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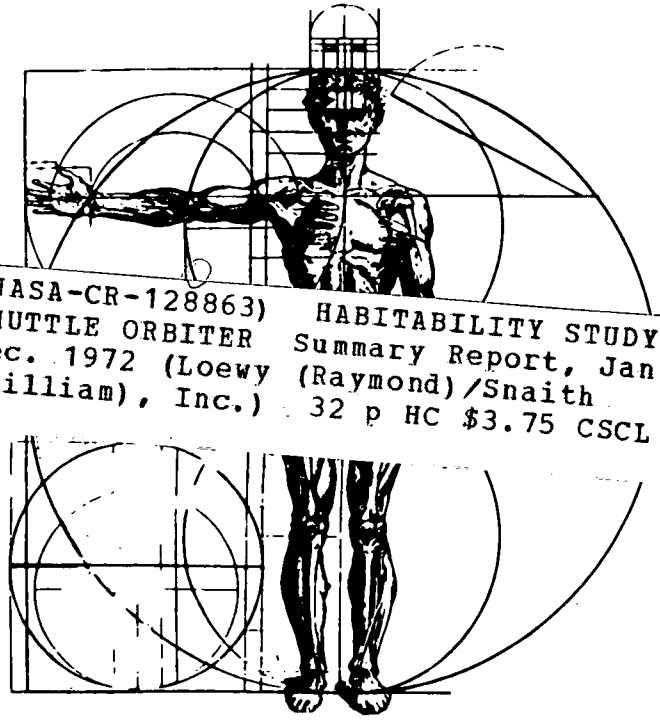
CONTRACT SUMMARY REPORT



HABITABILITY STUDY

SHUTTLE ORBITER

JANUARY 1972/DECEMBER 1972

PREPARED FOR **NASA** BY
RAYMOND LOEWY/WILLIAM SNAITH, INC.
110 EAST 59 STREET, NEW YORK, N.Y. 10022

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SECTION
A

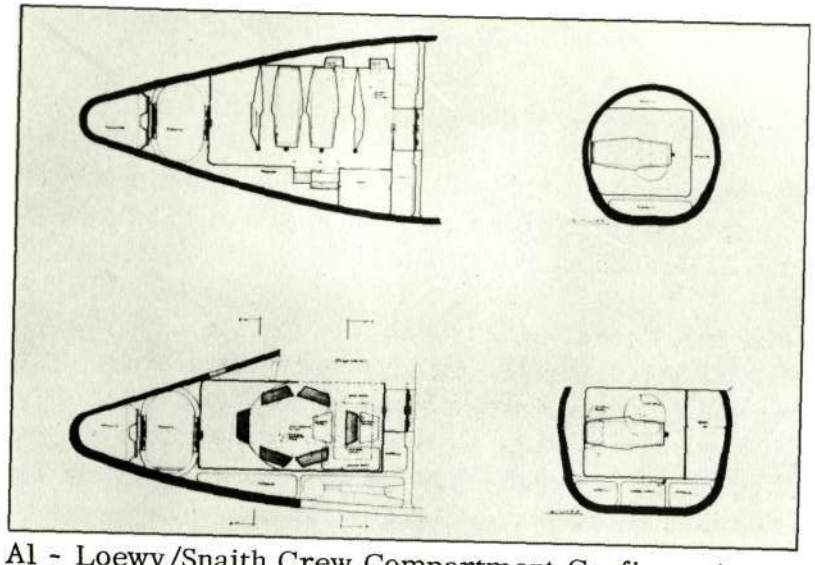
TASK Shuttle Orbiter Crew Compartment/X-Axis Docking

DESCRIPTION X-Axis docking crew compartment configurations were reviewed and evaluated by fabricating a full scale, partial compartment mock-up and full compartment model.

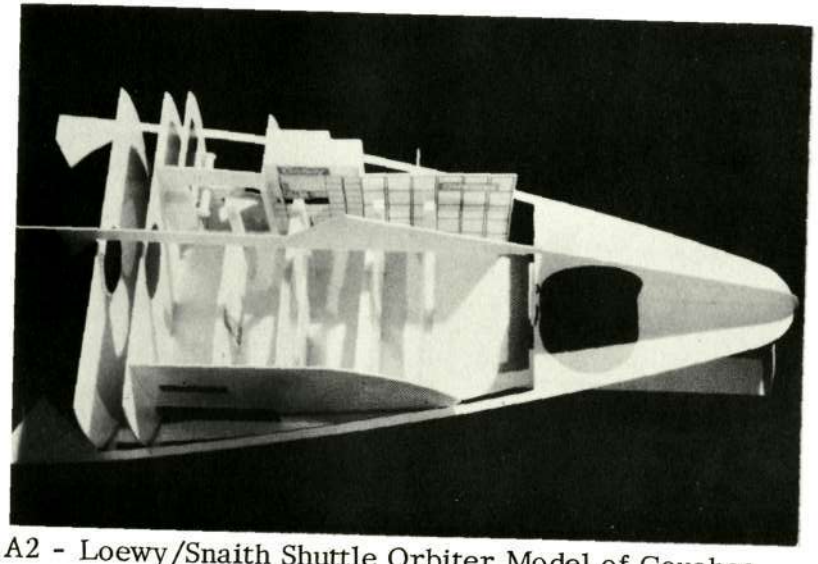
The design recommendations which were developed and incorporated in the mock-up for this configuration were as follows:

1 Provisions for adequate escape aisle (passageway) from couches to emergency hatch.

- Reorganization of crew compartment component to improve social orientation of space couches.
- Flight engineer provided with ability to maintain visual contact with flight deck personnel.
- Galley location which is readily accessible to space couches.
- Convenient access to hygiene compartment throughout entire flight orientation.

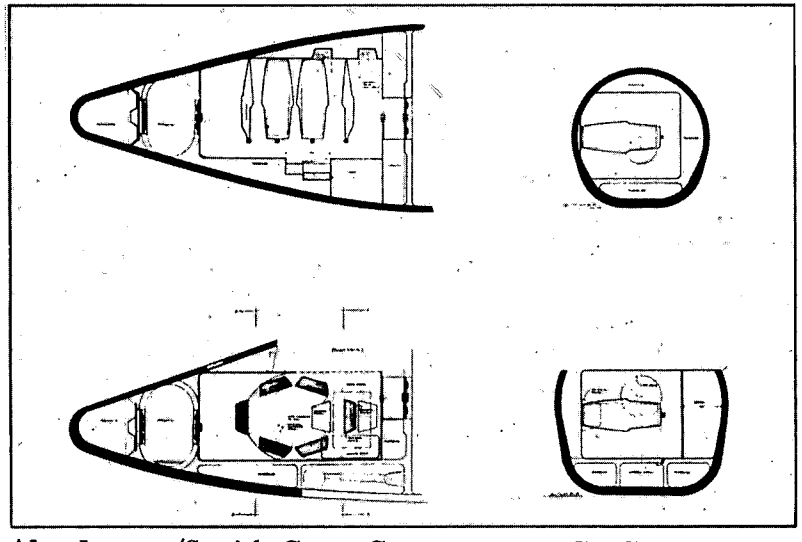


A1 - Loewy/Snaith Crew Compartment Configuration of X-Axis Docking Concept

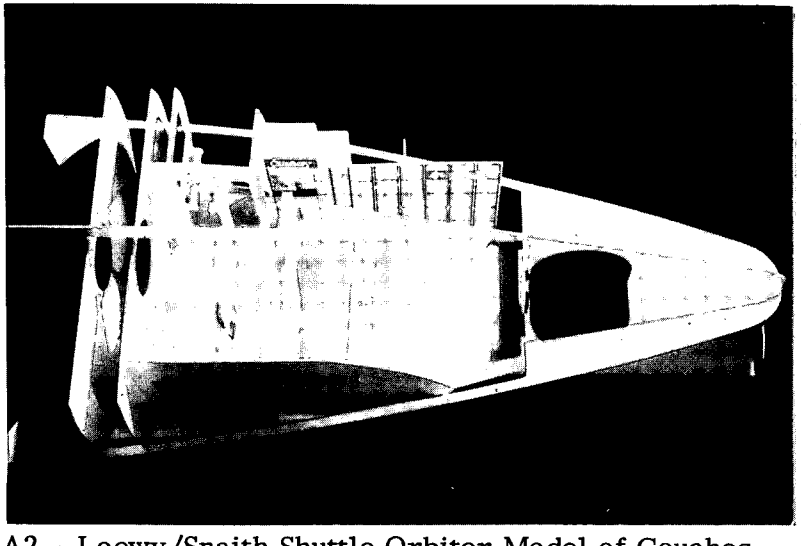


A2 - Loewy/Snaith Shuttle Orbiter Model of Couches in the Launch Orientation

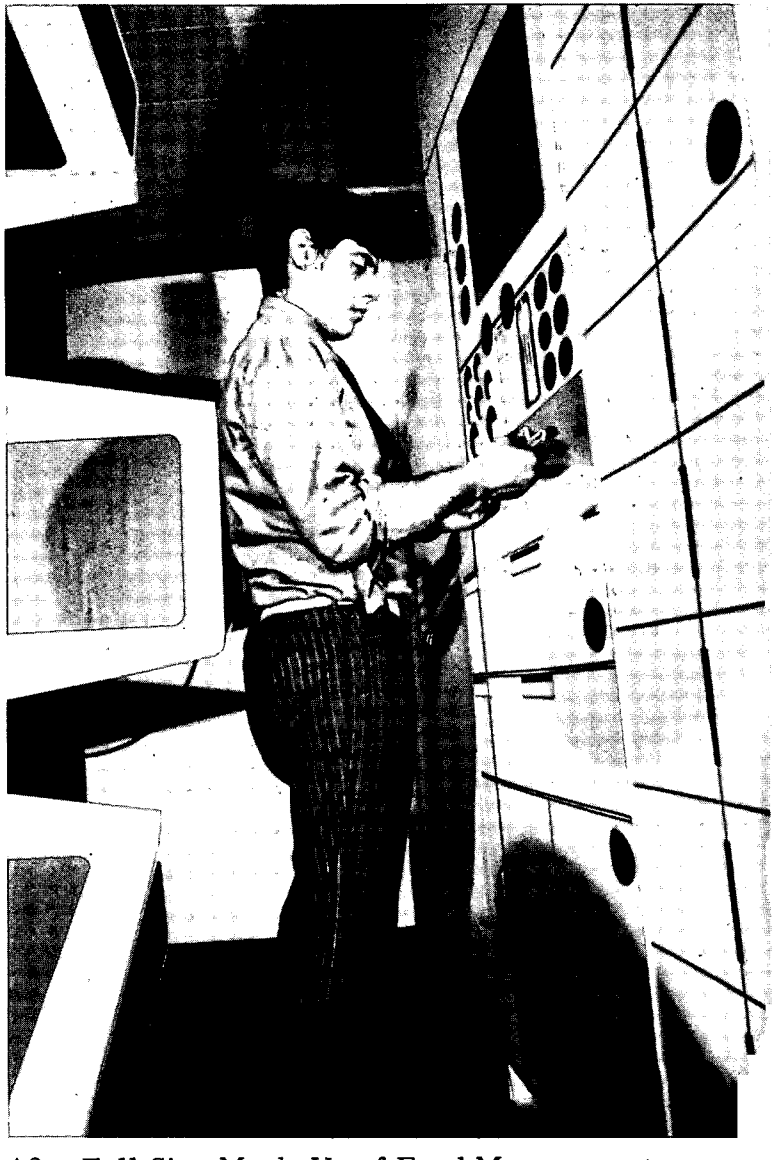
A3 - Full Size Mock-Up of Food Management Compartment



A1 - Loewy/Snaith Crew Compartment Configuration of X-Axis Docking Concept



A2 - Loewy/Snaith Shuttle Orbiter Model of Couches in the Launch Orientation



A3 - Full Size Mock-Up of Food Management Compartment

SECTION
B

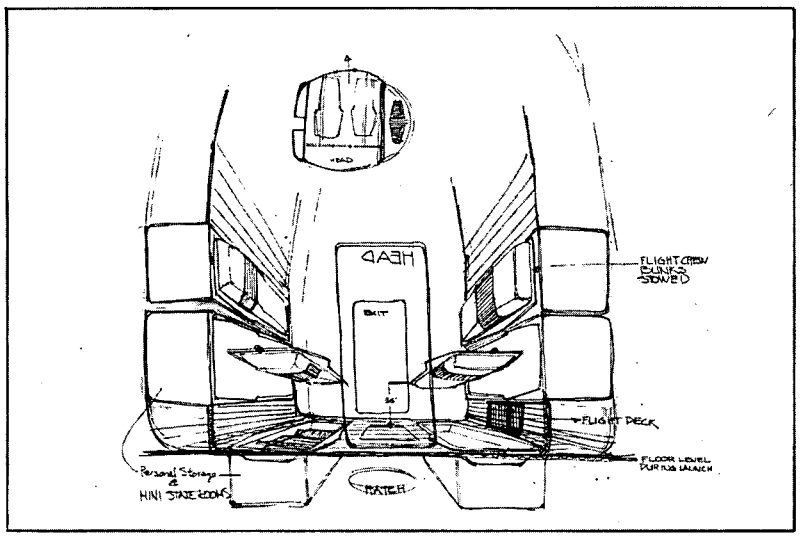
TASK — Shuttle Orbiter Passenger Compartment and Flight Deck Flexibility

DESCRIPTION — In the passenger compartment study, Loewy/Snaith was primarily interested in developing concepts aimed at solving the problems of space couch access during the various flight modes.

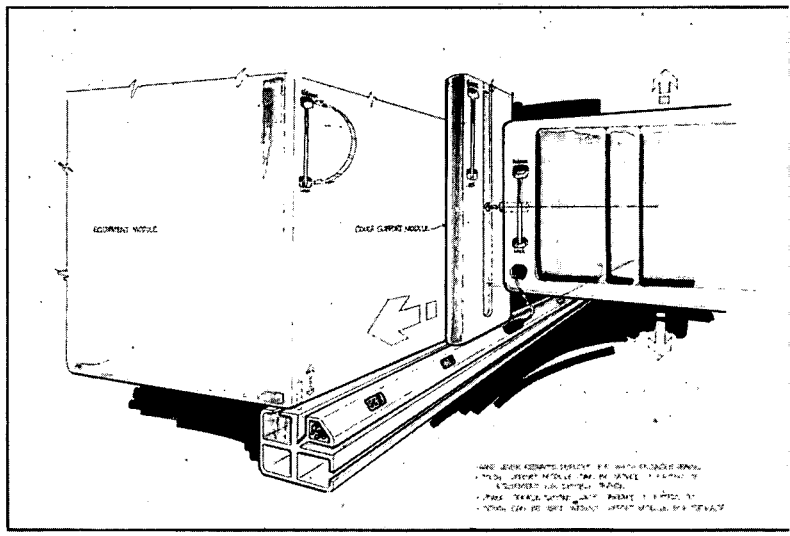
With the knowledge that future space flights may include the elderly, it was important to consider less strenuous techniques of maneuverability throughout the passenger compartment, and into space couch related activities. A flexible couch positioning system for this compartment was suggested to allow the couch position to be adjusted for maximum ingress and egress convenience during launch, reentry and zero-G flight.

The isolation of the flight deck from the crew compartments was another area we were requested to look into with the objective being the establishment of separate leisure and sleep facilities in that area.

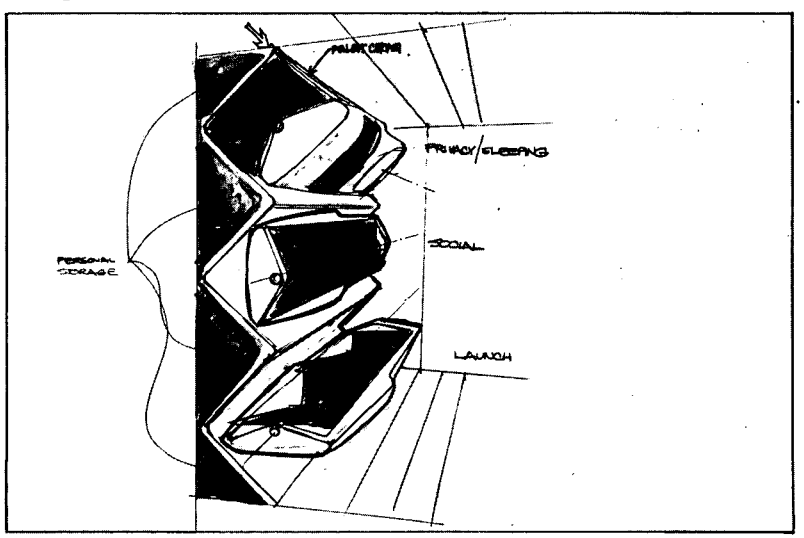
We illustrated that to accomplish this goal would require a larger flight deck area with much more versatile hardware.



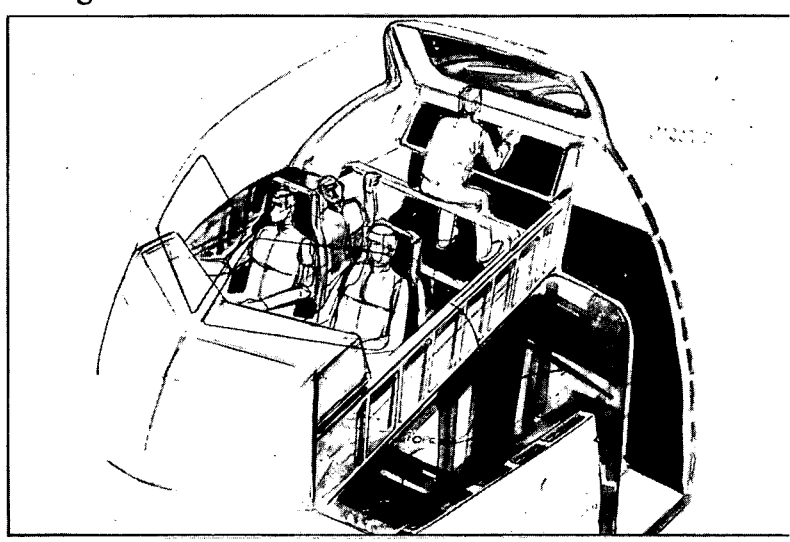
B1 - Space Couch in Bracket-Supported Modular Compartment



B3 - Space Couch and Track Detail of Modular Configuration



B2 - Couches Utilizing Partitions to Create Semi-Private Quarters



B4 - Flight Deck Crew and Area Configuration

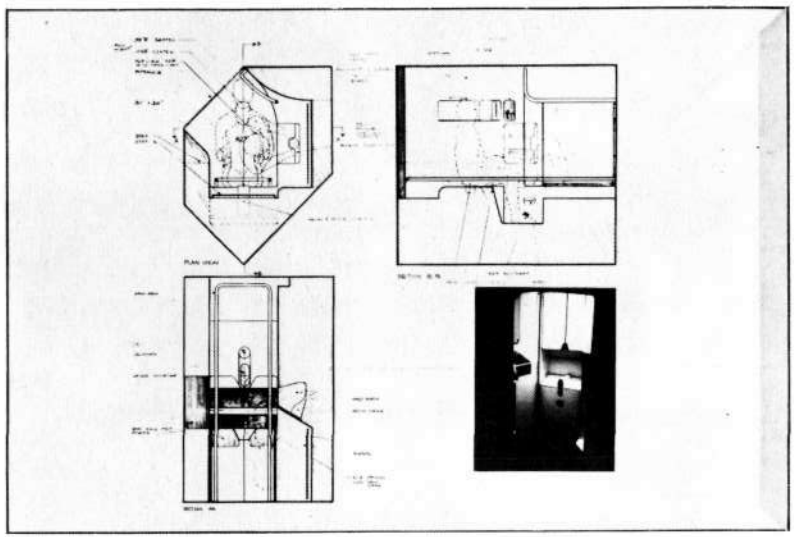
SECTION
C

TASK Restraint System for Hygiene Facility (Phase I)

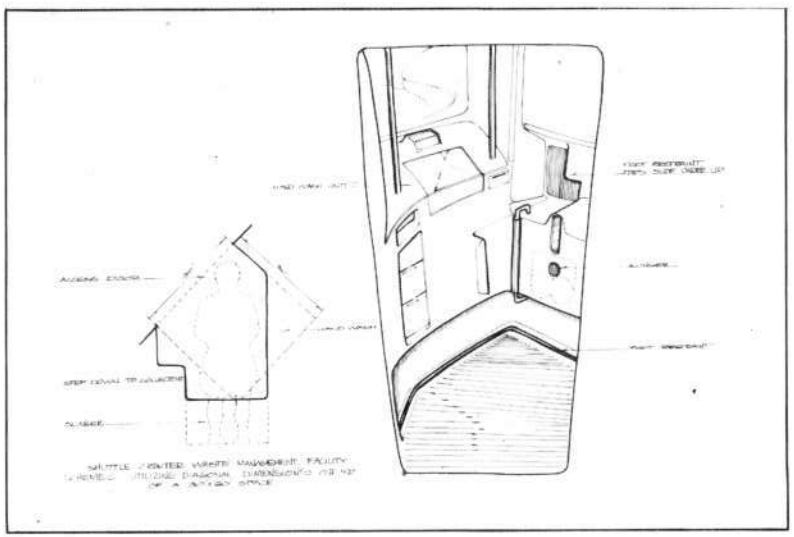
DESCRIPTION To obtain useful data from a restraint study, Loewy/Snaith, Inc. considered it important to first base line a hygiene compartment design to determine the relative merits of various restraint concepts under identical conditions. Preliminary analysis of the MSC compartment configuration demonstrated that adjustments in the layout were required to accommodate crewmen ranging in stature from a 95% male to 5% female.

By placing the fecal/urinal collector and hand wash units on adjacent walls, less space was utilized and component replacement was simplified.

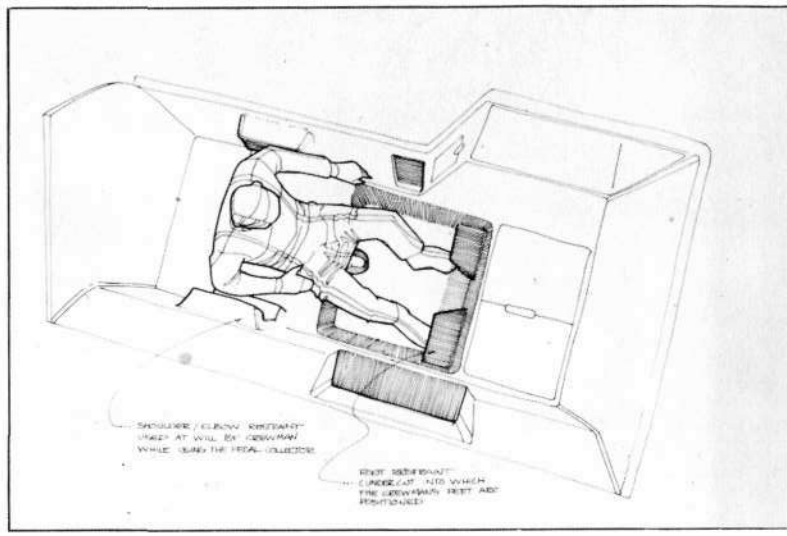
The design of various restraint systems was pursued after the hygiene configuration was reconfigured. Although an elbow restraint showed interesting possibilities to be explored in Phase II, it was determined that three points of bodily contact were necessary to achieve adequate restraint. Provisions for a lap belt were considered mandatory since abdominal pain from cramps might make voluntary use of a restraining device unrealistic.



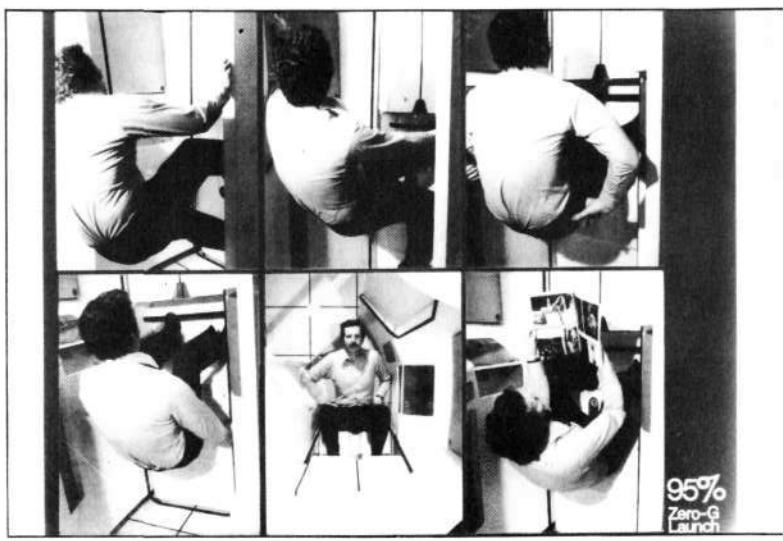
C1 - Loewy/Snaith Hygiene Compartment Concept for Shuttle Orbiter



C2 - Loewy/Snaith Hygiene Compartment Perspective



C3 - Hygiene Facility Shoulder Restraint



C4 - 95% Male - Launch and 0-6 Orientations in Hygiene Compartment

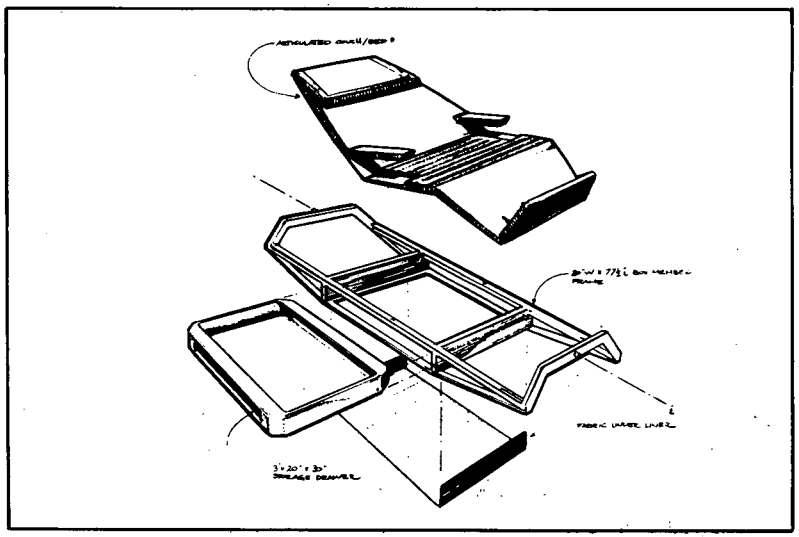
SECTION
D

TASK Small Passenger Couch

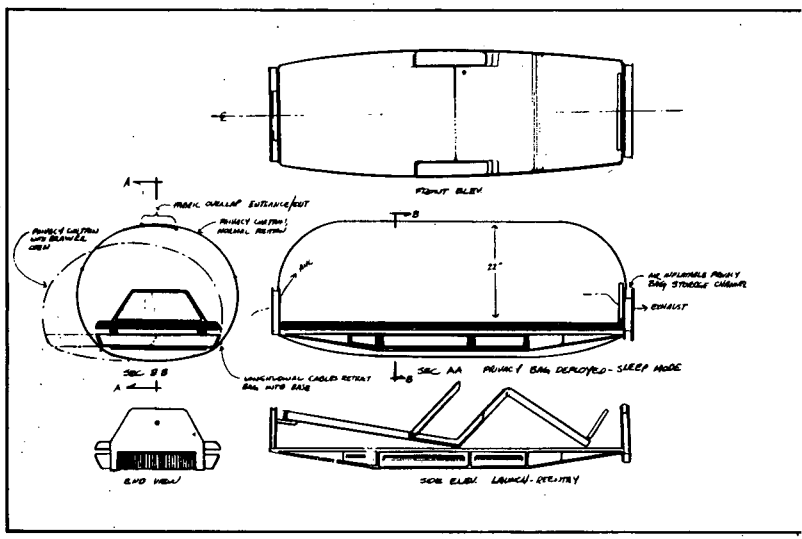
DESCRIPTION Experience and knowledge gained from the development of a large passenger couch helped establish the design direction for the smaller one which was limited to 77.5"L X 27"W X 14"D. It performs the same functions and maneuvers into the same orientations, and contains more storage space than the larger couch.

It adjusts from flat for sleeping, to upright, for in flight leisure and launch.

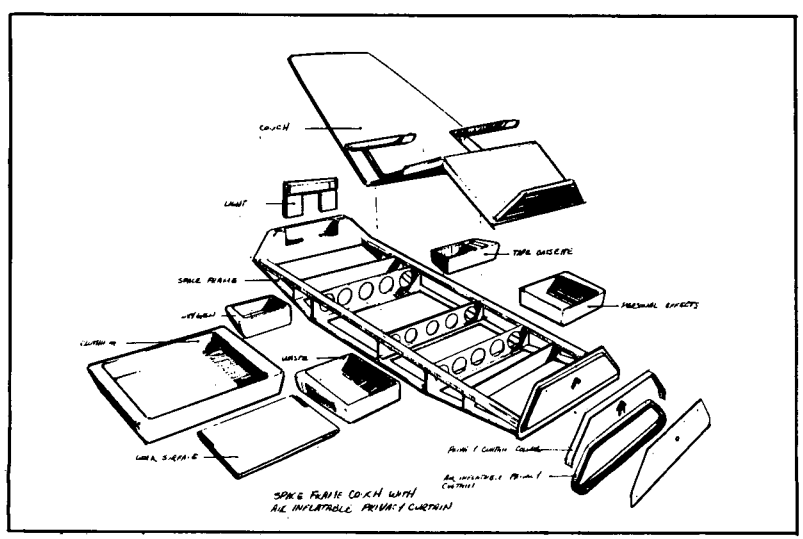
The small passenger couch body support planes ride on top of the structural space frame rather than being contained within it as in early concepts. This change allows the support planes to be designed to the maximum allowed width of 27". Immediate access items, such as personal gear, environmental controls and emergency equipment are organized for quick retrieval. All are located within an arms length of the crewman and obtainable while the privacy screen is in place.



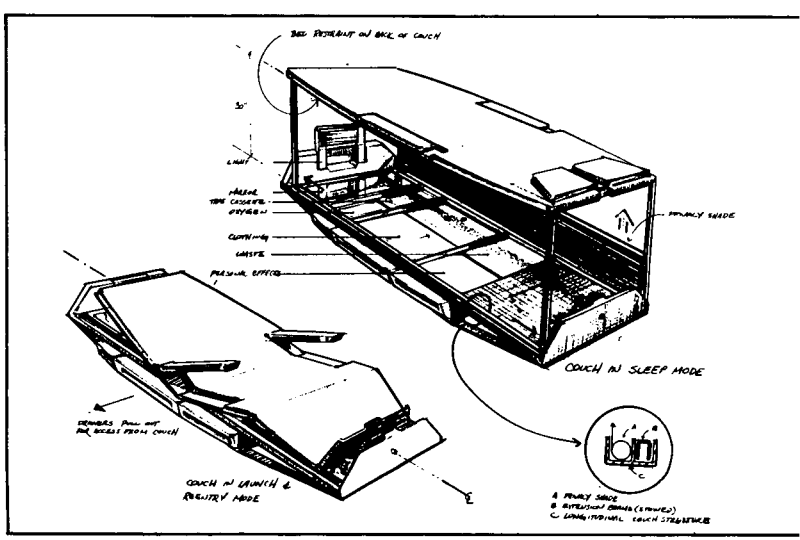
D1 - Minimal Structure Couch



D3 - Small Passenger Couch with Inflatible Privacy Screen



D2 - Exploded View of Small Passenger Couch with Organizers for Personal Items

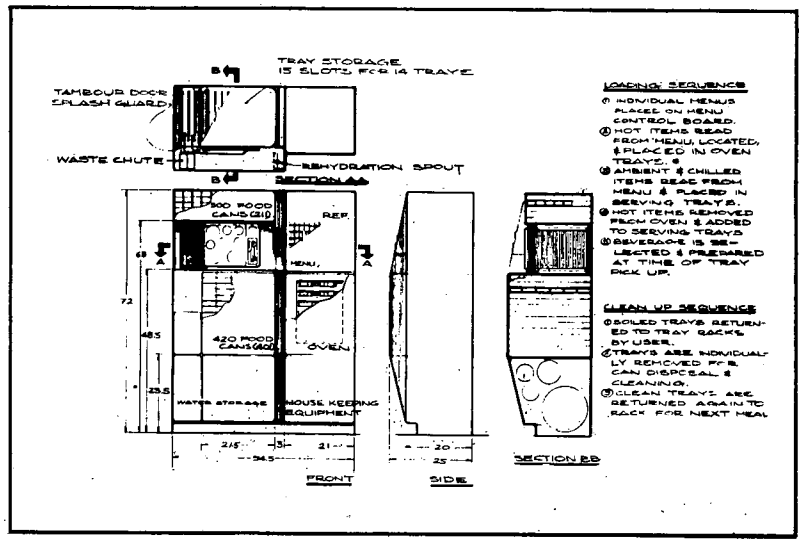


D4 - Small Passenger Couch with Extension Beam Privacy Screen

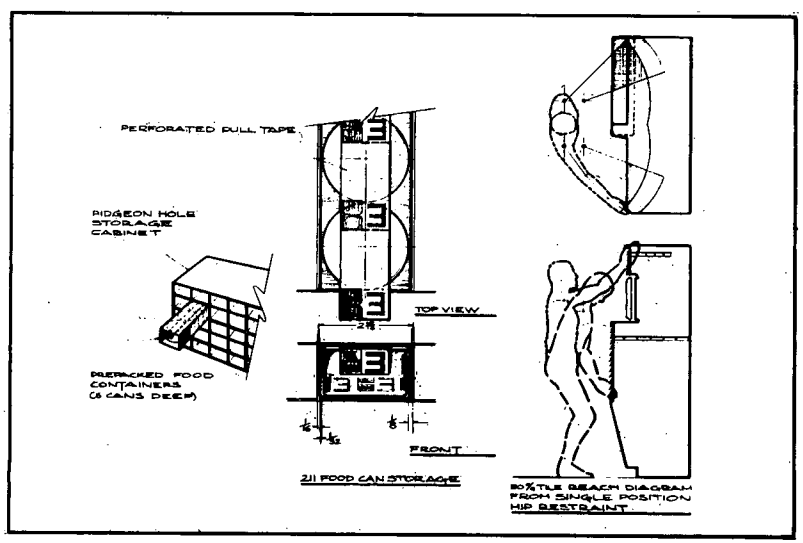
SECTION
E

TASK Orbiter Food System and Galley

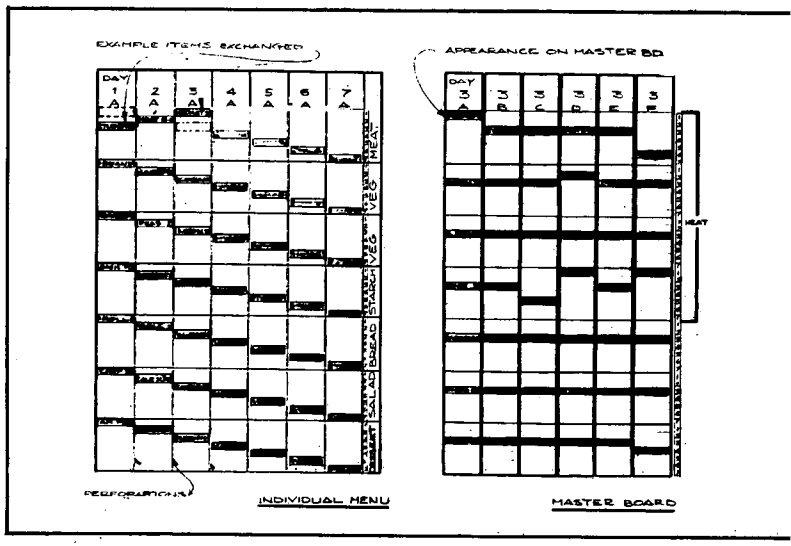
DESCRIPTION MSC requested that Raymond Loewy/William Snaith, Inc. review a design concept they had developed for the orbiter with the goal being a reduction in overall volume and a simplification of the food retrieval/preparation process. Two dimensional sketch and layout studies conducted resulting in three concept systems. A significant change in the system layout was that we recommended that a single flat work facade be used rather than relieved U-shaped facade as in the MSC system. This modification minimized dead air space and reduced the overall volume to less than 80 cubic feet, the desired goal. Reductions in food retrieval and preparation were achieved by incorporating specialized packaging and graphic concepts as explained in the final report.



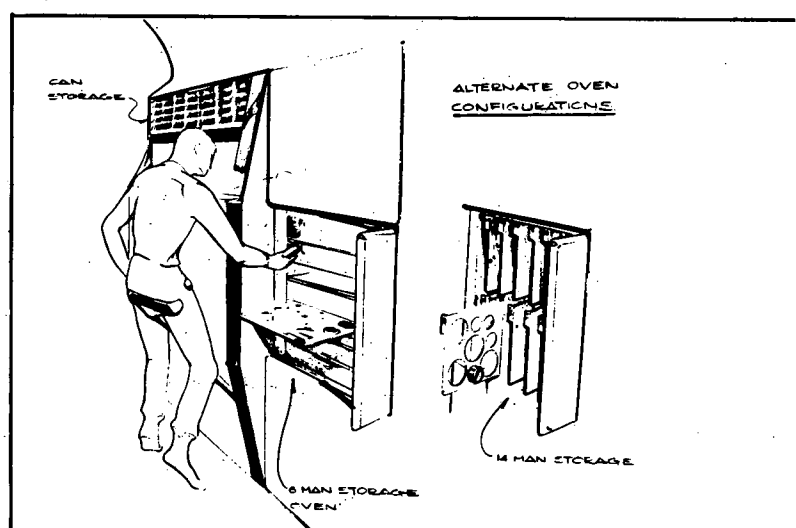
E1 - Loewy/Snaith Galley Configuration for Shuttle Orbiter



E2 - Identification and Storage Technique of Food Cans



E3 - Individual and Master Menu Cards



E4 - Perspective of Attendant Preparing Meal at Oven

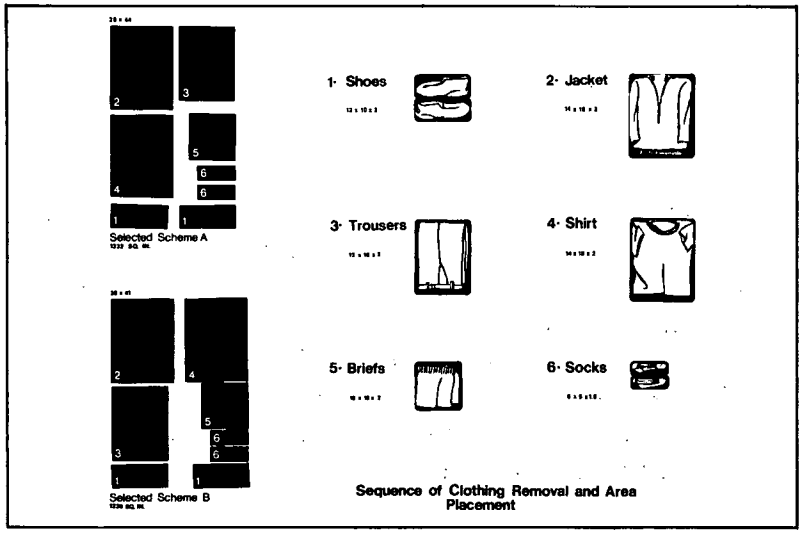
SECTION
F

TASK Temporary Clothing Restraint

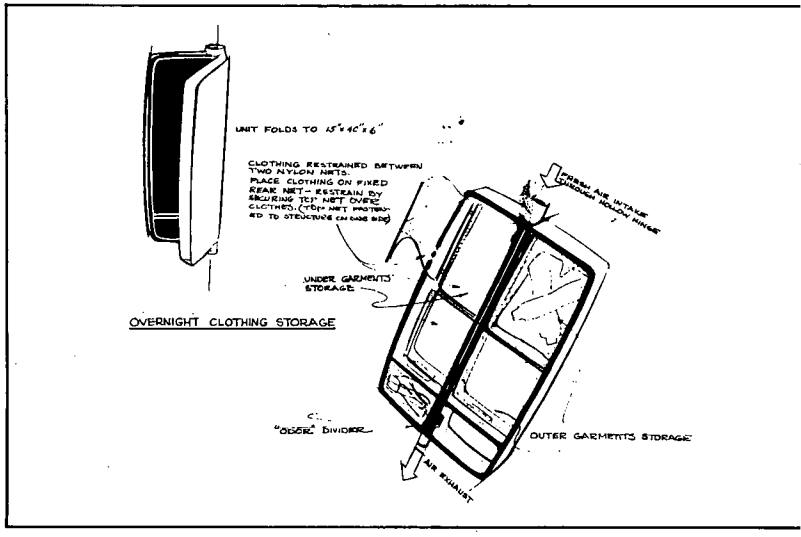
DESCRIPTION In the development of the overnight clothing storage unit, emphasis was placed on the prevention of odor transfer between garments. We recommended that the garments should be segregated into isolated areas by order level to prevent soiling of relatively cleaner items.

The clothing restraints were organized for maximum spacial efficiency and ease of access.

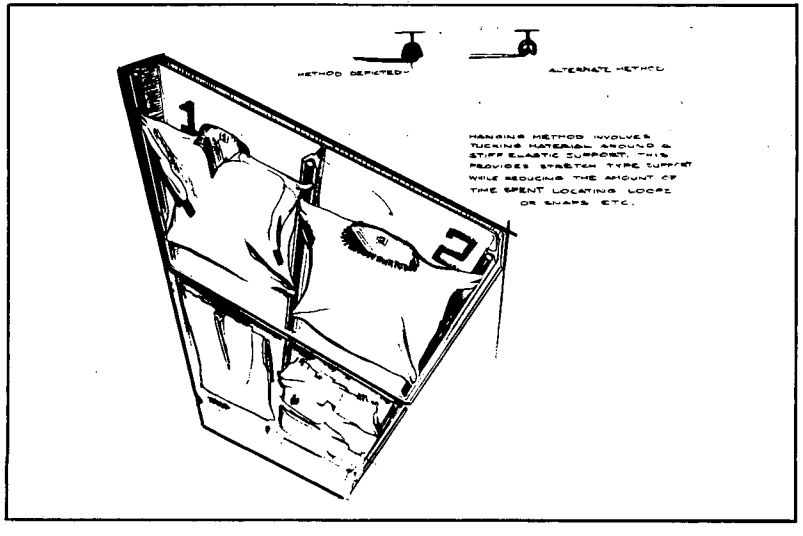
Concepts for the overnight clothing storage units included both fixed units and collapsible units which would totally or partially fold out of sight when not in use.



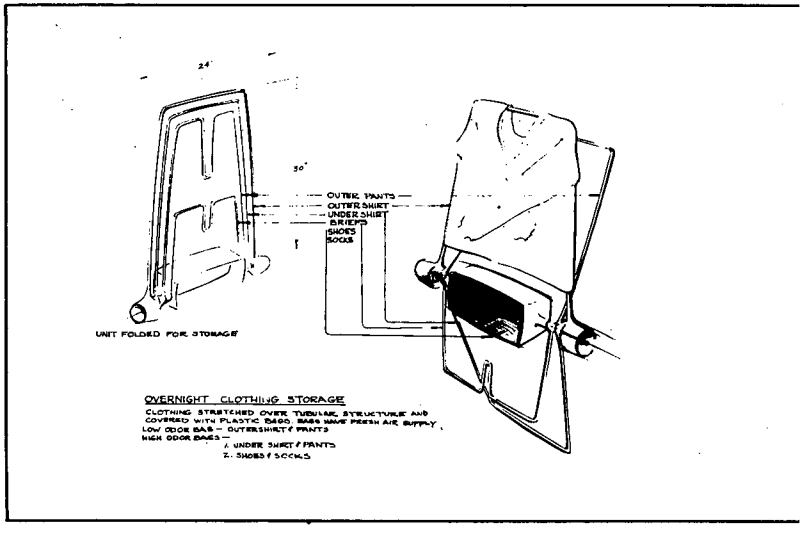
F1 - Two Accepted Clothing Layouts and Article Sizing



F3 - Partitioned Cavity Restraint - Netting Restrained



F2 - Clothing Restraint Using Rotating Rods to Tuck Clothing



F4 - Minimum Area Restraints - Rotary Wire Frames

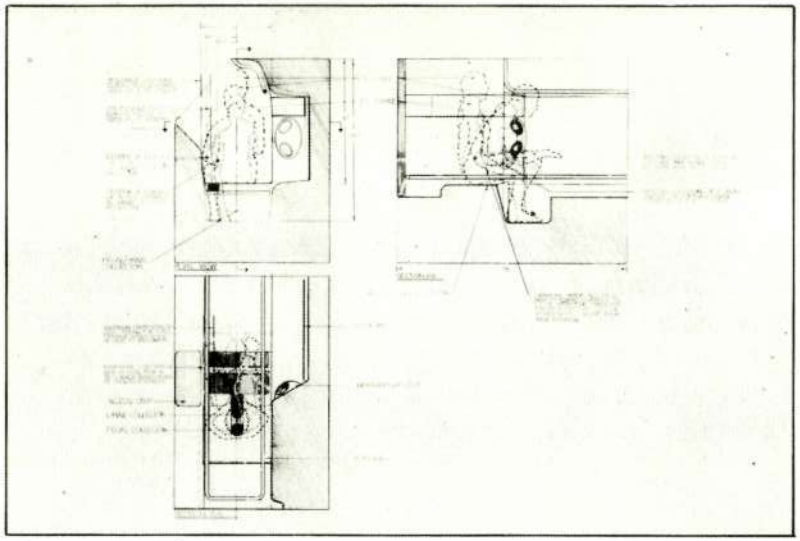
SECTION G

TASK Restraint System for Hygiene Facility (Phase II)

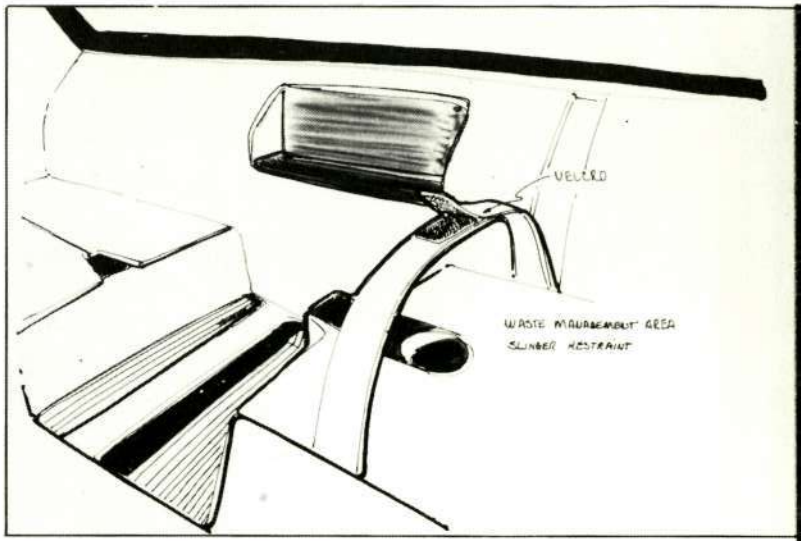
DESCRIPTION As a result of the Phase I study, interest was developed in investigating an elbow and shoulder restraint useable by 5% females through and including 95% male crew personnel when a seat belt restraint was not required. Additional study demonstrated that the concept was unrealistic if the system was to accommodate a full range of body sizes. The dimensional variations in their elbow and shoulder widths necessitated the design of an adjustable restraint device which we felt defeated the objective of the system which was maximum simplicity.

Parameters for an efficient seat belt to be used in the hygiene facility were established and emphasis was placed on minimizing the surface area of the restraint across the crotch area for optimum visual and physical access and minimum body contact.

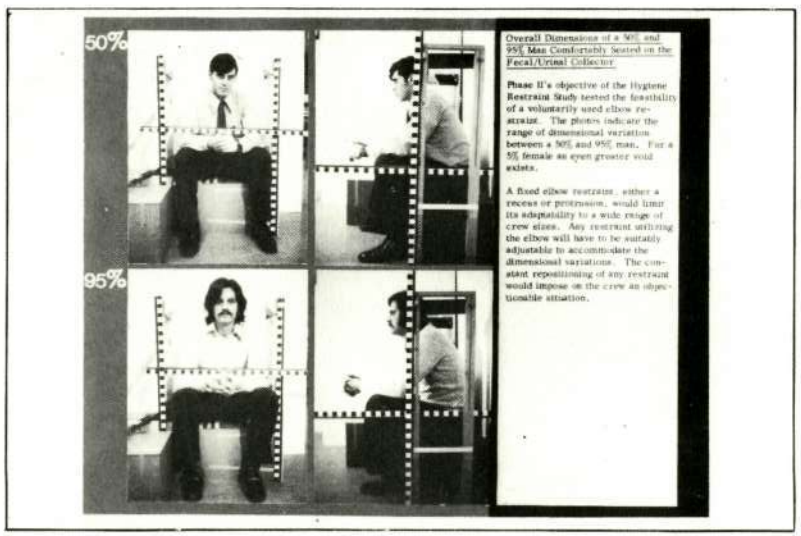
Concepts presented included the use of non-porous, easily cleaned belts and disposable tissue underlays between the belt structure and the user's skin.



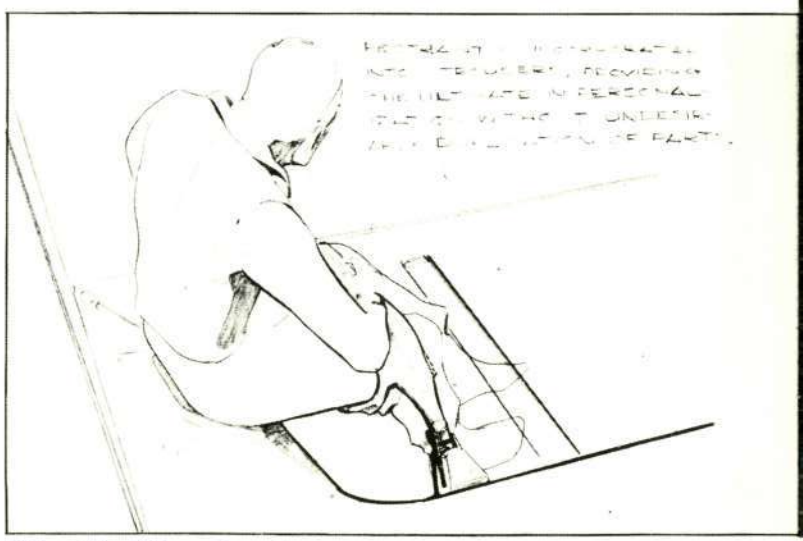
G1 - Loewy/Snaith Hygiene Compartment Showing Elbow/Shoulder Variations in Locations



G3 - Semi-Rigid Belt Restraint with Velcro Fastener



G2 - Dimensions of Seated Personnel - 50% and 95% Male



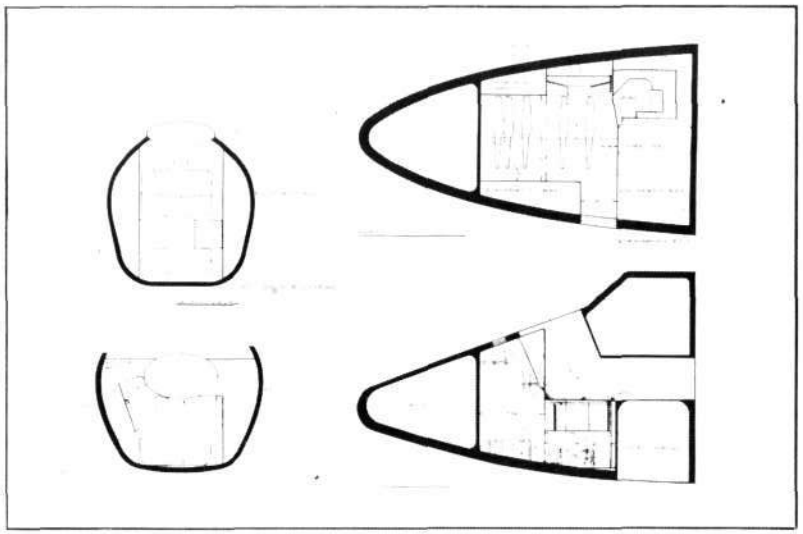
G4 - Clothing Coupler to Side Wall of Head

SECTION
H

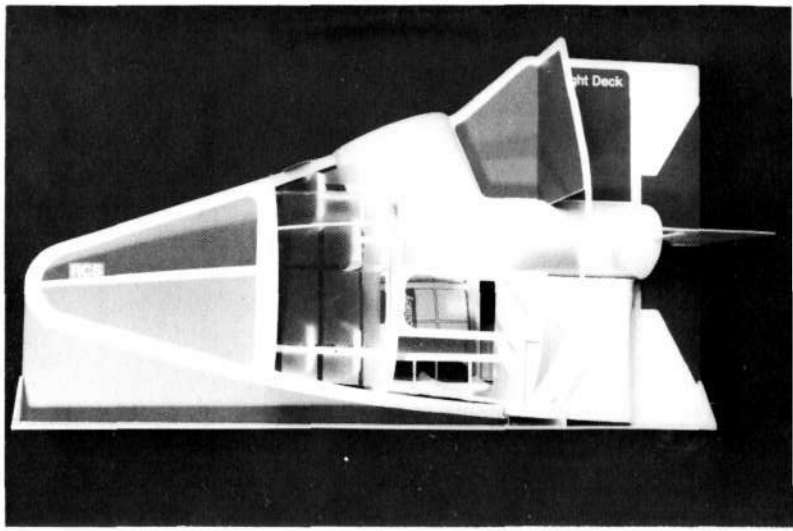
TASK Skewed Z-Axis Docking/Airlock Shuttle Orbiter

DESCRIPTION A 1/20 scale model of an MSC layout of the Z-Axis Docking Airlock Shuttle Orbiter was constructed to analyze the impact of the skewed-Z axis in three dimensions. The model illustrated that a negative habitability factor of the skewed-Z axis layout is the affect of the airlock location on the useable space in the compartment. Positioned through the center of the orbiter, it prevents effective of the available spacecraft volume.

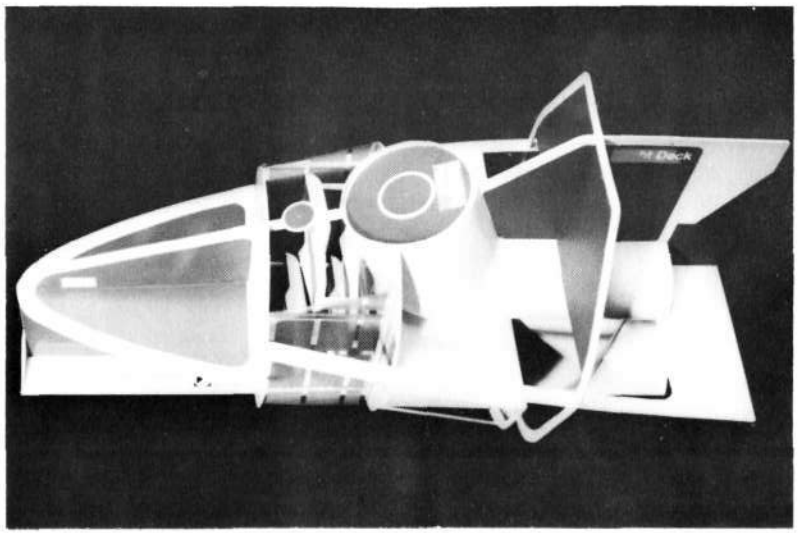
Loewy/Snaith does not feel that this solution adequately produces a workable relationship between compartments. Spacial volumes have not been used to their fullest extent because of present requirements placed on reconfiguration.



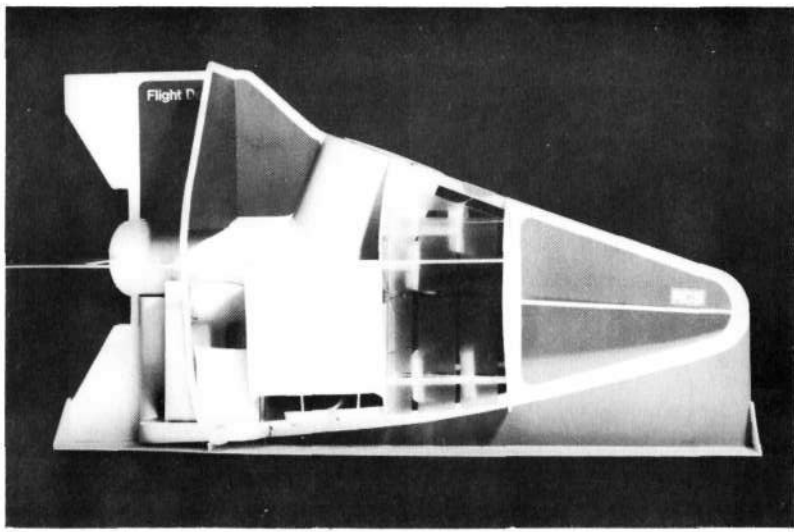
H1 - Loewy/Snaith Shuttle Orbiter Configuration of Skewed 2-Axis Concept



H3 - Shuttle Orbiter Scale Model - Viewing Galley Through Emergency Escape Hatch



H2 - Perspective View of Shuttle Orbiter Scale Model



H4 - Shuttle Orbiter Scale Model - Viewing Back Side of Galley and Head

SECTION
I

TASK Flexible Positive Work Station Restraint (Phase I)

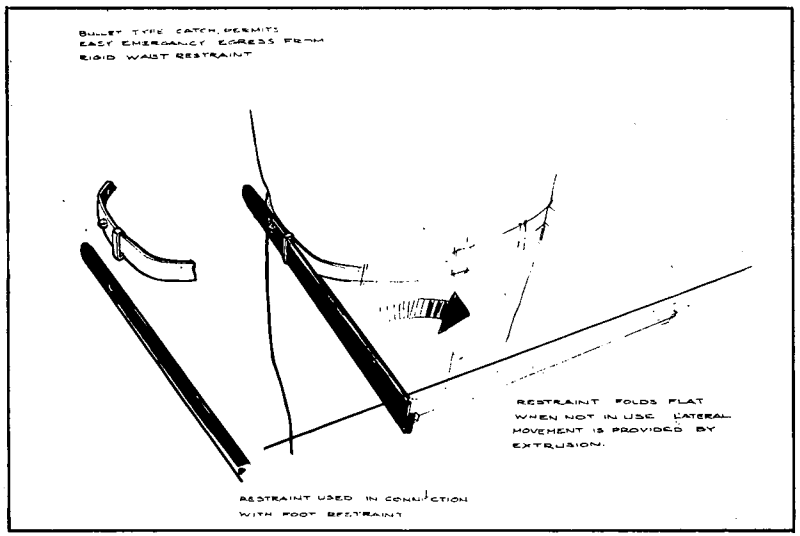
DESCRIPTION The development of a flexible positive restraint which will allow a crewman a limited amount of controlled movement was pursued in order to allow him to cover the largest work area possible without a conscious awareness of the necessity for restraint, thus allowing him to concentrate fully on his particular task.

It was Loewy/Snaith's feeling that a successful flexible positive restraint is one which would allow him to have both hands free while maneuvering as necessary to complete a particular task.

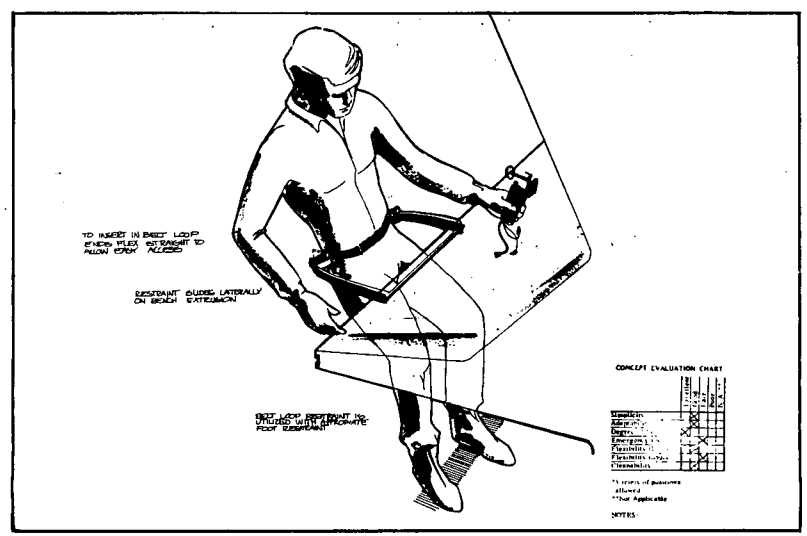
Although individual illustrations centered on either the foot or waist area, both areas are required to adequately produce a positive restraint.

It was decided that a three point restraint was necessary for stability and that any rigid restraining device above the waist would inhibit natural bending and limit the reach of a restrained individual. The restraint points selected, therefore, were the waist and both feet.

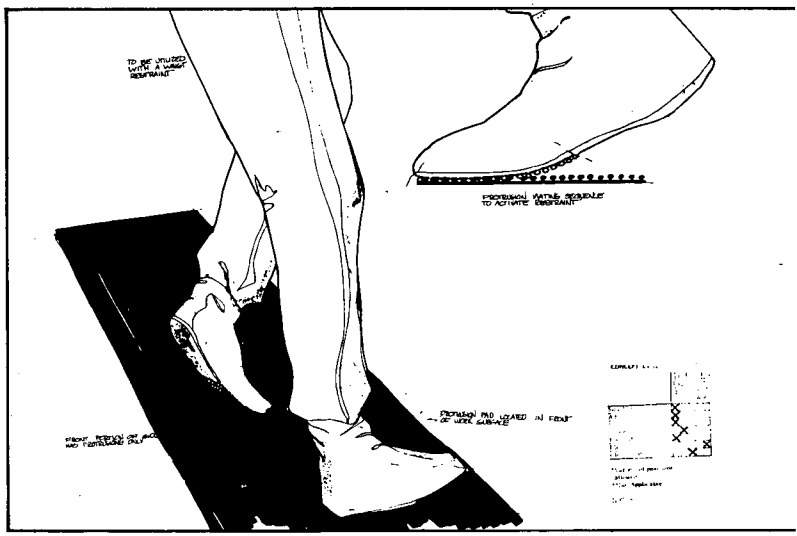
The concepts developed were to allow the restrained individual to walk parallel to a work bench utilizing various moveable or random access foot and waist restraints.



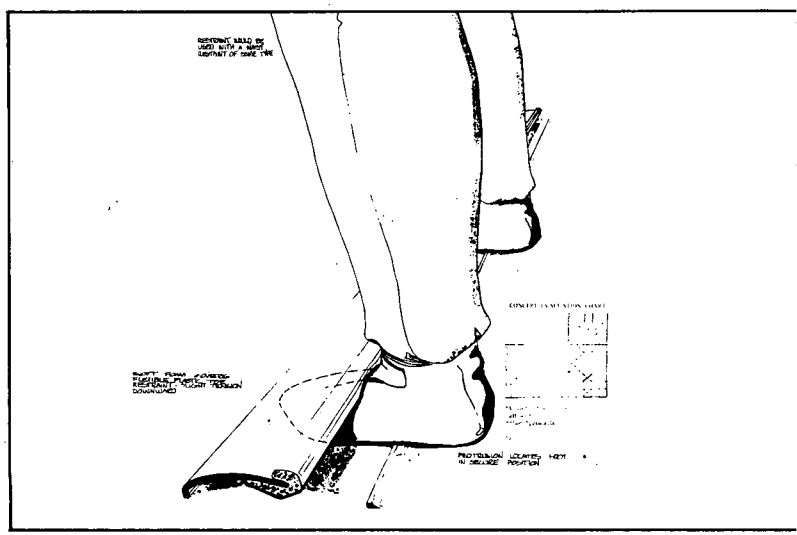
I-1 - Flexible Restraint Arm which Adjusts to Bullet Fastener on Belt



I2 - Horizontally Adjustable Restraint Arm Which Couples with Belt Loops



I3 - Mating Protrusion Devices on Sole of Shoe and Floor Area of Workbench



I4 - Foot Restraint with Foam Pad and Tension Adjustment

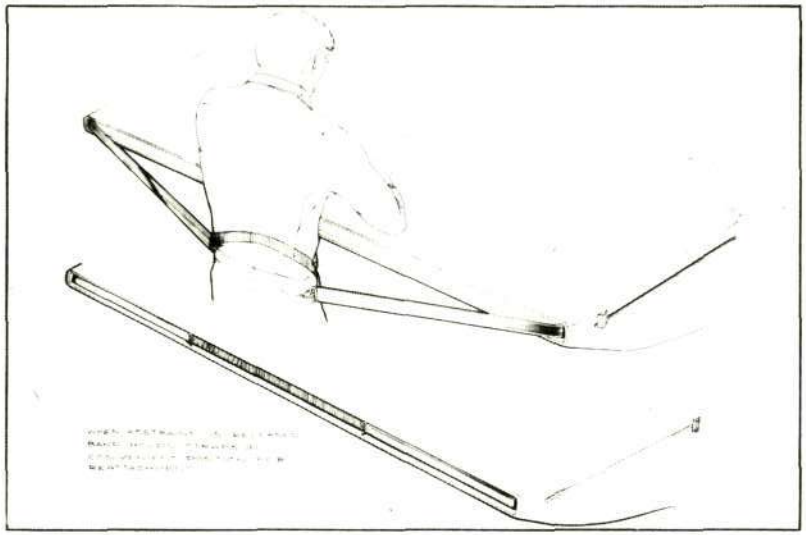
SECTION
J

TASK Positive Restraint (Phase II)

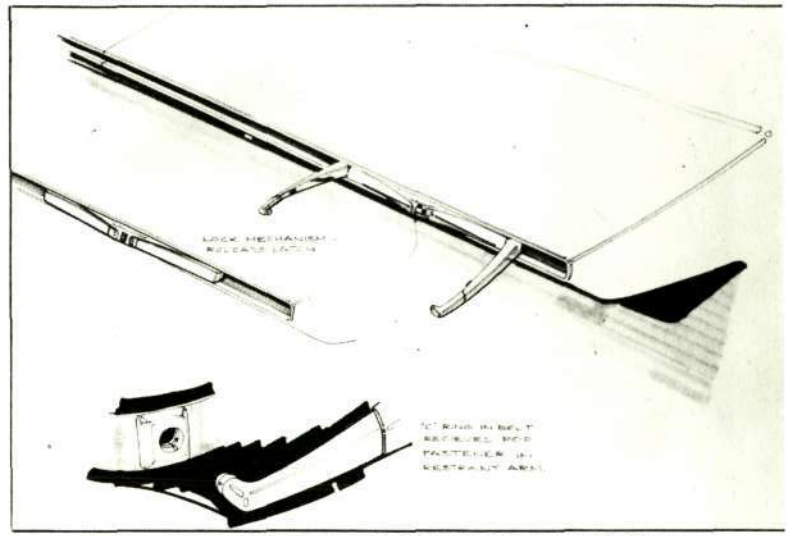
DESCRIPTION In Phase I, Loewy/Snaith illustrated the practicality of several concepts including a waist belt which interfaces with fold away arms, continuous revolving belt and an adjustable toe bar restraint to restraint feet in a selected location.

To better evaluate the effectiveness of each system, a presentation model was constructed incorporating all of the selected concepts. A closed loop belt system was located on the front surface of the bench which allowed free lateral movement with slack adjustment to enable movement away from the bench. The front surface of the bench also incorporated a sliding track with couplers located on adjustable fold away arms. When in use, the arms fold out of a recess and couple into the crewman's belt. The track allows the arms to slide the length of the bench while the arm length adjustment allows the crewman to adjust his distance from the bench.

An adjustable toe bar located near the base of the unit allows forward and reverse movement along a track. The foam covered bar conforms to slope configuration of the crewman's shoe.

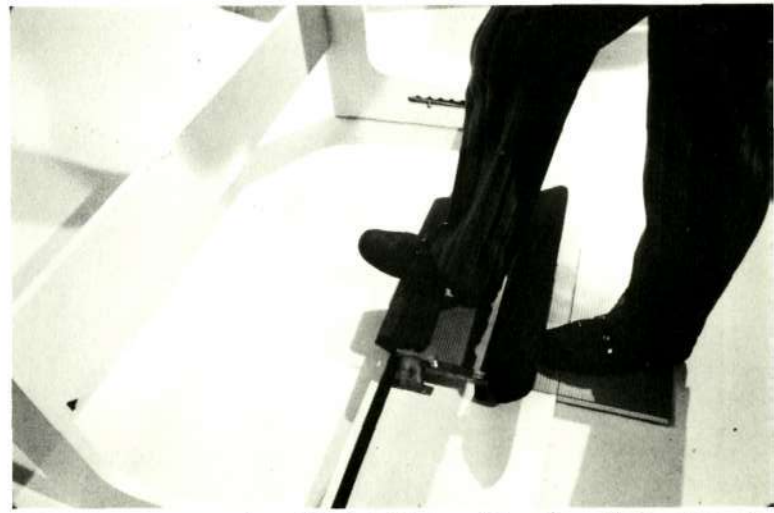


J1 - Continuous Revolving Belt with Tension Adjustment and Two "D" Ring Fastening Points



J3 - Adjustable Arms on Guide Rail with Bullet Fasteners

J2 - Demonstration Model of Center of Belt Fastener



J4 - Demonstration Model Using Toe Bar Adjustment with Spring Tension

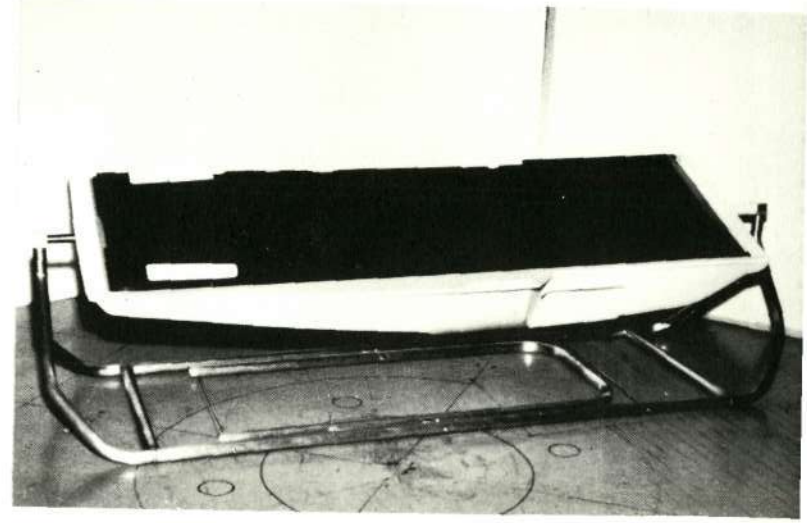
SECTION
K

TASK Shuttle Orbiter Passenger Couch - Full Scale Mock-Up

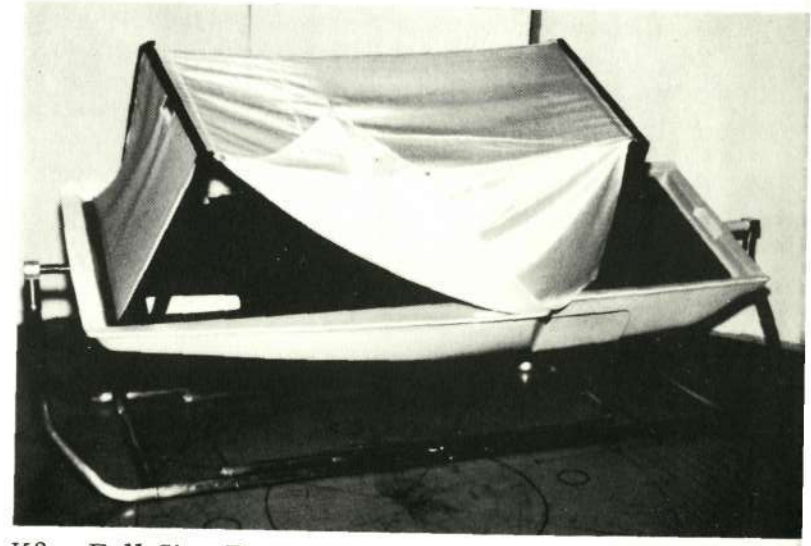
DESCRIPTION The purpose of this model was to demonstrate and evaluate the features in the original couch concept and was constructed for compatability with neutral buoyancy testing.

The couch is designed to provide all immediate needs of the crewman during leisure, sleeping, eating periods in zero-G and provide proper support for crew members during launch and reentry. Storage provisions, which are accessible while on the space couch are included to house garments and personal effects. Privacy is provided for by a roll out screen which folds away when not in use.

K1 - Full Size Demonstration Model in Liesure Mode



K2 - Full Size Demonstration Model in Sleep Mode



K3 - Full Size Demonstration Model in Sleep Mode with Privacy Screen

SECTION
L

TASK Data Format Card

DESCRIPTION The data format card is designed to serve as a guide to Skylab astronauts for evaluation of tasks and equipment at scheduled intervals in the Skylab missions. All responses to questions on the data format sheet are voice-recorded and transferred to ground control for analysis for future missions.

It is Loewy/Snaith's feeling that all answers should be brief, but allow explanations to personalize the responses. To prevent crew impatience with the card, the models developed stressed simplicity of format organization.

PULL UP

M487 SRF-A

IMPORTANT: Before beginning report read instructions below.

A. General arrangement and orientation of compartment
1 Excellent 2 Very Good
3 Adequate 4 Poor 5 Unaccept

Part 1

Instructions:
Identify compartment to be rated, then state letter code & numerical rating for each parameter (comments encouraged)
Example: WD/RM: A,2; B,3;...

Compartments:
WD/RM
HEAD
SLEEP
EXPMT
FWD/DOME
AIRLOCK
MDA/STS

Part 2

Instructions:
State letter code & numerical rating for each item (comments encouraged)

Rating/Use Frequency

1 Daily or every opportunity

2 Every other day

3 Once a week

4 Every 2-3 weeks

5 Never (Explain) difficult to use? design? not req?

L1 - Mock-Up of Data Format Card (Front)

PULL UP

M487 SRF-B

IMPORTANT: Before beginning report read instructions below.

Item ➡ 1. OWS fireman's pole

Letter Code:

A Convenience of In-Use Location and Orientation

B Functional Performance of Item

C Comfort and Ease of Use

Rating Definition:

1 EXCELLENT Improvements matter personal preference

2 VERY GOOD Minor improvements possible, but not really necessary

3 ADEQUATE Some shortcomings found and a few improvements necessary

4 POOR Shortcomings found and improvements necessary

5 UNACCEPTABLE Gross shortcomings found and improvements mandatory

INSTRUCTIONS:
State name and date (voice record all remarks)
For each item to be rated, identify item No., then for each letter code (A, B, C), state letter code and corresponding numerical rating (comments are encouraged)
Example: Item 1: A,3; B,2; C,3

L2 - Mock-Up of Data Format Card (Rear)

SECTION
M

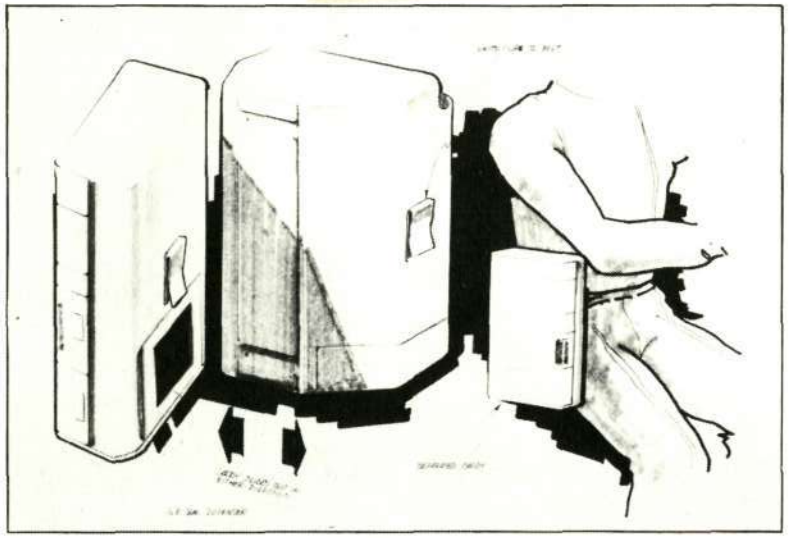
TASK Housekeeping Equipment Stowage

DESCRIPTION The housekeeping equipment stored in the galley facility consists of three basic parts: a master storage unit for central supply, a portable vacuum unit and a portable "caddy" section equipped with a limited supply of wipes, disinfectants, etc. to support general housekeeping activities.

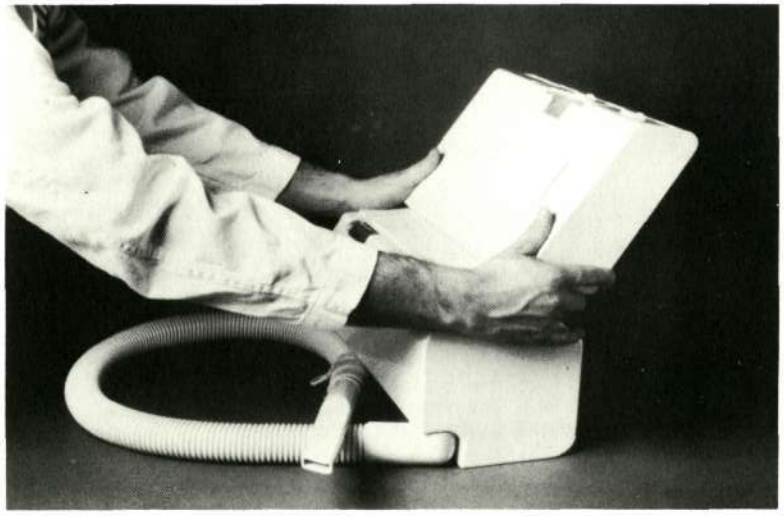
The caddy and vacuum unit were designed as two interlocking units which may be carried as one or separately. The storage units within the caddy for carrying cleaning agents and wipes have been aligned according to their use priority, and are entirely enclosed to prevent dispersion of fluid if a container becomes punctured.

The design of the unit was developed with the aid of full scale human factor mock-ups.

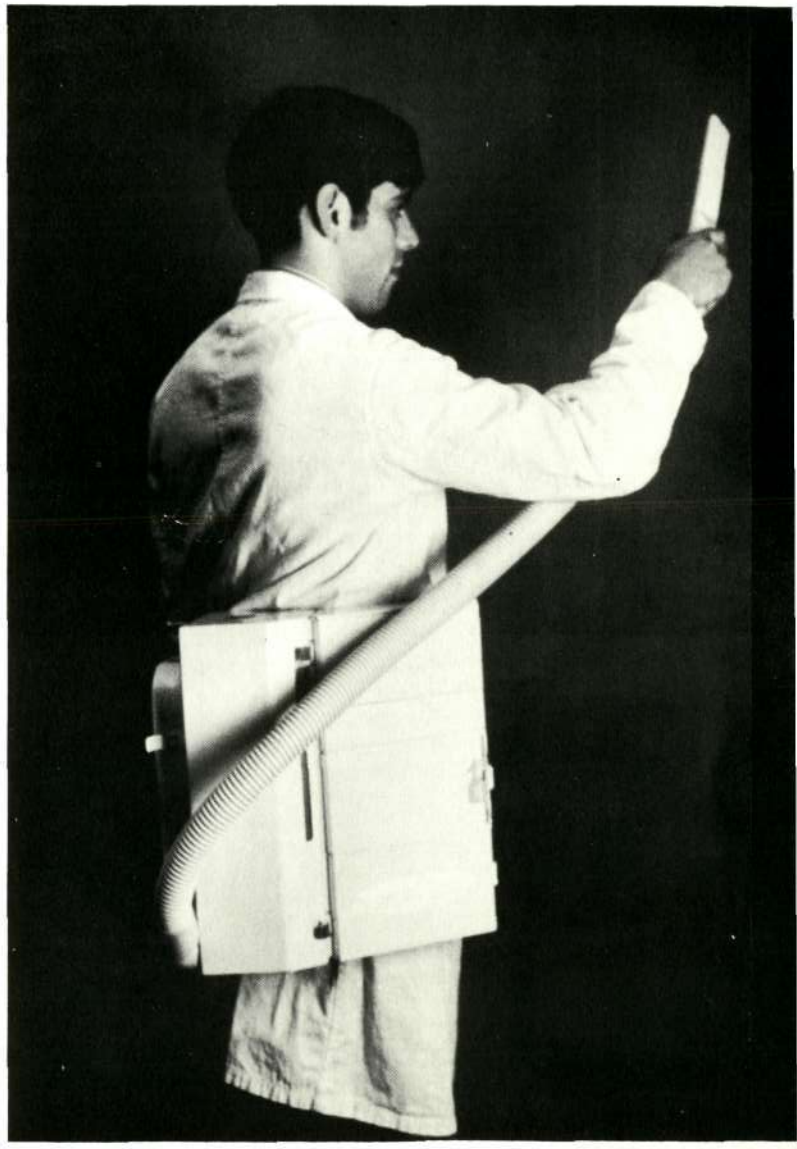
A tight visual scale model of the selected concept was fabricated and presented to MSC.



M1 - Illustration of Vac-Caddy Parts



M2 - Photograph of Final Model Disconnecting Caddy Unit from Vacuum Unit



M3 - Vacuum and Caddy Unit Mounted on Attendant's Belt

SECTION
N

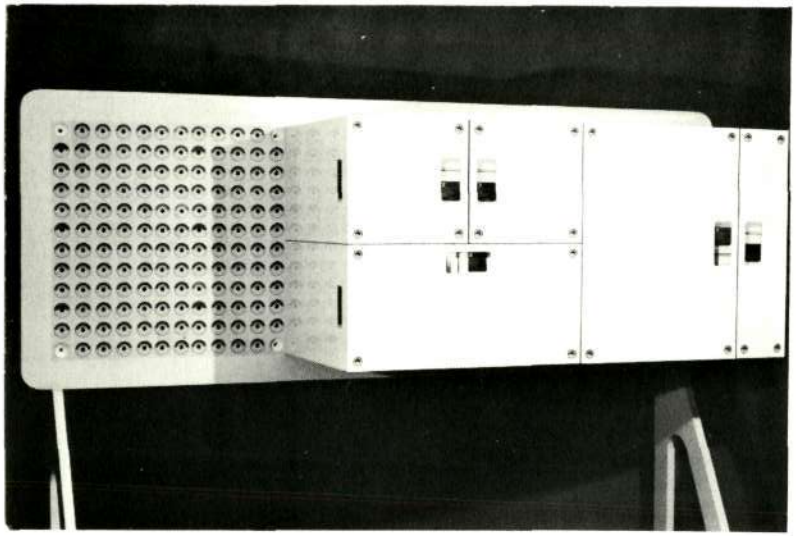
TASK Orbiter General Storage System

DESCRIPTION Mission storage requirements may vary from one mission to another, therefore, a locker system must be developed which will lend itself to transporting a variety of experiments, equipment and mission supplies into space. The rationale basis for the development of such a system is that a flexible storage system will reduce requirements for custom design of each piece of equipment which are single mission related and not designed as a shuttle component.

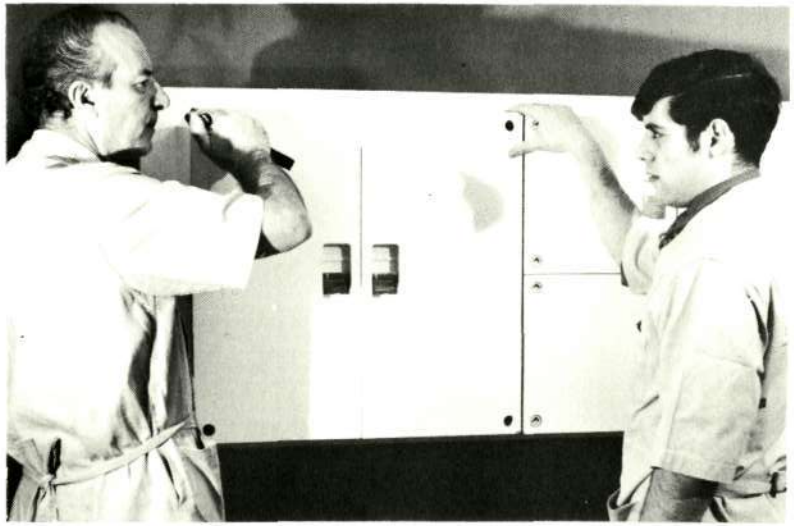
Inside the storage lockers is a system of trays (slid into "C" shaped extrusions) mounted horizontally, vertically, as a unit or individually. This gives a crewman an option in orbit to remove an entire locker, a single tray or several as a unit, if necessary, to transport that particular unit to a location within the spacecraft.

The components on the trays are restrained using various techniques. The tray sizes are dependent on the size of the storage locker being used, however, the methods of restraint are interchangeable.

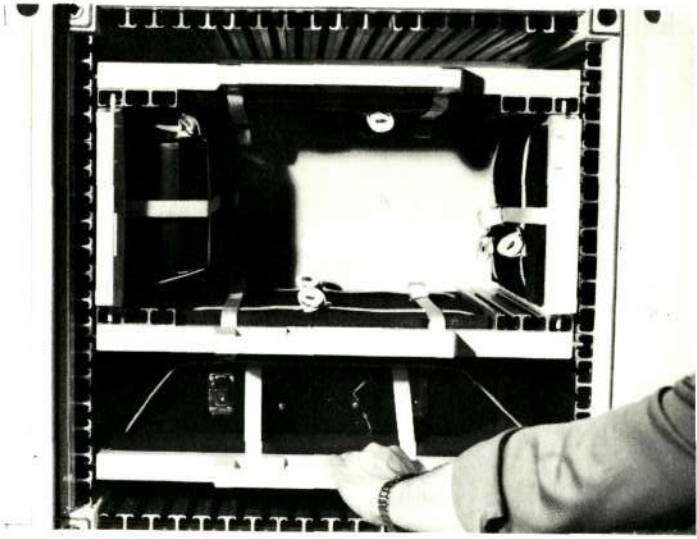
The system developed utilizes standard storage locker which would be available in various sizes based on a set modular growth pattern, (i. e. 24" X 24" X 16"; 48" X 24" X 16", etc.). The object of the master locker size option would be to provide the largest storage unit possible for each storage location based on the physical constraints of that location. The outer cases are attached to the shuttle structure by torquing threaded fasteners into threaded fittings arranged in a matrix in the structure.



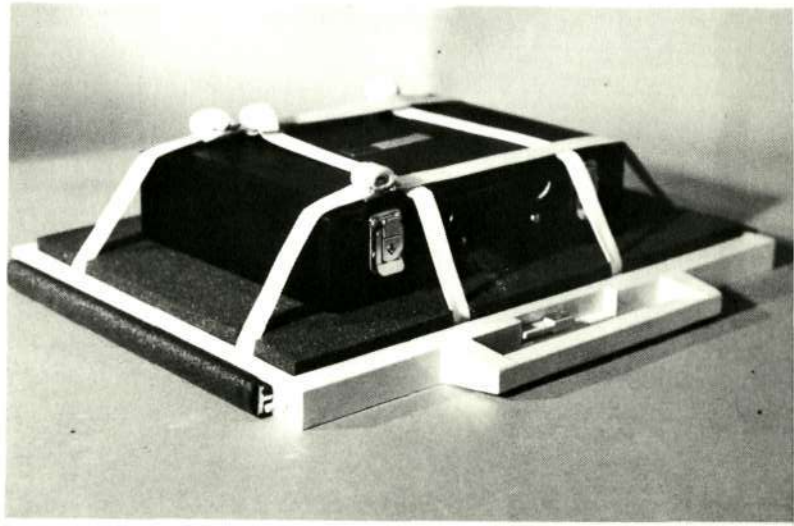
N1 - Storage Locker Demonstration Model Illustrating Support Wall and Modular Breakup



N2 - Installing 24" X 24" X 18" Storage Module



N3 - Interior View of Storage Locker with Single and Multiple Tray Groupings



N4 - Storage Locker Tray Details

The interior of the master storage locker is then divided up as required by using flat tray inserts which interlock with the extruded inside walls and interlock with each other in the same manner. Using trays as wide as the locker interior, enables it to be subdivided vertically at one-inch increments into any propositions desired relative to mission storage requirements. Sliding various width trays into the locker vertically between horizontal trays allows one to subdivide the case horizontally as required. The end result of this system is that a totally flexible storage system from which individual trays in total groupings and the items they contain, may be removed as desired.

FOREWORD

As required by NASA Contract #NASA-9-12479, this report summarizes briefly all tasks completed during the 1972 contract period for Manned Spacecraft Center, Houston, Texas. Selected illustrations and copy summarize each study which are more thoroughly covered in the final report.