weight and compatibility constraints.

APPENDIX C

DESIGN REQUIREMENTS

SHUTTLE ORBITER TRASH COMPACTOR

DESIGN REQUIREMENTS

SHUTTLE ORBITER TRASH COMPACTOR

1.0 OVERALL CONCEPT

The Shuttle Orbiter shall contain a trash compaction device suitable for use by crew members to support trash management operations as follows:

a. Provide temporary stowage of bulk wet trash items.

b. Reduce the volume of bulk wet trash items.

c. Provide clean trash package of reduced volume for disposal.

The trash compactor shall be located in the Mid-Deck area of the Orbiter at a position which is accessible to crew members for disposal of bulk wet trash items, compaction operation, and compacted trash package removal. It shall be capable of occupying the space of one standard modular stowage container and be mounted in the same manner. The user population will range from the 95th percentile male to the 5th percentile female.

1.1 TEMPORARY TRASH STOWAGE

1.1.1 Trash Stowage Bag. A replaceable bag shall be used in the trash compactor to serve as a temporary collection device for wet trash items. The bag sides shall be of flexible material to permit initial stowage of the bag itself in a collapsed configuration. For use, the bag shall be capable of being installed in the trash compactor volume and expanded to its full size. The bag access opening shall provide for the insertion of wet trash items and retain these items within the bag volume under zero-g conditions. The bag material and construction shall prevent liquid residue of wet trash items that have been inserted from migrating out of the trash bag volume.

1.1.2 Trash Stowage Bag Volume. The trash stowage bag shall be capable of retaining a maximum of 0.034 cubic meters (1.2 cubic feet) of bulk wet trash items.

1.1.3 Wet Trash Items. Wet trash items are defined as all empty food containers from a meal and wet wipes or tissues.

1.2 TRASH COMPACTION

1.2.1 Trash Compactor. The trash compactor shall be a manually operated, mechanical device capable of crushing wet trash items that have been inserted into the trash stowage bag.

1.2.1.1 Compactor Size. The trash compactor housing shall not exceed the outline dimensions of a standard modular stowage locker, 27.30 by 45.72 by 50.80 centimeters (10.75 by 18 by 20 inches).

1.2.1.2 Mounting. The trash compactor housing shall utilize the same cantilivered mounting method as the standard modular stowage locker.

1.2.1.3 Weight. The weight of the trash compactor assembly shall not exceed 4.36 kilograms (30 pounds).

1.2.1.4 Operational Force. The manual force required to operate the compactor shall not exceed 89 newtons (20 pounds).

1.2.1.5 Compaction Ratio. The trash compactor shall be capable of reducing the volume of a fully loaded trash stowage bag to at least one-third of its original volume.

1.3 TRASH PACKAGE

The compacted trash package shall provide a clean, manageable envelope that can be handled for transfer from the trash compactor to the trash stowage area.

1.3.1 Pressure Relief. Venting of the trash stowage bag through the use of millipore filter type material shall be provided. The filter shall permit gas transfer only. Additional liquid residue retention within the bag may be considered such as through the use of absorbent material as part of the bag inner liner.

1.3.2 Shape Retention. The trash package formed by compaction of the trash stowage bag and its contents shall be capable of retaining the size of its reduced volume by using suitable retention methods such as tie strings or straps.

1.4 VEHICLE INTERFACE

1.4.1 Mounting and Location. The trash compactor shall be capable of being installed, removed, and operated from a position in the forward modular stowage container tier. The preferred location is the fifth position from the floor in the center stack of containers.

1.4.2 Trash Package Disposal. The trash package shall be capable of being inserted through a 25.4-centimeter (10-inch) diameter access hatch to the wet trash stowage compartment.

1.5 MAN-MACHINE INTERFACE

1.5.1 Operational Posture. The trash compactor shall be capable of being operated by a crew member from the 5th percentile female to the 95th percentile male population while being restrained by suction-cup foot restraints.

1.5.2 Operation Use. All features of the trash compactor that require manipulation by a crew member shall be designed in accordance with the human engineering design criteria of MIL-STD-1472B.