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SPACELAB SOFT MOCKUP COMPARATIVE EVALUATION

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16. ABSTRACT

An assessment of two proposed Spacelab configurations with diameters of 14 and 12 feet was conducted by using two inexpensive wooden mockups containing cardboard fixtures. Also examined was an alternate mounting arrangement for the 12-foot diameter configuration, taking advantage of conforming equipment racks to the cylinder walls. A volume comparison of the three configurations was made using a life sciences payload which is considered to be one of the more voluminous payloads. As a result of the study, it was found that crew volume in the 12-foot baseline configuration appeared marginal for the life sciences payload, especially where crewmen were engaged in activities with competing demands. It was also found that the 12-foot configurations of life sciences payloads offered little margin for stowage or equipment growth. Increased demands would necessitate longer module lengths. Similar results could be expected with other large volume payloads.

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INTRODUCTION

Background

To assess certain issues surrounding the proposed reduction of the Spacelab diameter from 14 to 12 feet, NASA Headquarters, in early September, requested that two analogous mockups be constructed, one of each diameter. The mockups were to be "soft" (i.e., built from inexpensive, readily available materials such as plywood and cardboard) and were each to represent a life sciences payload, which was generally considered one of the more voluminous payloads.

The request further suggested that the study examine different options for mounting experiment equipment inside the cylindrical module. NASA Headquarters specifically suggested that the advantages of conforming equipment racks more closely to the cylinder walls be studied.

Configuration Diameter

Internal equipment definition for the life sciences payload was provided by the Mission and Payload Planning Office, MSFC, and was based on studies conducted under their direction by General Dynamics Corporation. The Engineering Division of Astronautics Laboratory provided detailed layouts of the service module section. Specific items accommodated in each mockup included:

1. Life Sciences Equipment Units (Per Life Sciences Payload Definition and Integration Study, Tasks C& D, Report No. CASD-NAS73-003, General Dynamics)

   a. Visual Records and Microscopy
   b. Maintenance, Fabrication, Repair, and Ancillary Storage
   c. Data Management
   d. Life Science Experiment Support
   e. Preparation and Preservation
   f. Biochemistry/Biophysics Analysis
   g. Biomedical and MSI Research Support

h. Small Vertebrate Holding, Primate Holding, and Vertebrate Research Support Unit

i. Cells and Tissues, and Research Supply Unit

j. Operating Table

k. Centrifuge — Powered

l. Laminar Flow Bench

2. ECS (MSFC Drawing No. 30M20241)

a. Heat Exchanger — Cabin Air

b. Heat Exchanger — Rack Cooling

c. C&D Console

d. Digital Units

e. TV Recorders

f. Data Management

g. Storage (Tape, TV Camera, etc.)

3. Miscellaneous

a. Ducts

b. Lights — Powered

c. Grid Floor

d. Fire Extinguisher

Three mockup end items were constructed.

1. 12-Foot Diameter Baseline — This mockup, built to a cross section as shown in Figure 1, was 25 feet long and included a 5-foot long "minimodule" section, a 16-foot long experiment section, and a 4-foot long certrifuge section.

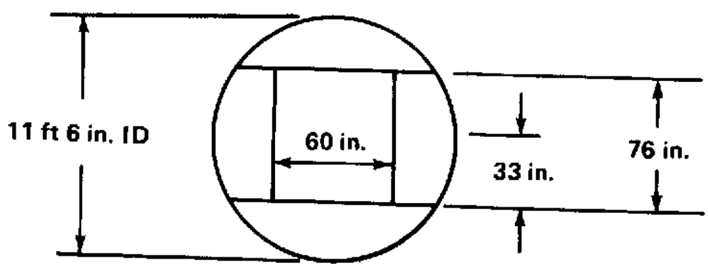


Figure 1. 12-foot diameter baseline cross section.

2. 14-Foot Diameter Baseline — The shell for this mockup was already available and was remodelled for this effort. The cross section used (Fig. 2) was analogous to that used in the 12-foot baseline mockup. The 14-foot baseline mockup was 20 feet long, consisting of a 16-foot experiment section and a 4-foot centrifuge section.

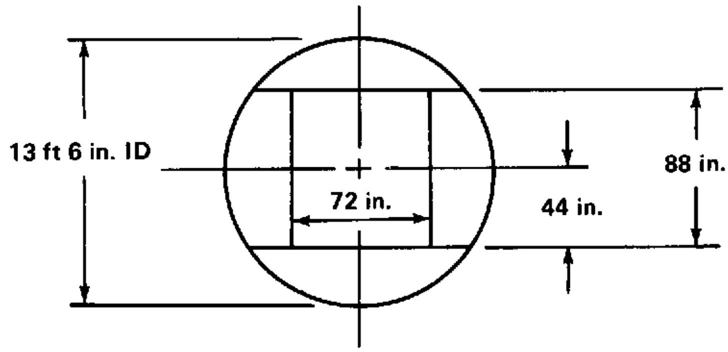


Figure 2. 14-foot diameter baseline cross section.

3. 12-Foot Diameter Alternate — A 5-foot long, 12-foot diameter section was constructed to investigate advantages and disadvantages of an alternate interior arrangement in which crew volume was increased by lowering the restraint deck and conforming racks more closely to cylinder walls (Fig. 3).

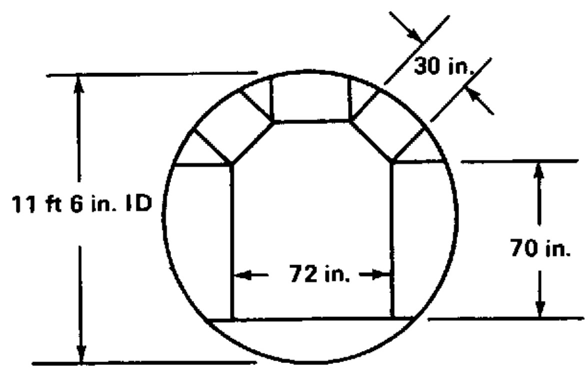


Figure 3. 12-foot diameter alternate.

A series of photographs illustrating the configurations of each of the mockups is included as an appendix to this report. Test subjects have been positioned in each photograph to illustrate clearances associated with various typical tasks. It will be noted that several arrangement details of the 12-foot diameter baseline differ from the 14-foot diameter baseline. Initially, both payloads were arranged similarly; however, to accommodate later guidelines from the MSFC Mission and Payload Planning Office, the 12-foot baseline was modified. These modifications were relatively minor (revised console and rack position, revised operating table configuration, etc.) and did not affect the basic assessment of volume adequacy.

VOLUME COMPARISONS

Table 1 summarizes identifiable volume requirements and available volume resources in each of the three configurations. The various entries on the table are described as follows:

1. Resources — Volume resources, defined below, include all space available for experiment mounting and related stowage.

a. Total Rack Volume — That volume bounded by the faces of the side racks and the Spacelab pressure shell as shown in Figure 4.

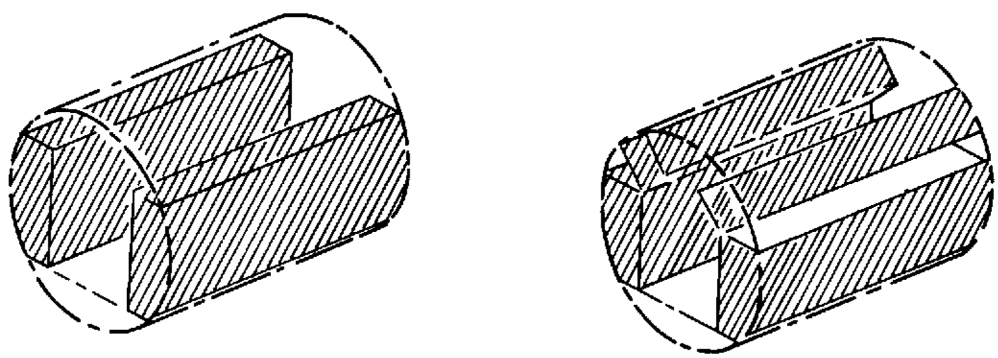


Figure 4. Rack volumes.

b. Overhead and Below Deck Volume — That volume overhead and below deck readily accessible and available for stowage, and not filled by utilities (air, electrical power, etc.) as shown in Figure 5.

TABLE 1. VOLUME COMPARISONS — 12-FOOT AND 14-FOOT DIAMETER CONFIGURATIONS BASED UPON 16-FOOT LENGTH

		14-Foot Baseline	12-Foot Baseline	12-Foot Alternate
Resources	Total Rack Volume	747	570	655
	Readily Available Overhead and Below Deck Volume	451	270	64
	Total	1198	840	719
Identifiable Assessments	Overhead and Below Deck Volume Used by Lighting, Intercom, Astronaut Aids, Stowage Structure, etc.	70	70[b]	70
	Life Sciences Payload as Shown in Mockup	400	400	400
	Additional Experiment-Related Distributed Items Not Now Shown in Mockup (Includes 40 Percent Packing Factor)[a]	256	256	256
	Additional Crew Support Storage for 30-Day Mission (Includes 40 Percent Packing Factor)	19	19	19
		745	745	745
	Margin (cubic feet)	453	95	-26
Other Possible Assessments	Additional Trash Stowage (Estimate)	50	50	50
	Windows in Payload Bay (2)	70	35	35
	Subtotal	120	85	85
	Overall Margin (cubic feet)	333	10	-111

a. For example, data management unit, visual records provisions, miscellaneous research provisions, research consumables, film, tape, etc.

b. Estimate of volume required based on Skylab experience.

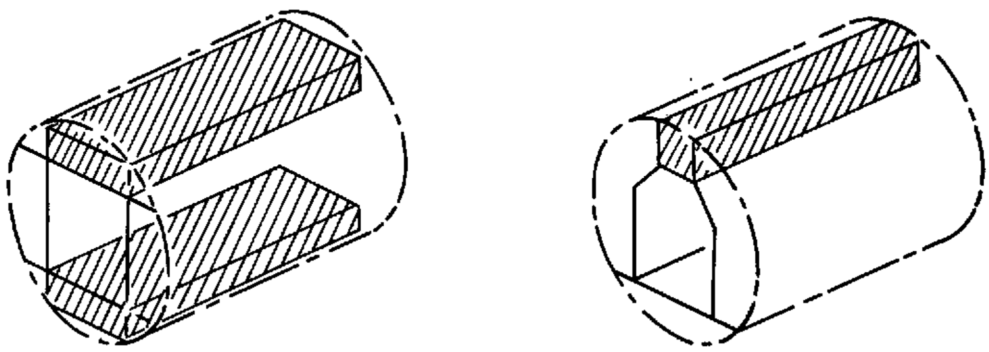


Figure 5. Stowage volumes.

2. Identifiable Assessments — The various anticipated demands against the above volumes are:

a. Overhead and below deck estimated volume required by lighting fixtures, astronaut aids, stowage structure, intercom equipment, etc.

b. Life sciences payload primary experiment equipment, including specimen holding chambers, analysis equipment, etc.

c. Additional experiment-related stowage items such as research consumables, data management equipment, films, tape, etc.

d. Crew provisions which, for a 30-day mission, cannot all be accommodated in the orbiter.

3. Other Possible Assessments — In addition to the above volume demands, additional requirements may develop. Typical of possible additional volume assessments are windows and increased trash stowage provisions.

4. Stowage Volume Summary — As Table 1 shows, there is little excess for the 12-foot diameter baseline configuration and a deficit for the 12-foot alternate, and, when the impact of possible additional assessments is considered, the condition is aggravated. This comparison demonstrates that:

a. Given current volume and payload length specifications, there is little or no margin for equipment or stowage growth in the 12-foot diameter configurations. Increased volume requirements will demand greater payload length.

b. While the alternate configuration provides a greater rack volume, it offers less overall useable equipment and stowage space than the 12-foot baseline configuration.

5. Crew Volume — Figure 6 graphically summarizes the tabulations described above. It also shows available crew volumes (based on three men) in each configuration. For comparison, available volumes per crewman at three Skylab locations are shown. The first, the biomedical area in the Skylab crew quarters, is shown because of its general functional similarity to the life sciences payload used in the mockup. As shown, in this Skylab area, each crewman is provided with an approximately 200-cubic-foot volume, and this appears adequate for the jobs to be done. The wardroom, also in the crew quarters area, provides approximately 100 cubic feet of free volume per crewman, and this has been judged by Skylab crewmen to be too restrictive.

Adequacy of volume per crewman proves to be highly sensitive to general arrangement, or layout within a region. The last comparison value cited on Figure 7 shows that the MDA provided three crewmen with more volume per man than did the workshop biomedical area; yet, the MDA volume was judged by crewmen to be inadequate. The MDA design did not attempt to retain a consistent visual reference direction; there was no "up or down". Experiment and operational equipment were mounted such that, to be operated, crewmen might be oriented along any vehicle axis. Not only did this occasionally place crewmen in "each other's way", but it demanded unnecessary time for orientation upon first entering the module. In the MDA, many unrelated functions may take place in physical proximity. This is another reason the MDA volume has been judged overly restrictive. For example, one crewman reported some difficulty operating at the ATM console, while other crewmen were preparing for an earth resources experiment, translating along the vehicle axis to or from the workshop, or monitoring the airlock module console. These difficulties arose from incompatible lighting demands, physical impingement of adjacent crewmen, communications requirements, etc., all of which, reportedly, were highly distracting.

It might be tentatively concluded that given a consistent visual reference and given that all crewmen are engaged in the same activity in a region, volume per crewman should be between 150 and 200 cubic feet. Each of the three configurations meets this criterion. However, if the crewmen are engaged in independent tasks with potentially incompatible lighting, communications, or movement requirements, necessary volumes may be considerably greater.

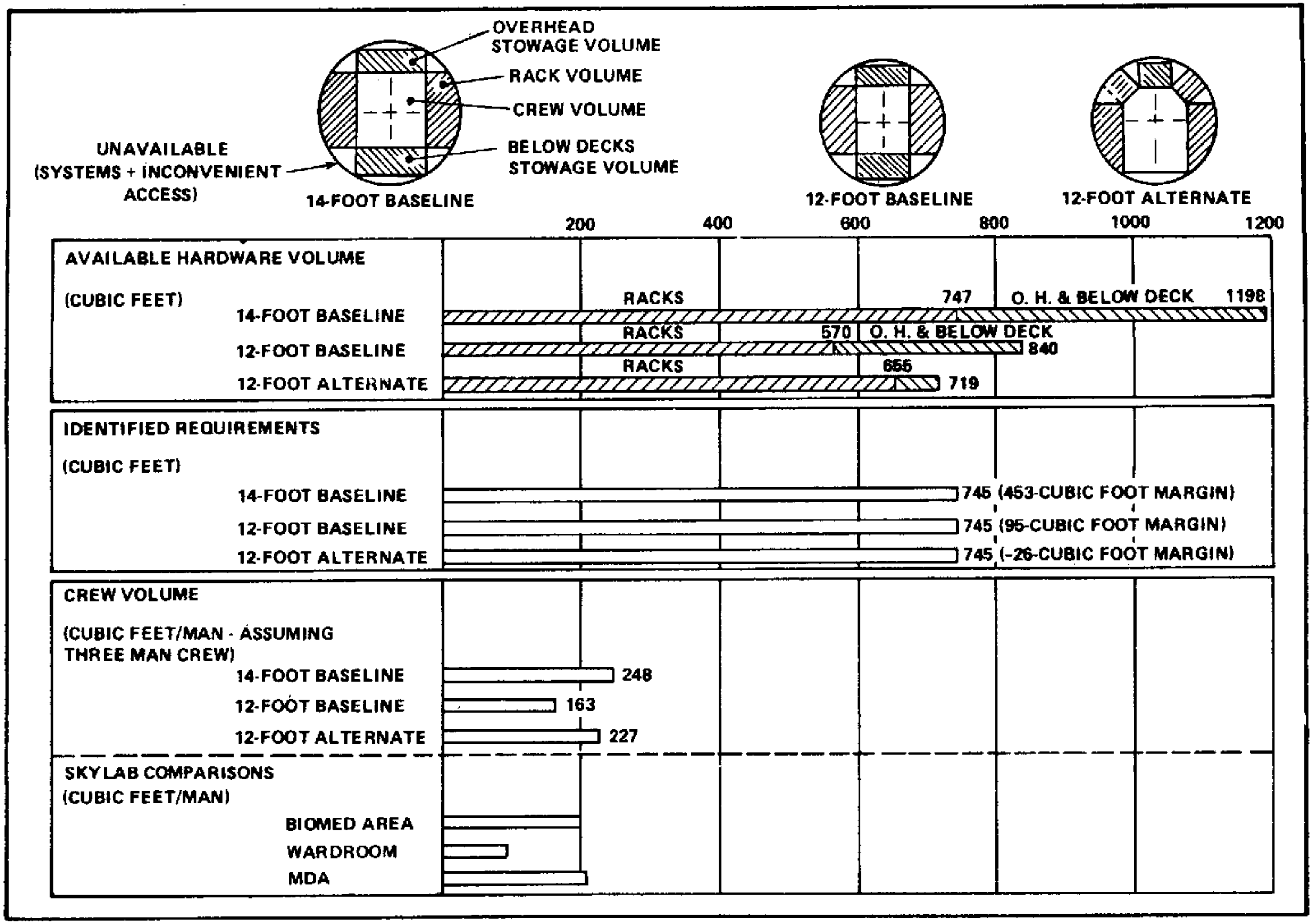


Figure 6. Volume comparisons — 12-foot and 14-foot diameter life sciences payloads (based upon 16-foot length).

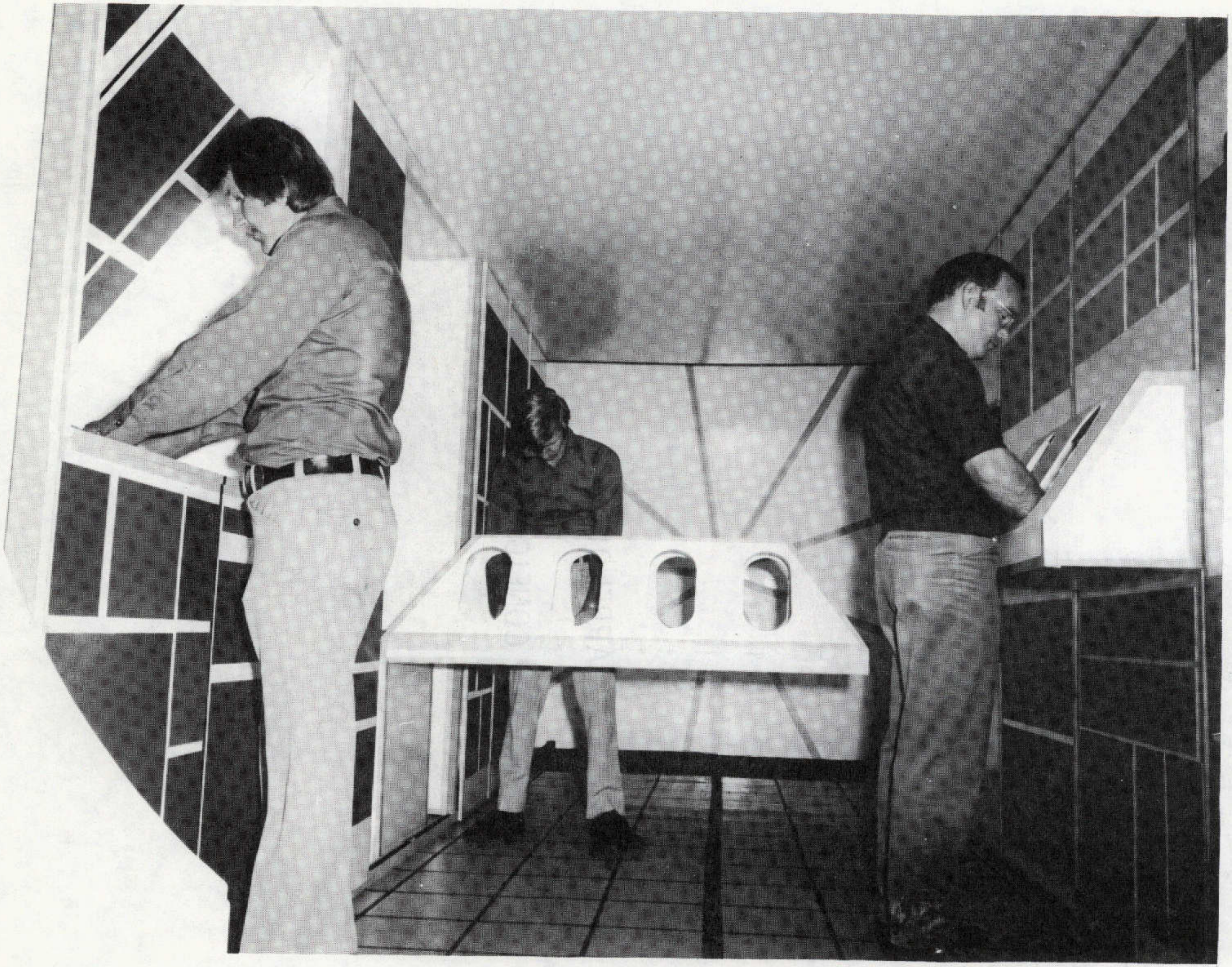
CONCLUSIONS

1. Crew volume in the 12-foot baseline appears marginal for a life sciences payload, especially where crewmen are engaged in activities with competing demands.

2. 12-foot diameter configurations of life sciences payloads offer little margin for stowage or equipment growth. Increased demands will necessitate longer module lengths. While other large-volume payloads have not been investigated, similar results would be expected.

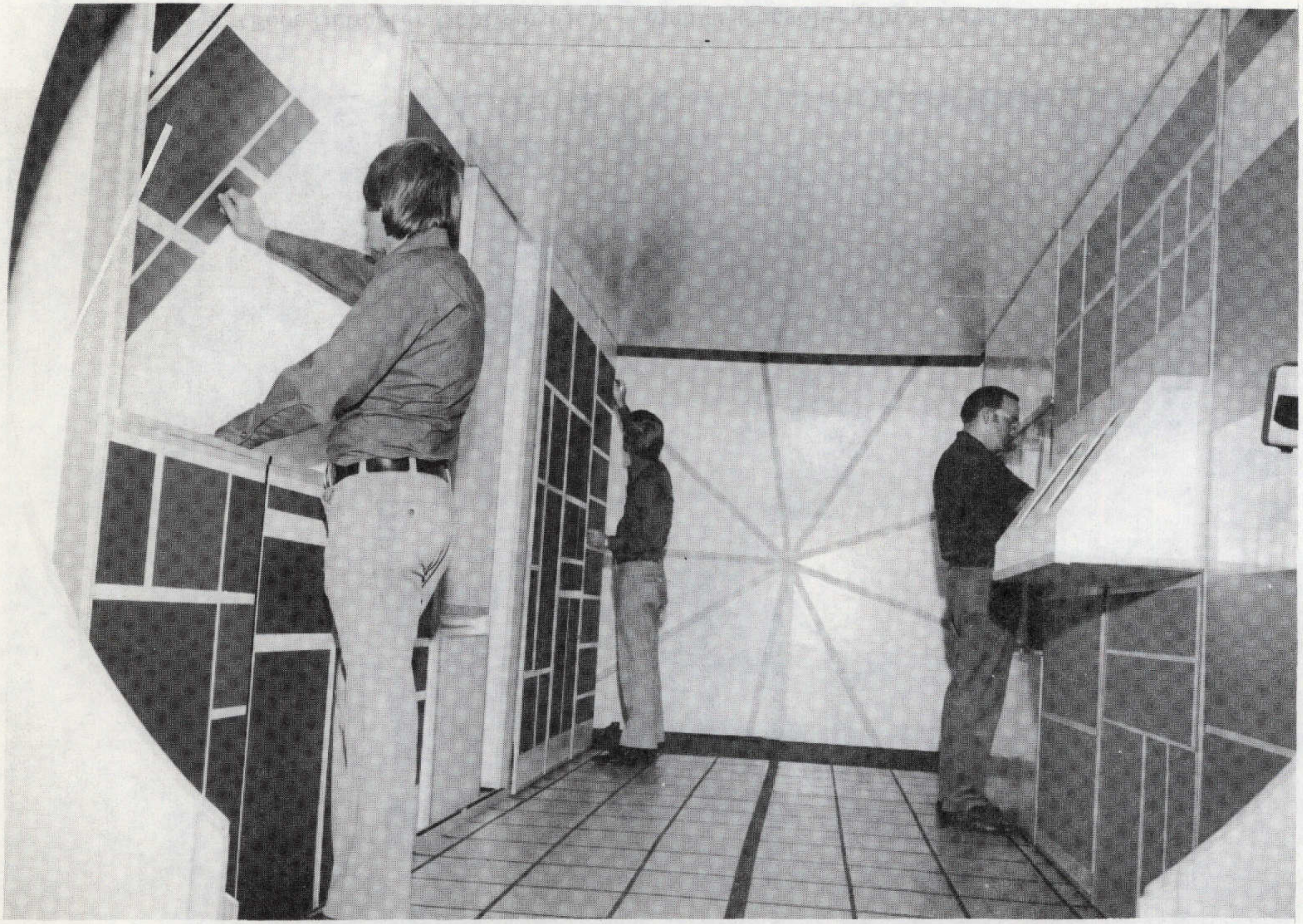
APPENDIX

MOCKUP CONFIGURATIONS



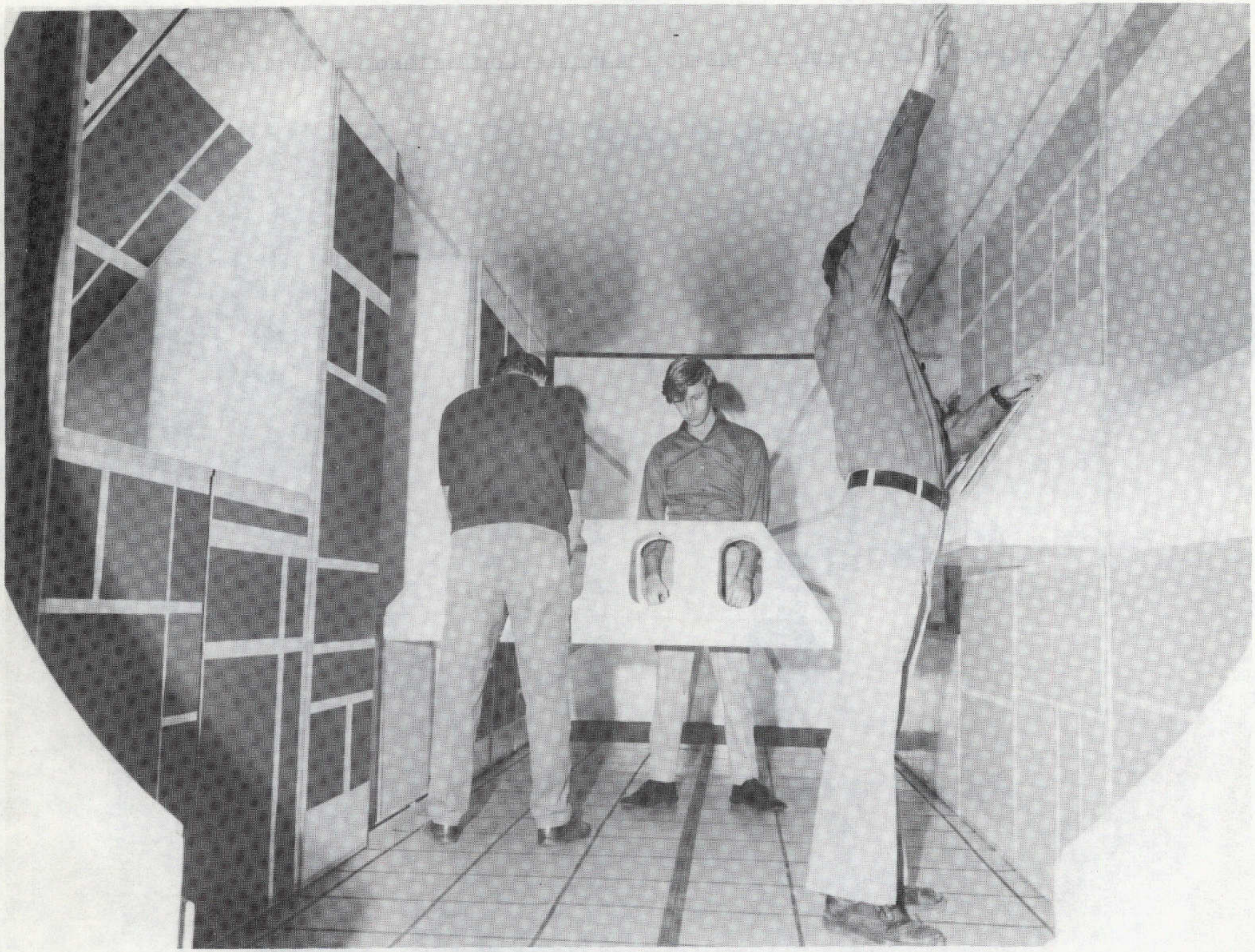
14-Foot Diameter Configuration — Men at Console, Glove Box, and Operating Table

12-Foot Diameter Configuration — Men at Console, Glove Box, and Operating Table

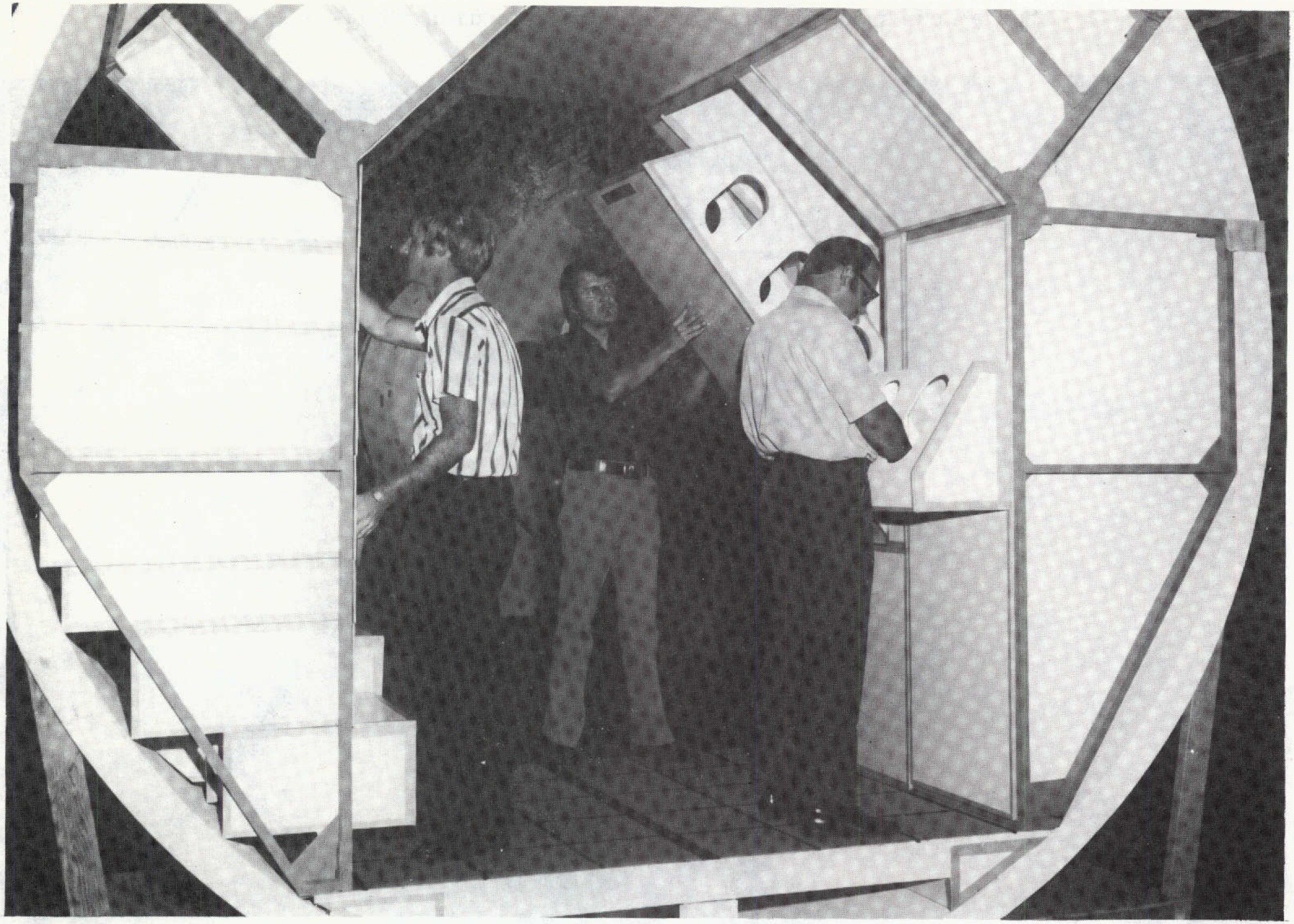


14-Foot Diameter Configuration — Men at Console, Primate Cage, and Equipment Rack

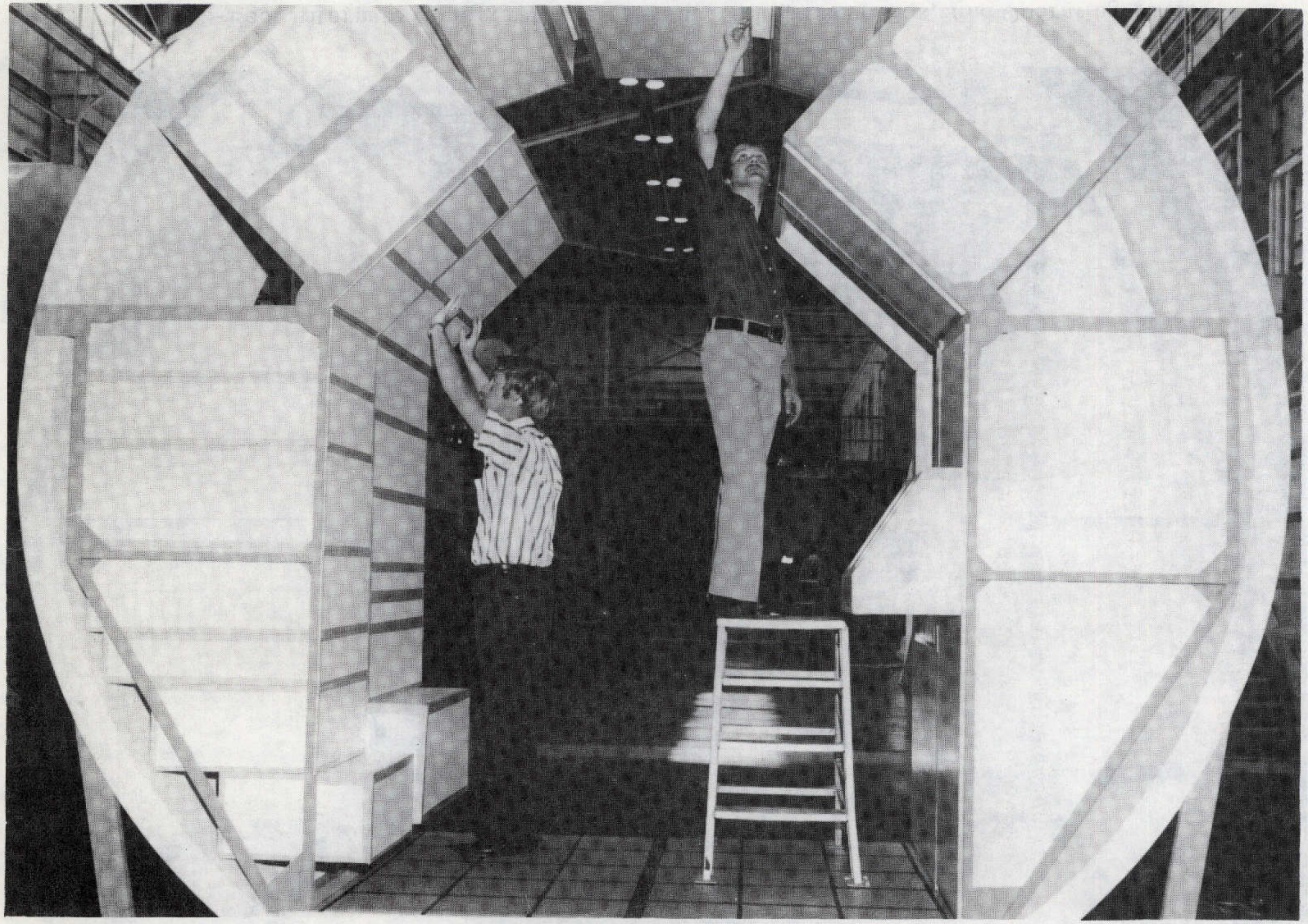
12-Foot Diameter Configuration — Men at Console, Primate Cage, and Equipment Rack



14-Foot Diameter Configuration — Two Men at Operating Table and One Man at Glove Box



12-Foot Alternate Configuration — Men at Racks, Glove Box, and Operating Table



12-Foot Alternate Configuration — Men at Racks and Ceiling

APPROVAL

SPACELAB SOFT MOCKUP COMPARATIVE EVALUATION

By Harry Watters

The information in this report has been reviewed for security classification. Review of any information concerning Department of Defense or Atomic Energy Commission programs has been made by the MSFC Security Classification Officer. This report, in its entirety, has been determined to be unclassified.

This document has also been reviewed and approved for technical accuracy.

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