development.

needed to communicate our ideas and to establish a foundation for future
tasks, sketches, mock-ups, mechanisms and models were the mediums
quickly provide NASA with a variety of creative solutions for the project.

As a consultant design office, we have provided habitability design services
for the Orbiter Program as requested by MSC. It was our goal to


for the Manned Spacecraft Center, Houston, Texas, from January 24, 1972 to

This report covers work accomplished by Raymond I. Lowey/William Buhl/D, Inc.

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Following the task assignment, a meeting was scheduled for January 12, 1972.

To develop a working crew compartment configuration which satisfies the operational requirements for launch, zero-G, and re-entry modes.

A 39" passage through the crew compartment extending from the atrium to the rear.

Immediate access necessary to emergency escape hatch and head during launch.

Crew compartment consisting of a 96 X 180 X 108" W X 196" L module.

6-man crew maximum of 4 crewmen occupy crew compartment at launch.

Consider operation in 3 modes of orientation: launch, zero-G, re-entry.

Shuttle Orbiter Crew Compartment/X-Axis Docking

3 January 1972

MSC - Allen J. Louter

Shuttle Orbiter Crew Compartment/X-Axis Docking
can be tilted to suit individual preferences.

To allow the entire crew to have visual contact with each other. The couches
were (Figure 4), the head and gallery are along a common wall with a "passageway
enabling to define routes of travel and outline activity areas. In the crew compartment-
and accessibility of the hygiene compartment to individual crew couches. An aisle was
emphasized was placed on the accessibility of the emergency escape routes during launch

Advantages

Crew Compartment Description
Avionics is dispersed throughout the vehicle. A more integrated plan is needed.

Mobility through the craft is very limited in all flight modes. A specific passageway

Chapters 5 and 6 store for launch which require under the pretender and flight instruments.

To reach exit platform.

Access to the emergency escape hatch is awkward. Unnecessary maneuvering is required

The system entrance has no visual contact with the pilots.

Launch entrance to the hygiene compartment is difficult. Extreme body maneuvering

Pictures A2 and A3
Low/straight approach
by either one galley attendant or each crewman. 

The area has been designed to accommodate 6 men for 7 days, operated escape hatches. The located escape is in position on a wall opposite that of the compartments. Located adjacent to the head, it is positioned on a wall opposite that of the (Figure A9)

Galley Compartment Description (Figure A9)

With some free passenger movement, the space coach support poles tend to overpower the compartment and interterm ceiling, creating maneuverability room for the entire length. coaches along their structural support falls to a position near the floor or obstruction can be alleviated, however, by splitting the two extreme spans between the four coach positions near the outside space walls. The suggested by placing the two end coaches in a social configuration, centered A 39" passage, extending from the atrium to the rear bulkhead has been re-

Disadvantages

of 24", is required to house the adequate volume.

The airlocks have been integrated in the area of the rear bulkhead. A deep

supports which double as modularity aids to the crewmen.

Easy accessibility to the head has been provided via an aisle and the coach

and a few steps to the other skin.

The escape hatch has been placed adjacent to the rear bulkhead.

To have visual contact with the pilots.

The system's control panels have been integrated to allow one systems engineer

(2)

(4)

(3)

(5)
craft to gain access from the rear bulkhead position. A shaded collector will enable
preparation area. Possibility of meal selection is somewhat limited due to storage capacity and
limited room for maneuverability (conflict with space couches from rear).
Galley attendants obstruct passage while preparing food.

Disadvantages

(b) Food may be prepared at Gally unit.

(c) Couch to rear food.

(4) Individual space couch food preparation (food tray jacked into individual’s

(3) Standard SkyLab food cans utilized.

as well as housekeeping storage in a minimum sized area.

If contains all stores, food preparation devices, food service implements,

The Gally location is in an area readily accessible to the space couches.

Advantages
Difficult collector maneuverability in head for different orientations.

- Must sit down to use hand wash and to urinate in re-entry.
- Trousers must be removed to urinate/defecate.

Advantages

- the 3 orientations
- Hygienic handwash doors enable two opposite stabilizing motions convinent to
- Units limited to one wall (modular replacement).
- Pitcher, Zero-C.
- Fecal collector and hand wash unit adaptable to 3 orientations (launch, 1-G.

Disadvantages

- units interfere with the walls through the center of the pivot.
- Unfits into the various modes as does the fecal/urinal collector. All services to these
- to satisfy requirements in all attitudes. The handwash unit, elevated directly above,
- Pitcher (Figure A9). This was accomplished by pivoting the collector around an axis
- the fecal collector to be used in all phases of orientation including inter atmosphere 1-G.
A final presentation was scheduled for February 9, 1972.

To explore possible solutions to the problems of access to the space craft in its various orientations.

Consideration in design for maneuverability of elderly and women.

Access to head and escape hatch during launch.

Orbiter passenger compartment size limited to 90" H X 108" W X 196" L.

6-man crew.

Operational in three modes of orientation: launch, leisure/sleep, re-entry.

Existing Concept

Analysis of Schedule

Task Objectives

1 4 3 2

Parameters

Date Assigned

Center

Task

Section
...avoid deterring any innovative ideas.

Shuttle orbiter hardware and systems was not a primary concern in this phase of the prime objectives of this effort. The interface of these facilities with the equipment necessary during each of these modes were providing accessibility to the environment necessary during each of these modes were providing accessibility to the environment necessary during each of these modes were providing accessibility to the environment necessary during each of these modes were providing accessibility to the environment necessary during each of these modes were providing accessibility to the environment necessary during each of these modes were providing accessibility to the environment necessary during each of these modes were providing accessibility to the environment necessary during each of these modes were providing accessibility to the environment necessary during each of these modes were providing accessibility to the environment necessary during each of these modes were providing accessibility to the environment necessary during each of these modes were providing accessibility to the environment necessary during each of these modes were providing accessibility to the environment necessary during each of these modes were providing accessibility to the environment necessary during each of these modes were providing accessibility to the environment necessary during each of these modes were providing accessibility to the environment necessary during each of these modes were providing accessibility to the environment necessary during each of these modes were providing accessibility to the environment necessary during each of these modes were providing accessibility to the environment necessary during each of these modes were providing accessibility to the environment necessary during each of these modes were providing accessibility to the environment necessary during each of these modes were providing accessibility to the environment necessary during each of these modes were providing accessibility to the environment necessary during each of these modes were providing accessibility to the environment necessary during each of these modes were providing accessibility to the environment necessary during each of these modes were providing accessibility to the environment necessary during each of these modes were providing accessibility to the environment necessary during each of these modes were providing accessibility to the environment necessary during each of these modes were providing accessibility to the environment necessary during each of these modes.

With the knowledge that future space flight may include the elderly, it was important to consider less strenuous techniques of maneuverability throughout the flight.

1. **C Horizontal Pitch - The head should be available.**

2. **Launch - Under the effects of 1-G the passengers on the launch pad should have immediate access to all space couches, the hygiene compartments and the escape hatch(es).**

3. **Leisure/Space - In zero-G flight all areas of the passenger compartment should be accessible, including the hygiene compartment, the food management unit, the athletic and related facilities.**

The primary modes of orientation within the Shuttle Orbiter include:

1. **Approach to Entry/Return**

2. **Entry/Return**

3. **Entry**

4. **Launch**

5. **C Horizontal Pitch - The head should be available.**
Temporary clothing storage

as partitions to create semi-private quarters during sleep and provide areas for
modular couches. The configuration enables the spacecraft ships to be utilized

Figures B/ and D1 demonstrate the versatility of the arrangements of

obtaining access to the space couches.

As illustrated in Figures B/ and D2, the couches used in launch are positioned

to increase the mountable and dismountable accessibility.

supporting the space couches allow the crewman to raise or lower them in order

Figure D/ is another modular example of the flexibility provided. The brackets

for the flight deck crew to use in zero-G only.

The diagonal couches shown are

shown in Figure D/ utilizes these modular units. The compartment configuration

easy mounting, escape and hygiene facility access. The leisure mode demonstrates the gimballed procedure the couch performs to enable

the leisure mode demonstration the gimballed procedure the couch performs to enable

Figure B/ illustrates an example of modularization in the three couch orientation modes.

modules, the space couches would articulate for easy access.

compartments to be completely reconfigured quickly between missions. Within these

couch, storage and service, interplanetary life on earth would enable the passenger

zation of compartments would be a procedure worth pursuing. Quickness, including

With the possibility of frequent "on pad" servicing, it became evident that modular-

Description

Modular Compartment Environmental Systems

APPROACH A

13
Tracked compartment environmental system (Figures B2-12).

**Disadvantages**

- Self-contained system compartments exhibit tendency toward a clausetrophone.
- Limited mobility and variation in layout (Figures B2-3).

**Advantages**

- E Central aisle provides efficient traffic pattern.
- Flexibility of couch positions (Figure B2).
- Privacy screen provided by available storage unit doors (Figures B2 and B7).
- Easy access to couches.
- Privacy is provided.
- Couch and sleep compartment designed as one component.
- Servicing is easy and parts are interchangeable.

**Approach B**

Repositioned elsewhere, orientation, it can be reduced via spring post ends covered with a spun fiberglass material.
Articulated Space Couch Utilization.

To increase accessibility to the space couches in the various modes of orientation, an approach C

1. Description

Articulated Space Couch Utilization.

D Disadvantages

b Excess room is necessary to accommodate interchangeability of facilties.

a Problems of permanently attaching units to withstand launch "G" loads.

2. Description

Advantages

One continuous area useful for experiments and leisure activities.

Open space is possible by sliding all the couches to one end of the orbiter, exposing couch interchange through the tracks, to jacks mounted at interfaces, a completely flexible facility and work stations. Axes between them is utilized for crew maneuvering to the couches area, as well as space couch articulations. Fixed permanently at launch, the couches

The partial track creates a flexible system which allows adjustments in mission...
Flexibility of compartment configurations.

Object jointly:
- May be arranged to create a continuous 39" clear area extending the interior.
- Increase I-C accessibility.

Advantages:

mounting.

Figure 6 illustrates two revolving cylinders, each with two couplings. Passengers
in a configuration where the couplings face each other.

When mounted horizontally for access, they pivot inboard and the tracks, can be maneuvered parallel to
achieve their functions in various orientations. Illustrated in a position con
increase mountability ease.

Figure 7 demonstrates the manipulations the space couplings are capable of to
deck to the passenger compartment, yet allows for individual compartment identity.

Visual communications and adequate maneuvering area to translate from the flight.

of the speakers. If visual elements are area into the next, it makes partial
open scheme by "fairly" the central deck creates passenger access on both sides.

Figure deck and passenger compartment in illustrated in Figure B. A key feature
occupancy concurrently. The extend of audio-visual communication between the
was emphasized and considerations were made not to obstruct activities which were
unnecessary travel to the passenger compartment for this activity. Utility of space
undisturbed and repositioned behind the seat as a sleep station, thus allowing
the equipment at all times. Figure illustrates the use of the flight crew seal pad.
result in a more efficient use of space and provide for instant access to monitoring.

2

To accommodate restrooms for the crew mode of operation, this approach would
accommodate restrooms on the passenger compartment. We investigated the possibilities of reconfiguring it
tions and control monitoring. We investigated the possibilities of reconfiguring it
nent. Since the systems engineer's station was to be used mainly for flight open-
neccessary between the pilot and systems engineer located in the passenger compart-
ent the operational station, yet not initiated audio-visual communications
concerned with separating the lessee/lessee activities area in the passenger can-
ook out the flight deck, Raymond Lowry/William Smith, etc. was primarily


1

Description

Flight Deck Configurations.

Advantages:

Large compartment usable area is necessary to accommodate these conflicts.

Positioning of individual couch is dependent on location of others.

Extrame mechanical.

Disadvantages
a. Combo activity areas.

Disadvantages

- Maximum accessibility to separate compartments from high deck.
- Open deck concept gives the feeling of spaciousness.
- Sleep refresh available for light deck use.
- Inter-compartment audio-visual communications provided.

Advantages

3

c

b

2
In order to fully evaluate the task of restroom systems, Raymond Loyd

INTERIOR VOLUME APPROX 30" X 30" X 78".

In 1-C Pilot, crewmen may use the standing urinal facility only.

Rectal/Urinal collector used in launch, Zero-G.

30th to 95th percentile personnel sizes.

Accommodate male and female personnel.

C Atmosphere Flight - axis of orbiter parallel to horizon.

b Zero-G.

a Launch - axis of orbiter perpendicular to horizon.

Hygiene compartment to be operational in three attitudes:

14 FEBRUARY 1972

WSS - Gordon Rossi

Restroom System for Hygiene Facility (Phase I).

TASK OBJECTIVES

6

5

4

3

2

PARAMETERS

DATE ASSIGNED

CENTER

TASK

SECTION

23
To allow enough head clearance, utilize space opposite the collector unit. An interior area of 40" X 30" is necessary. The area in between accommodates back-up volume. The volume would normally Figure C illustrates the handwash unit and rectal/urinal collector on adjacent walls.

To launch, above the handwash unit provides head clearance if defecation is required prior to wash. The cavity base would be used for defecation prior to hit of upper left wall. The cavity

Figure C illustrates an alternate version of a hygienic facility. Back-up rectal

restroom concepts.

The preliminary studies of the hygienic facility conducted were aimed at minimizing

the volumetric requirements of the hygienic facility and developing appropriate

in the launch mode.

use of the handwash unit while seated on the rectal/urinal collector is restrictive

its use in an awkward body orientation not conducive to easy waste elimination. Figure C. The lack of head room in the seated rectal position (zero G) dictates

The existing system fails short in certain areas of compatibility with 99% to 95%

parts its required.

to achieve "off-the-pad" defecation, "on-pad" checkouts and space tight re

The existing MSO Houston Shuttle Office Personnel Hygiene Facility (Figure C)

need that preeminent review held in March to discuss concepts developed to date.

A final presentation of this task was scheduled for 4 April, 1972, with an inter-

exiting concept

primary

arrangement studies

preliminary

analyses of

schedule
The arrangement allows for location of all facilities requiring plumbing and back-up of restaurant's desires.

Figure C9 - Use of elbow or shoulder restraint incorporated with side walls creates desirable.

Figure C8 - Thigh restraint which creates pressure directly to some crevemen.

Figure C7 - Shoulder restraint maintained comfortably. Requires ward pressure on shoulders may be uncomfortable. Required.

Figure C6 - Location of belt restraint too near seat area. Necessary. to "D". This desirable.

Figure C5 - Thigh restraint which creates pressure directly to some crevemen.

Restraint system concepts for the hygiene facility follows:

A cross section of general comments received on the preliminary critique of the facility with the area, a "40" head clearance is attained in a "30" X "30" facility. By positioning the elbow on the railroad or Figure C2 to "30" X "78". By positioning the elbow on the railroad or Figure C2 to "30" X "78". By positioning the elbow on the railroad or Figure C2 to "30" X "78". By positioning the elbow on the railroad or Figure C2 to "30" X "78". By positioning the elbow on the railroad or Figure C2 to "30" X "78". By positioning the elbow on the railroad or Figure C2 to "30" X "78".
By walking vertically through door.

1-C Flights - Handwash and urine collector are usable. Hygiene is accomplished.

Zero-G-All systems in use.

The door into the feet compartment of the reca/uralcolletor used by side access. Hygiene would be accomplished by stepping down through a pedestal to axial of shuttle orbiter. The use of waste management units in

This scheme positions the personal hygiene unit and reca/uralcolletor per-

the maximum exertion possible.

Mobility aids and rest room provisions are built in or flush with surrounding to

the reca/uralcolletor for standing urination use only.

A second reca/uralcolletor, leading to the same collector tank, was placed below

eliminated.

Headroom clearance problem for a person using the reca/uralcolletor is

Figure C illustrates Approach B Integrated into an MSC Houston scheme.

Figure C7-C18 Approach C

Pictures C15-C16

This arrangement is somewhat similar to the NASA arrangement, however, by

in the shuttle transfer, the handwash unit is now accessible in all orientations.

Creating a headroom clearance problem previously expensive. Originated

allowing the vehicle wall curvature to increase into the compartment without

volume of all concepts studied with no reduction in maneuvering ease.

All mobility aids and rest rooms are built in or flush with the adjacent surfaces

the feet section of the reca/uralcolletor.
FIGURE C22 illustrates how a 50% female would use the compartment during Zero-G and 1-G flight modes.

Carried with the individual crewman around this water it would be

compelled into the unit he was utilizing.

position. Carried with the individual crewman around this water it would be

of the hygiene facility, as well as work stations which require several temporary

Figure C21 demonstrates the use of a portable multi-purpose restraint adaptable

for.

well as properly positioning the body in a seated position on the recalc/urine collec-

tion unit (in most schemes or several inches behind the body) of a unit. A recalc/urine

which was essential to give the hygiene facility. We also feel it is essential to give the

enabling areas of the crewman. We also feel it is essential to give the

bathrooms exposed body contact and bases

with the development of an appropriate restraint system for the hygiene area.

throughout this study, Raymond Lowey/Willem Drijver, etc., has been concerned

wash for better accessibility.

the personal hygiene unit to minimize cross contamination. The only change

The recalc collector has been positioned low in the compartment relative to

The round shape in the lower corner taking maximum advantage of that space.

In addition to making the most of the upper corners, this arrangement locates

seated on the recalc collector with a diagonal view of the compartment cross section.

To take maximum advantage of the space available, we have achieved an individual

excess plumbing and overall equipment volume was minimized.

By placing the recalc/urine collector and the handwash unit on adjacent walls,
### Waste Management Volumetric Comparisons

<table>
<thead>
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<th>RECOVERY AREA</th>
<th>HAMILTON STANDARD</th>
<th>LFS SCHEME A</th>
<th>LFS SCHEME A + NASA ARRANGEMENT</th>
<th>LFS SCHEME B</th>
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**Note:** All figures rounded to nearest.

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**Waste Management Arrangements Volumetric Comparisons**

- **C23 - 35% Male Compartment Utilization**
- **C22 - 5% Female Compartment Utilization**
Required resteratnts and mobility aids appear to be:
- Dirt collection of pelt and stove area cavities.
- Interference with wipe procedures.
- A may be direction to explore.

A voidance of contact of exposed skin areas with (de)posable segment
which must be overcome, include:

- Straining device essential, Problems related to the use of a Lap belt system,
- Creation of the individual, The pain of cramps will need to use of a positive re-
- A „lap belt“ was considered a necessary „stop gap“ device to be used at the dis-

Utilizing the equipment noted.
The total compartment volumetric requirements is approximately 150 cubic feet
approximately 50 cubic feet is required for maneuvering within a helicopter facility.

Observations are noted:

Based on information gathered from the volumetric compartment, the following
relationships
into maneuvering areas, хрudes and back- up components to figure volumetric
of the compartments on a volumetric requirement basis. We broke down the facility
The chart shown in figure C4 was developed to provide a comparable analysis

STUDY EVALUATION

Launch orientation.

Figure C3 illustrates a 95% make using the compartment during Zer0-G and
Approach C.

Toward the development of an elbow and lap restraint utilizing a revised restraint system for a hygiene facility (Phase II) will include effort directed at crewman protection.

c. "Elbow" restraint and/or "lap" restraint (degree of use - option)

b. Hand rails (to maneuver between facilities - option of crewman).

a. Foot restraint/reel (available for use at crewman's discretion).
Version as detailed in the parameters above.

A D the coach will perform the same functions as the earlier larger small passenger coach. With maximum dimensions of 77.5' L X 27' W X 14' H.

Raymond Loevy/Willion Spaulding, Inc., has applied the knowledge and experience gained in the development of a large passenger coach to the

Maximum dimensions, 77-1/2'L X 27'W X 14'H.

Accommodate 5% female - 95% male.

Lighting and communications.

Garment, personal gear storage, trash disposal, issue dispenser.

Provide crewman with comfortable personal area to include provisions for

By rotation the coach along its longitudinal axis,

Reorientation of the coach phases of flight operations will be accomplished

Serve as a support (seat) for all modes of operation.

TASK OBJECTIVES

5
4
3
2
1

PARAMETERS

DATE ASSIGNED

14 February 1972

MSC - Gordon Rysavy

Small Passenger Coach

D

SECTION
accomplish this adjustment by revolving the leg section 180° to expose
legged for launch and storage legged for sleep, Figure 2. and D.
This concept restricts the support to two basic configurations, bent
and extending the cockpit padde to provide more usable area for body support.

Figure D illustrates the concept of minimizing the structural components
which was rather limited,
when the coach was configured for sleep and the amount of privacy pro-
duced in a comfortable, but rather large unit (8.4 m X 3.6 L X 2.4 H). This
resulted in a three dimensional model. Emphasis was placed
on comfort and adaptability to the various flight modes. This effort
critically evaluated the

2.77” width, the first generation passenger coach was aimed primarily
at developing the transition support concept to a point which it could be
the perimeter of the coach, we were able to take full advantage of the
problem from a structural viewpoint, looking at methods of achieving

Based on the critique of the first generation space coach, we approached

1972.

Following the task assignment, a final presentation date was scheduled
for April 4, 1972. With an intermediate preliminary review in March,
equipment are included in the coach design.

of a restrained crewman, environmental controls and emergency
hydraulic systems. These have been successfully located within arm's reach
immediate access items, including latches, trash disposal, personal
and has increased the accessibility and overall usable coach space.

A less pronounced cushion configuration with a low retaining wall, it
Privacy

Figure 3-13. Approach B

Figure 2-14. Approach A

The main clothing storage area within the privacy area when the couch is configured for sleep. The main clothing storage area is usually within the privacy area when the couch is configured for sleep. The main clothing storage area is usually within the privacy area when the couch is configured for sleep.
From behind, to a position over the crewman's head.

In the sleek mode, a canopy will pivot along the axis of coach rotation.

Located between the legs of the base of the coach, access items including oxygen, life jacket, etc., may be placed in storage.

The over-the-seat storage is located behind the seat back. Immediate release configuraton.

The driver begins the knee orientation during launch and within the area, the coach is adjusted for two major seat cushion modes -

The structure of the compartment surrounds the entire small passenger coach.

mean enclosing them.

strategically placed, a priority screen can be drawn between the two.

The same axis of rotation as the coach is a location in front of the rear head of the seat mode, it is placed around the seat, to the side of the coach. For the sleek mode, it is placed around the seat, to the side of the coach.

The over-the-seat storage is positioned on a cradle-like structure oriented between the two points, the knee location and the back. The coach length is adjusted

in many ways the SkyLab crew compartments, walls and deep compartment doors; the seating compartment resembles a vertical position, support rods stored in the structure pivot into

FIGURES DJ-28
APPROACH D

FIGURES DJ-36
APPROACH C

C „approach suggests the possibility of combining a conventional coach

with an airline passenger seat arrangement, adjusting is limited.
The study established the credibility of the small passenger coach concept. From the station was not considered in this study phase. In general, introduced late in the concept development to allow for removal of the down requirement for the coach to fold to 28' W x 28' D x 39' T was in-

duction of scheme "D", which considered desirable features. At break-
The integral sleep compartment concept of Scheme "D", and volume re-

COACH STUDY COMMENTS
SMALL PASSENGER

49
Frozen foods will not be considered for the 42 man/day mission.

Food Type: dry 30%, shelf stable 30%, and perishable 20%.

All foods will be precooked, packaged, and served in individual containers.

Keeping:

Galley volume 100 cu. ft. (80 cu. ft. galley facility - 20 cu. ft. house-

the unit.

All food and equipment related to the galley function to be stored in

One-man food preparation and clean-up.

3 meals per day with limited choice per meal.

42 man days (6 man/7 days - 14 men/3 days).

14 February 1972

DATE ASSIGNED

MSC - Gordon Rysavy

CENTER

Food System and Galley

TASK

E

SECTION
Semiconductor area contains spillage, but does not isolate attendees.

Storage units and preparation equipment are limited to an annular width.

Attendees not required to stand in congested area.

Work counter is directly to the front for viewing ease.

Figure E1

Existing Concept

Analysis of Schedule

The initial review meeting was scheduled for April 26, 1972.

Provide for snack and leisure foods.

Provide for selection of courses per meal.

Human factors layout to reflect frequency of use of various units.

Use of conventional food preparation systems.

Minimize time, decisions, and skills required.

To develop food system and facility concepts which emphasize:

Task Objectives
### Activity/Equipment Relationships Within the Galley

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Warmers</td>
<td>Meal Preparation</td>
</tr>
<tr>
<td>Oven</td>
<td>Refrigerator</td>
</tr>
<tr>
<td>Water Dispenser</td>
<td>Portable Water System</td>
</tr>
<tr>
<td>Tray Dispenser</td>
<td>Menu</td>
</tr>
<tr>
<td>Snack Food and Beverage Storage</td>
<td>Cleaning Agents</td>
</tr>
<tr>
<td>Cleaning Agents</td>
<td>Emergency Oxygen</td>
</tr>
</tbody>
</table>

(X) indicates a relationship and need for access.

---

**Existing MSC Food System and Galley Concept**

- [Diagram of galley and equipment relationships]
soup and salad choice was offered. A selection of two vegetable types was possible. A single piece of bread was available. The types of food available were limited for the purpose of this study. To ensure the crew obtains the proper amount of nutritional content.

Selection

Choice of selection which meals he will eat on a specific day.

Menu

Particular function,

issues within whose proximity and the need for their access during a meal, to select the food he desires during the meal. For lunch, the crewman will select the food he desires to eat within their food, he will be asked to eat certain types of foods. To

Activity Equipment Relationships

Positive

by the galley attendant and added time in meal selections.

Dispersed placement of preparation facilities requires frequent body maneuvers.

Duplicate of volume creates unnecessarily large galley.

Retriever access requires attendant to step back and bend.

Study Analysis

3

2

1
placed into their containers. Briny cans are placed into the waste container.

At the meal's conclusion, the food trays are returned to the galley and

upon which six food trays are placed.

The counter surface utilizes the vertical surface in front of the attendent

serving trays.

After necessary refrigeration or heating, the cans are placed in individual

and located them in individual stowing preparation racks by food type.

Prior to meal service, the crewman selects what food items he desires

included as the size of the crew increases.

required. Built of modular units, additional storage components may be

a radial arm restraint system which allows the attendant to move as

around the galley around the outside curvature of the vehicle and utilizes

amount of work and storage area accessible to the attendant. Thus, allowing

the volume requirements of the system and to increase the

FIGURES E3-E7

APPROACH A

To minimize volumetric requirements of the system and to increase the

Food preparation requires that the attendants have both hands free.

Hands free restraint concepts have, therefore, been developed.

6

Restraint Systems

Food cans necessary to supply 6 meals for a 7-day mission.

may be available per meal per man. This results in a total of 862

Food volume quantities are based on the fact that 7 food cans are the

5

Food Volume Quantities
next meal module into the access area.

the column room which it was returned. A slight pressure forces the
filled with all 6 (14) tray inserts, it is sealed and repositioned on top of
another, now empty, food can. Into the waste storage module. Once
When an individual returns his tray, he places the tear-off sheet with the

to the proper temperature.

is then plugged into the galley or the crewman’s coach to bring the food
and condiments which are stored above the tray lowerator. The tray
had been pre-loaded by the attendant, and select his beverages, utensils
If a crewman were to eat off schedule, he would obtain this tray which

guided.

directions on the tray direct the attendant as to which food item is to-
When a food item is stored cold, a cavity is pressed on the sheet. The
Those cans requiring refrigeration are placed in the tray receptacles.

backed which double as a protective seal, while on the trays.
The entire meals come on tear-off sheets. The sheets are aluminum

any meal by notifying the attendant.

identified for a particular day and meal. A crewman may interchange
meals he desires on a particular day. They are then packaged in modules
Before the mission, each crewman has the opportunity to select the

and organize of individual courses.

their convenience without rethinking a minimum of the breaking out
the food trays enable individual crewman to warm their own food at
APPROACH B

To limit the amount of involvement which is required by the attendant,
For access when next needed, the tape is pulled, the retaining cans stay at the front of the refrigerator. When the required number of cans of a given type may be removed. Pull holes with an indent for perforated tape. By pulling on the tape, pull access to the food cans is simplified by linking them together in a telephone.

Housekeeping equipment and water storage are located at the base of the preparation areas.

6 Waste disposal chute is located at extreme left of work counter. This provides easy access when emptying trays, yet removes it from prime. Reference to hot items list.

5 The refrigerator unit is centrally located between food storage areas with the oven.

Food storage areas surround the primary work area and are adjacent to reference to hot items list.

4 The area, situated immediately below the display, is accessible for easy counter storage and waste unit.

Compact layout enables operation from a single fixed restocking point.

3 Prime work functions easily viewed including display, water dispenser, counter storage and waste unit.

1 For the following approach includes:

Each crewman is allowed to substitute any food item on a given day, with

APPROACH C

FIGURES B2-B15
Approach C
Perspective of Attendance Preparing Meal

E13 Individual and Master Menu Cards

E14 Identification and Storage Technique of Food Cans
The chart summarizes the relative volumetric requirements of different meals. (Figure 16)

Meals are prepared by the individual crewman at the time of tray and utensil pick-up.

Trays and stores are identified with the crewman's name and number.

The prime work area serves the dual purpose of tray display and tray follow-up by chilled foods.

Prepared, the items in the oven are removed and placed in appropriate trays. Items on the menu are then placed in serving trays. When ready, items are placed in the hot air convection oven. Fourteen trays require heating are placed in the hot air convection oven. Fourteen racks. 

Water is added to those items requiring refrigeration and those items which are boiled. 

A chart illustrating which foods must be heated and where they are found.

The chart illustrates which foods are to be arranged on a master board which provides graphic scope of the items offered that day. After selecting the selected meals, the chart illustrates the relevancy for a food service or meal service. The chart for the mission duration. Meals are printed on ad-

These meals are issued to each crewman representing the three meals needed.
### Food System and Galley Relationships

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Food System and Galley Arrangement</th>
<th>MSC Requirement Study</th>
<th>Approach A</th>
<th>Approach B</th>
<th>Approach C</th>
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<td>6.14</td>
<td>9.2</td>
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<td>5.0</td>
<td>2.5</td>
<td>9.0</td>
<td>4.9</td>
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<tr>
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<td>9.0</td>
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<td>2.2</td>
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<td>Total Portable Water</td>
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<td>9.2</td>
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<td>7.0</td>
<td>13.4</td>
<td>11.1</td>
<td>11.1</td>
</tr>
</tbody>
</table>

*Not applicable*

Food storage modules are used.

Food heated in any.
In the development of the overhead clothing storage, particular emphasis was placed on the prevention of odor cross-contamination. It was felt that the different levels of odor producing garments should be segregated.

Mission Duration: 7 days.

<table>
<thead>
<tr>
<th>TASK OBJECTIVES</th>
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<td>5</td>
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<table>
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<th>TASK SECTIONS</th>
</tr>
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<td>f</td>
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Task objectives:

- Target size: 30'' x 24'' x 4'' minimum 1.67 cu. ft. (MSC Study 30'' x 24'' x 4'').
- 1 pair briefs, 1 pair socks, 1 pair shoes.
- Overhead garment storage to include: 1 pair slacks, 1 shirt, 1 jacket.
- Base of access from a single rehearsal point.
- Accommodate all necessary clothing apparel.
Soldier clothing storage is included with clean garments and personal gear.

Storage unit:

Productive Garments, i.e., trousers, boots, and shoes near the bottom of the scheme. Measure 31\(\frac{1}{2}\) X 43\(\frac{1}{2}\), (1'230 sq. in.) positions the higher door and slider to the left and trousers and blouses to the right.

Productive items are placed near the base of the storage unit with size and figure F2 and F3 phone across the layout. Scheme A, measuring 29\(\frac{1}{2}\) X 31\(\frac{1}{2}\), can also be established.

The overall dimensions of the garment restage systems developed were kept to a minimum. Clothing should be stored in such a manner as to permit adequate ventilation.
In the front of the base, pull up into place to seal the unit.

Items: Once clothing items are in place, a second roller shade, located above the curtain rail, is pulled up into place and secured to prevent the lower frame from moving. This roller shade curtain located in the part of the base, is pulled up into place. The lower frame is radially opened to form a rectangular frame. A dislocation frame is radially opened to form a rectangular frame. A

In Figure P7, a collapsible parallel frame type frame is used to minimize

Minimum Area Restrictions

Area required for storage:

Clothing items. The unit folds in half when closed to minimize the wall

clothing items. The unit folds in half when closed to minimize the structure and over the

clothing by raising an air lift between the structure and over the

"false" to allow passage of garments into units, as is. Figure P8 shows

order level compartments. Figure P7 utilizes parallel bungee cords, which

clean up the appearance of the unit while enabling separate access to different

windows free state. Figure P6 utilizes individual doors. It's

Wrap around skirt elastic supports (Figure P7), retains the garments in a

main/han door separation and clearly designate proper clothing placement.

These schemes retain the clothing items within partitioned cavities. They

Partitioned Cavities Restrictions

Method of access and restrictor, not demonstrated.

Not enough area available to store clothing neatly, wrinkled free.

Ventilation of air-non-existent.

No odor separation between high and low odor producing garments.
Clothing is restrained, when rotated, acts as the cover for the unit. A half open continuous belt. Clothing items are restrained with Velcro structure. Fresh air enters the top. Figure P12 demonstrates the use of easy access. Figure P11 is mounted under the couch, provided into front position for an over covering is drawn to conceal the entire unit when in use.

In Figure P10, dublet frames fold into each other to produce a hat.
Devises, if necessary, should be accomplished without utilizing mechanical
means, if necessary, should be accomplished without utilizing mechanical
of adapting the system to personnel in 50% female to 95% male. Adjust-
ploy Rockstar System. Specifically, the study was to examine the problem
MSC requested that additional work be directed at the development of the

Adaptable from 50% female to 95% male crewman.

Techniques of Rockstar should be simple.

Degree of Rockstar should be the option of the individual.

Three points of Rockstar are necessary when using the Rockstar/functional collection.

Volume within the hygiene facility.

Dirty cubic feet is established as the accepted maneuvering space and clear
developed.

Lift the accepted "L" shaped hygiene compartment (Loswy/Snath - MSC

PARAMETERS

DATE ASSIGNED

April 5, 1972

MSC - Gordon byssay

CENTER

TASK

SECTION

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TASK OBJECTIVES
Phase II Variations in the Hygiene Compartment Configuration

The hand-wash unit previously configured with frontal access has been modified to receive a spherical acrylic bubble with individual hand holes and an individual seat on the seat collector to use the unit more easily.

An individual seat at the seat collector to use the unit more easily.

Exposure skin areas contact the belt is considered undesirable.

Lap Belt Restraint

A final presentation was scheduled for May 31, 1972.

Existing Approach

An early analysis of

Figure A-C2

Approach

Lever/Snatch

1

2

3
is one which requires consideration.

Then an object has been created with the elimination of another body.

The psychological disturbance in the knowledge
of a commonly used facility has decreased in which more than one crevemen
which tend to overshadow is possible attributes. The hygiene compartment,
as generally noted in the past, the lap restraint has many ingenious qualities

Lap Restraint (Figure 6-C16)

stationary elbow restraint appears unfeasible and impractical.

because the extent of protrusion varies substantially between crevemen, a

Recesses.

objectable situation, and create potentially unhappy undercues and

The concern of protrusion of any restraint would impose on the crew an
which would be necessary to decrease the hygiene compartments wall with.

For a 95% female. To adapt to a smaller individual a mechanical device

recess deep enough to accommodate a 98% male would be unlikely large

Recesses conducted with a wide range of body sizes indicated that a stationary

Restraint.

of the hygiene restraint study tested the feasibility of an active elbow

inherent in developmental possibilities on elbow restraint. Phase II

The results of the Phase I study of the hygiene compartment created

Elbow Restraint (Figure 6-C8)
A poor restarin (2).

Three points of restarin (defined by Marlin Neurial Buoyancy Study):

1. Poor Fertilization, Observations include:

   Information gathered from the restarin study reinforces the utilization
   accomplished.

   On each side of the collector as guide rails, these guidelines could be
   shifted of this amount would be negligible, but by utilizing the hand
even farther than two inches from the center on the slinger. A restarin
   varied more than two inches from the center of the slinger. A restarin
   indicates the belt restarin indicates the different body widths.

   The photo series of 5% male - 95% male crewmen seated on the real
   experienced cramps.

   Restarin is not practiced, such as during periods when an individual is
   seated by the restarin, the restarin may be only used when conscious re-
   verse to an upright position when in use. This amount of position
   released in an upright position when in use. If can be easily released when
   stopped. It can be be forming to automatical.

   Flexible non-porous material, such as styrene reseals little maintenance
   where pleased by the crewman,

   Where it comes in contact with skin. These are not part of the restarin,
   these are disposed of. Another position under the restarin

   A liquid of top and bottom an it is being drawn to the center. After use,
   one illusorizes a retractable belt which when drawn captures
   several of the conditions. It enables each crewman to select the degree
   severed of the condition. 1" ease on the condition is proposed in
   "near-of" class as a means of locating the body concept is proposed in
   the 908. The availability of

   Body isolation a crewman desires within the restarin. The availability of
   with each unit, an option should be present as to the extent of personnel
   the degree of skin contact, while using the hygiene compartment, varies
The extent of restraint mobility should be kept minimal because of its
limited effects.

The degree of tension should be kept up to the individual.

desirable - disposable restraint cover issues.

An option of personal isolation from communally used units may be
preferred over lap belt restraint.

c. Hands: Guide rails properly placed may suffice and, in fact, be

b. Lap belt: When manual restraint is not possible or desirable.
The final presentation of the 1/20 scale nose model of the shuttle orbiter was scheduled for May 31, 1972.

Analyze the existing approaches and develop recommendations to improve the overall habitability of the crew compartment.

Reaction control system restricted to nose location.

Common wall surface.

Hygiene and gallery unit positioned on same side of the orbiter with accommodate six men for seven days.

Bay and wheel well.

Utilize the skewed Z-axis dock/airlock system in a shuttle orbiter con-

SCHEDULE

TASK OBJECTIVES

5

4

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2

1

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DATE ASSIGNED

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SECTION

April 5, 1972

Skewed Z-Axis Dock/airlock System Shuttle Orbiter 1/20 Scale Model
mode.

enable the crewman to mount the recul collector safely in the pre-launch
two-section tambour door is utilized. Steps are located in the walls to
facilitate entry into the compartment in all modes of operation, a large
crew's, can be used to descend into the hygiene compartment. To
hygiene compartment. A ladder, convoluted to the four launch occupied
The possibility of launch pad delays necessitate pre-launch access to the

Hygiene Compartment

passenger compartment could create a dangerous pre-launch situation.
The unsecured vertical drop from the top couch to the rear bulkhead in the
orientation is limited.

The accessibility of the hygiene compartment to all occupied couches in launch
head movements of the attendant.

Aftcock protrudes into the pressure position of the Galley Interference with the

access to the hygiene compartment is extremely difficult; no steps exist

FIGURE 4
APPROACH
TOEY/SNAITH

FIGURE H6
EXISTING APPROACH
ANALYSIS OF
Creating a larger pass-through area
permits the couches to be located close to the deck during Zero-G periods.
Items to be repositioned during the various flight modes. This feature
the space couches have been mounted on support columns which enable

high.

Cabin through the compartment and is stored during Zero-G and re-entry
between the second and third coach. This does not limit passage or command.

During the pre-launch period, a removable bulkhead has been installed
To prevent the possibility of a lone dangerous fall from the top space couch

Passenger Compartments

has been greatly increased.

Hygiene entrance is now at the attendant’s feet and this maneuvering room
rotates 90 degrees allowing the top toward the nose of the orbiter. The
eliminate these interferences, the food management unit has been
standing volume so that it tends to limit the attendant’s head movements.

In the original layout, the entrance to the hygiene compartment is obstructed

Food Management
allow for lateral or radial movement.

Flexible restraint concepts were developed in early work bench studies to

assistments.

In contrast to the individual’s physical maneuvering patterns during the tasks
water rests, the rests should be adaptable enough to

and allow him to concentrate fully on the particular task. Unlike existing

to free the crewman of conscious awareness of the necessary for restraint,

The development of a positive flexible restraint is being pursued in order

resistant flexibility to allow limited controlled movement.

Adaptable to a variety of work stations, displays and surfaces.

Operational with a minimum of effort.

(15 minutes or more).

Positive restraint to be used during relatively long periods of time

EXISTING CONCEPTS

ANALYSIS OF TASK OBJECTIVES

DATE ASSIGNED

PARAMETERS

MSC - Gordon Rye

CFT

MAY, 1972

TASK

SECTION

1

2

3

4
With no adjustment required on site (work station, etc.).

Adaptable to all individuals.

Laterai movement allowed.

Ease of ingress and egress.

Unfavorable:

Commens (Figure II)

Difficulty of ingress and egress.

Unfavorable:

Tension unstable.

Capability of adjustments for different sized individuals.

Latitude of slight right to left.

Unfavorable:

Commens (Figure II)
1 Lateral movement restricted.

Unfavorable:
2 Restricted positively.

Favorable:
1 Vertical adjustments possible.

(Comments (Figure 13))
2 Requires excess amount of space.

Unfavorable:
1 Lateral movement limited to radial pattern.

(Comments (Figure 14))
2 Hands free movement allowed.

Favorable:
1 Vertical movement allowed.
allowing the individual to perform his activity. At the

deck or on an adjacent, these concepts increase positive

restraint while

the crew has a multitude of foot placements available. Either

integrated into the individual or as a part of the work

station, these concepts rely on positioning of the foot in

undercuts to properly re-


Wedge Restraints (Figures 16 - 119)

mechanical slide and reel type systems.

restrained multiple movements, varieties of restraint devices

were explored utilizing

In a pinch can act as a restraint or tether support. To provide for control

of the proximal of the front edge of the work surface to the user's

waist makes

Waste Mounted Restraints (Figures 19 - 115)

collision possibilities.

surface over a larger enough area to provide the user a choice of foot lo-

applied to its surface. The other half could be placed in front of the work

control by the crewman, his half of the restraint device being used

vent, usually the single portion because of its use in maneuvering

The concept depends on abrasive or interlocking surfaces. The foot

High Friction or Interlocking Restraint (Figure 18)

during movement. These can be used a high friction surface for pushing off

of various degree, the non-purpose surface (16) requires a smooth

of interface equipment or surface preparation (17) require various degrees

near. Restraint concepts shown in Figures 15 to 17 require various

of a work station, the foot wear should not interfere with normal move-

its effectiveness as a restraint assist. We feel that when not in the area

In several concepts, portions of the shoe has been redesigned to improve

Our Approach

Foot Wear Recognition (Figures 15 - 17)
using these systems.

Figures 1-4 illustrate the use of a two-point attachment concept with a
lateral movement with tension adjustment on the right.

Develop test mock-ups of selected concepts illustrated in Section 1.

Adaptable to a variety of work stations, displays and surfaces.

Operational with a minimum of effort.

Positive restraint to be used during relatively long periods of time

**APPROACH**

**TASK OBJECTIVES**

1. Positive Restraint (Phase II)

**PARAMETERS**

**DATE ASSIGNED**

**CENTER**

**TASK**

**SECTION**

**June 1972**

MSC - Concord Hospital
mechanism which provides for adjustable positioning of a bar foot positioner.

relative to the work station for maximum effectiveness. To illustrate the
flexibility by enabling the crewman to select the location of the toe bar
of the toe bar has been increased. Conventional fixed toe bars allow lateral
side of the toe bar to distribute pressure over a larger area of the foot.

All concepts shown utilize a high friction elastomeric material on the under-

port and effectiveness of the toe bar and allow for an increase in flexibility.

Approach C

Figure 19-12: Illustrate toe bar concepts conceived to increase the com-

Approach B

The concept shown in Figures 15 through 18 permits lateral movement

A recess under the bench's front edge.

When not in use, the arms fold away into

the side of the crewman's belt. When not in use, the arms fold away into

male concepts on the ends which connect to female concepts attached to

to stop side movement when not desired. Adjustable length arms contain

edge of the work surface. The side displacement has a lifting device

by use of a sliding restraint device held in a track attached to the front

The concept shown in Figures 15 through 18 permits lateral movement
seat controls and instrumentation were to be included, but not functional.

earlier Lowey's math concept. Wash comforters, emergency oxygen,
movable clothing container and one for small personal items as per
landing, and General O-GB specifications. The mock-up was to include a re-
sealed personnel and maneuver into several orientations: launch, re-entry,
 buoyancy tested. The concept was to be capable of accommodating various
be constructed to withstand routine ingress and egress in L-G and neutral
them to see whether further effort was warranted. The mock-up was to
Lowey's math was directed to fabricate a mock-up to demonstrate the

is to be provided for sleeping.

and personal effects and must be accessible from the couch. Privacy
work. Storage provisions are to be included for the crewman's Garments
crewmans needs for rest and recreation, eating, sleeping and medical
per crew member. The multi-functional couch is to provide all the
To concentrate several habitation needs into one piece of equipment
due to limited volume within the spacecraft, consideration must be given

January 1972

MSC - AL Lountre

Shuttle Orbiter Passenger Couch - Full Scale Mock-Up

PARAMETERS

TASK OBJECTIVES

DATE ASSIGNED

CENTER

TASK

SECTION
High shading for sleep.

The system does not afford the coach occupants complete privacy, but rather deploy both shade systems from a retracted position in the coach. The system was designed so that an individual could lean from the privacy. The system was also designed so that an individual could lean over-the-shoulder privacy and a flip-up roller shade device located at the over-the-shoulder privacy and a flip-up roller shade device located at the base of the coach which contained a folder three part shade for slide prematurely. Concepts illustrated in Figure K3. The system shown in the previous figure was cutout into the mock-up based on the A noticeable privacy screen system was built into the mock-up based on the.

(FIGURE K6): were fabricated to allow for full range testing.

To meet user usage requirements, we fabricated a 2” x 4” steel bar requirements stated in TASK OBJECTIVES.

were fabricated to develop the coach concept in more detail as per the lowly/shortly to develop the coach concept in more detail as per the.

FIGURES K-4-K8
OUR APPROACH

FIGURES K-3
CONCEPT
EXISTING
and sliding center with items to be evaluated.

Reaalignment the card into a sleeve carrying constant rotating instructions

cluttered format with compartment data on the revolving wheel. L-2-I

at any one response, avoiding unnecessary search for data. L2 is a

Raymond Lowry/William Snith, Inc. They isolate information pertinent

Figures L-2-L-4 show examples of preliminary concepts developed by

the entire sheet for appropriate items.

with a confusing display of information forcing the individual to search

Card received for reference. In our opinion, it presents the crewman

Card, an example of a Data Format

Developed by MSC. Figure L-1 illustrations an example of a Data Format

appropriate procedure for use and present a legible sequence.

To prevent crew members with the card, it should clearly outline the

feeling that all comments should be brief, but allow for personalized responses.

During periods of task and compartment evaluations, it is Lowry/Snith's

task development.

To ground control, it be considered as input for future mission design and

task evaluation. All evaluations will be voice recorded and transferred

be used several times during the mission for a guide for equipment and

to be carried in pockets of the Skiyab Crewman's Garments and it is to

The Data Format Card, limited to two sides and 5 X 8 inches in size, is

September, 1972

MC - Gordon Rysavy

Data Format Card
meaningful evaluation selections and the option to elaborate when desired. The Data Format Card concept is currently being re-evaluated due to
required.

one item in the cut-out window at a time, concealing other data until
equipment to be reduced are on the sliding section. This positioning only
remaining have been placed on the stationary sheave while the tasks and
using shades of grey to visually relate similar areas. Instructions and
Data Format Card. Information has been displayed in an orderly sequence
figures L7 and L6 show the final results in the development of a refined

CONCLUSIONS

FINAL APPROACH

II
Pull up

Example: Item: 4.3.9.3

Instructions:

1. Correct and improve
2. Moderate
3. Adequate
4. Poor
5. Unacceptable

Improvements Required:

Poor: Some short-comings found, but no improvements necessary.

Adequate: Some short-comings found and a few improvements necessary.

Moderate: Where improvements possible, but not.

Good: Where improvements found and a few improvements necessary.

Excellent: Where no short-comings found and all improvements necessary.

Note: Always report these items intact, except the Code in the last month.

Example: V6/D. A. B. C.

Instructions:

1. Correct and improve
2. Moderate
3. Adequate
4. Poor
5. Unacceptable

Improvements Required:

Poor: Some short-comings found, but no improvements necessary.

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Moderate: Where improvements possible, but not.

Good: Where improvements found and a few improvements necessary.

Excellent: Where no short-comings found and all improvements necessary.

Note: Always report these items intact, except the Code in the last month.
The portable unit, re-supplied at the master stowage unit would contain
limitless supplies needed to clean these areas.

The vacuum requires three feet of hose on the caddy and a detachablefive
foot extension for the gallley area - total length, eight feet.

Combien storage provisions for waste generated during housekeeping chores
station area and easy passage through hatches.

Placement of the caddy on the body must allow close movement at work

The caddy and the vacuum must be usable as one unit or individually.

The caddy must be capable of being loaded and used while stowed in the
master stowage unit.

The requirements of the housekeeping caddy and master stowage unit are
as follows:

<table>
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<tr>
<th>TASK OBJECTIVES</th>
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<td>4</td>
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<tr>
<td>3</td>
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<td>2</td>
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<tr>
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</tbody>
</table>

PARAMETERS

DATE ASSIGNED

September, 1972

MSC - Gordon Ryaby

Housekeeping Equipment Stowage

SECTION
maneuvering throughout the spacecraft. No provision has been made for containing the vacuum hose while

The open configuration of the caddy does not provide spillage protection.

excessive amount of time.

Assembling the unit for use away from the master unit requires an

entire unit for attachment of the hose.

Use of the vacuum while in the galley area requires its removal of the

unit.

No restraint device has been provided for use away from the master

No logical organization of components placement is apparent.

The caddy must be removed to reload.

Following problems do exist, however:

The present master storage unit exposes all caddies to the housekeeping agent.

empathetic to access requirements and zero-G movement.

order of frequency of use. Develop a unit form and restraint system

Locate all items within unit for maximum ease of accessibility and in

agents and devices so as to prevent escape of fluids.

Develop a clean form to prevent soil build up. Contain carrier cleaning

FIGURE MA

EXISTING CONCEPT

ANALYSIS OF
5 Pick up full C. P. bags, if necessary.
4 Deposit used dry wipe in C. P. bag.
3 Dry wipe.
2 Wet wipe.

Sanitation and/or disinfection agent.

Wipe Cleaning

1 Use expanded sponge and/or wet wipe.

Emergency Clean

4 Switch accessory (repeat 3).
3 Clean area.
2 Attach vacuum accessory to hose nozzle.
1 Attach hose.

Vacuum Cleaning (Either in storage unit or remote location.)

The following use description was established:

Design and Development of Housekeeping Systems for Managed Spaces.

Using the work sequence described in paragraph 1.4 of the "Preliminary
around hose and it did not appear that the unit would inhibit movement.
The individual has access to all stored components and the wrap
position under the arm wrapping to the rear was considered the most de-

Body placement and task operations of the caddy were studied and a

Relationships

and to evaluate the effectiveness of the proposed component layout re-

figured to obtain minimum overall area to enclose the necessary items

within the housekeeping equipment. The required volumes were con-
stations were conducted to define the approximate volume necessary to

Following the task sequence evaluation, preliminary three dimensional

1. Full C. P. bag storage.
2. Dry wipe towel dispenser.
4. C. P. bag dispenser.
5. Spunge/verc wipe dispensers.

use as follows:

We have arranged the storage units based on the frequency and order of
To prevent an accidental recall, extend the desired length of the cord is snapped into a friction fit groove.
The outer cord on an inertia reel houses the cord when not in use. When

Top for easy access.

During periods of crewmen transfer and all controllers are placed near the vacuum hose is stored flush with the back of the unit to prevent sagging.

To all units.

Storage vertically the crewman's side for equal ease of access.

The selected controller is configured as a wrap around unit, positioning all

However, access to the rearmost storage will be difficult.

A slim side mounted caddy is illustrated in Figures M5 and M6, and a

Then the chest to avoid inhibiting leg movement, as illustrated in Figure M3.

When the unit is to be used, it would have to be mounted in an area other vacuum unit weight to be used. If does not obstruct the users passage through hatches, however, if the

Figures M3 and M4 represent a convenient location of stored components.

manageable by a left hander.

Size (4'-1/2" to 18") was considered restricting and the layout was un-

The minimal 3'-1/2" inch which allows free arm movement. Overall

Peripheral recess, shoulder and wrist straps restrict it to the body.

Figure M2 is a side mounted vac/caddy. The vac hose is stored in a
M14 - Illustration of Vac-Caddy Detail

M16 - Photograph of Final Model

M15 - Photograph of Final Model

M13 - Illustration of Housekeeping Unit Housed in the Galley Area
and limit weight to manageable limits.

Frontal area size limitation, 24" X 24", to facilitate movement in order

Depth limited to 18 inches.

Modular breakdown at locker heights to increments of 6, 12, 18 and 24

Simplifies installation methods to facilitate ground crew re-supply process.

System to be loaded in 1-C, utilization of system in 0-C.

PARAMETERS


A final demonstration model was constructed and pre-

locker system. A final demonstration model was constructed and pre-

further investigation was warranted due to the importance of the storage

for several proposed systems for storage lockers, it was decided that

for June 21, 1972. As interest grew at the Marshall Space Center

The tentative due date for concept development was initially scheduled

May 1, 1972

MSC Houston - Gordon Rasyay

Shuttle Orbiter Storage Locker System

DATE ASSIGNED

CENTER

TASK

SECTION

125
requirement to completely rebuild if one complete column were to be
which is restricted to that designed into the system.

STRUCTURED TO WITHSTAND LAUNCH VIBRATIONS

allows for height adjustments based on "modular increments"

INVENTORY PRIOR TO LAUNCH

adequate restorations within locker, to secure wide variety of items.

PROVISIONS TO CARRY LOCKER, OR PART OF IT, TO OTHER AREAS OF THE CRFT.

ability to remove storage lockers in 0-G and transport to other areas of

WITHSTAND INTENSE LAUNCH VIBRATIONS.
It increases.

space behind the lockers or where available storage depth is less than
decreased at 6 inch increments. Thus takes advantage of otherwise unusable
is still 18 inches; however, near the base of the curve, depths may be
acceptable reach distance for an average cremation. The maximum depth
incure. Previous concepts limited lockers to a depth of 18 inches; an
designed to make use of the volume created by the specialchat's curve.

Figure N4 illustrates a system of storage lockers of varying depths.
locking plans on the rear of the surface of the lockers, interlock with the grooves.
module. Allow for vertical adjustment as required. Over-the-center
grooves, located behind the track at intervals compatible with the vertical.
Figure N3 allows more vertical adjustment. Close-up speared horizontally

Tolerance.

fastening technique was not positive enough and required a controlled
and tied into the wall via inserted receptacles. It was felt that this
in front of the surface exposed on the rear surface extends through the units
inserted. The drawer of the locker allows access to the rear end. A
Figure N2 uses a structural wall upon which the storage modules are

Preliminary Phase

APPROACH

TOEY/SNATH

areas of the chair.

4 Inconvenient method of relocating components of a locker to other

3 No visible means of transporting individual lockers.
Interior Sample Cross Section of Storage Locker

Solution Preliminary Graphic and Organizational

Mounting Wall Development of Locker System with

Small Depth Lockers Minimal Space Sliding Hardware for Use

129
the same manner. Using pallets as a guide as the master case interlock, the interior of the master storage case may be divided up as required. To solve this problem, a locking system of extended storage pallets was conceived as an answer. The locking system, illustrated in Figure 1, is inner-containers that accommodate the variety of article sizes and shapes. Over this, the problem still exists as to how the interior of the pre-structured problem is addressed. The only way to address this problem is to leave some flexibility based on a 6 inch crewman from the general to the specific and area of storage.

Figure 1 illustrates a problem which we addressed lightly in the pre-structured problem, which is the problem of organizing and communicating the logistics. The problem of organization would not be solved by launch vehicles. MSC pointed out that a locker which was not made up of one piece, would be destroyed by launch vehicles. Loosely/successfully, the crew also studied a modular technique for assembling various connectors into a slot and lowering the locker into place. The key requires studying for vertical space between each storage unit. The key requires studying for vertical space between each storage unit. A disadvantage exists in the requirement that the support walls, A disadvantage exists in the requirement that the support walls, and act as a bearing surface upon which the key slot breaks may be mounted. Threaded tension bars are utilized to complete the storage. In Figure 1, the bearing surface upon which the key slot breaks may be mounted. Threaded tension bars are utilized to complete the storage.
position when not in use.

Lockers are mounted on the rear surface of the storage unit which recesses are flush.

utilized consists of spring loaded latches located in the recesses. These latches are designed to keep the items safe when not in use. The storage system

exist with these features which adapt itself by repositioned latches in the support panel. However, we understand that these features are not necessary in securing the item. Articulated latches were considered for use in securing the item in a square matrix to allow for both horizontal and vertical positioning. In the mounting plane, the recesses are arranged in a 2 inch interval.

Located at each rear corner of the locker, 1 cone-shaped recesses

Master locker installation is accomplished by inserting positioning cones

| 3. Lockers Mounted |

Figures 11-113 show a few of the recessed concepts presented.

Figure 11 shows a cut-away detail of the locking mechanism selected and

sizes and shapes to the pallets.

units and each other, and methods of recessed articles of various
depressed, the details of locking the pallets to the master structure

With the appearance by MSC of the pallet system, detailed concepts were

II Development Phase

may be removed as desired.

Detailed patterns on total groups of pallets and the items they contain

vertical length patterns into the case vertically between horizontal pallets

proposition desired relative to mission structure requirements. Storing

the case can be subdivided vertically on one inch increments into any
N10 - Preliminary Storage Locker Tray - To Suspend Small Objects

N12 - Preliminary Storage Locker Tray - Open Config.

N9 - Section of Tray Locking Mechanism

N9 - Section of Tray Locking Mechanism

N11 - Preliminary Storage Locker Tray - Perforations

N11 - Preliminary Storage Locker Tray - Perforations to Accept Tool Mounted Fasteners
Laden trays to be mounted in the same locker horizontally or vertically.

The adaptability of the storage locker system is dramatized in Figures 133.

(c) Locker Interchangeability

That the handle lever serves to locate any alpha-numeric identification.

double door lockers acts independently. The illustration also shows

door access hole. As Figure N12 shows, each door lock on the

located on all four interior surfaces and the corner mounting socket head.

N17 illustrates a close up view of repetitive track extension shapes

placed by any of the other formats.

spooling four 12W X 12H, 12W X 18D, 18H X 18D, and 18H X 24W

All storage locker combinations are a breakdown of 24W X 18D.

12W X 18D, 12H X 18D, 18H X 24W X 18D, and 18H X 24W X 18D.

modules have been limited to the following sizes: 6H X 24W X 18D, 12H X

Special cases may exist where unusually large lockers may be required.

(b) Locker Sizes

in locker mix.

Each locker is supported independently allowing last minute changes.

are threaded at the rear end for torqueing to the mounting surface.

are access holes behind which are located some other heads. These heads

from surface in each of the four corners (Figure N17 and N18)

surface and does not require opening the locker. Located on the

Passing the lockers to the wall is accomplished from the front

...
N16 - Pour 12H x 12W x 18 Lockers Replaceable

Small Object from Restroom
- Preliminary Storage Locker Tray

N13 - Primary Storage Locker System Positioned

N14 - Final Storage Locker System Positioned

on a Mounting Wall

N15 - Several Locker Groupings Interchangeable

Storage Units Stacked Neatly in a Compartible System

N12 - Three 12x24x18D Module with a 24H x 24W x 18D Module

Dimensions of a 5x4x3 Meter Module
of the locker module.

Identical tray retaining capabilities as those mounted on the interior
as on Figure NZ2. The extrusion on these trays would have the
ejection channel integral which would be used to form tray ground.

nents, equipment or experimeters on the trays, Figure NZ2 is an

Figures NZ4-NZ8 represent several concepts for retaining compartment.

stored and the direction in which it will best accept the launch loads.

The tray orientation will be established by the character of the article

Component Resistances

holding on to the tray handle.

The locking action can be accomplished with the thumb while

The selection lever is a smooth portion of the extrusion to the left and right of the

lower located on the front hand grip is turned 180° clockwise and

on the two outer edges of the trays. To lock the tray in place, a

trinions with a slight resistance caused by shock mounted foam pads

is demonstrated in Figure NZ3. The trays slide in between two ex-

the required area of the spacers. A detail of the locking mechanism

detial trays or a group of trays locked together and carry them to

as illustrated in Figure NZ2, the drawers are able to remove in-

of the storage locker by sliding trays only.

The drawer type character of the trays allow access to the deep end

available.

depending on orientation requirements relative to C-loads and space
N28 - Netting Enclosure for Storage Tray Restraint

N26 - Adhesive Foam Surface Restraint for Storage Tray

N27 - Twisted Netting Restraint for Storage Tray

N25 - Strap and Buckle Restraint for Storage Tray

Storage Tray
Principles involved, as illustrated in Figures N30-N37, to better illustrate the concept and evaluate the practicality of the demonstration model of the storage locker system was constructed.

An elastomeric pouch suspends between the sides of the tray in close proximity with each other, especially during launch vibrations. Between nets and between trays should be adjusted to prevent inter-connection at desired intervals for proper restoration. Space be-

Figure N27 enables some components, usually of medium size, to hang completely free. The netted pouch is twisted and hooked to a slotted entry point which prevents dispersion of articles when the lid is opened in 0-G.

Small objects are placed on an adhesive coated surface which pre-serves dispersion of articles from shielding the object free. For smaller articles, Figure N26 has an insert made of wedge-shaped foam.

Figure N25 is a general purpose restraint, an insert used mainly for larger objects sealed in a container. Straps in two directions would prevent the expected vibrations from shifting the object free.