Concept Applications Ltd.

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DESIGNER'S HANDBOOK

ENVIRONMENTAL PLANNING FOR GROUP STABILITY

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Contract No. NAS 9-10998

NASA MANNED SPACECRAFT CENTER
Crew Systems Division
Houston, Texas

August 1971

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Hempstead, New York

TECHNICAL REPORT STANDARD TITLE PAGE

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle Designer's Handbook: Environmental Planning for Group Stability		5. Report Date August 1971
		6. Performing Organization Code
7. Author(s) Henry E. Bender John Fracchia		8. Performing Organization Report No.
9. Performing Organization Name and Address Concept Applications, Ltd. P.O. Box 52 Hempstead, New York 11550		10. Work Unit No.
		11. Contract or Grant No. NAS 9-10998
12. Sponsoring Agency Name and Address National Aeronautics & Space Administration Washington, D.C. 20546		13. Type of Report and Period Covered NASA Contractor Report
		14. Sponsoring Agency Code

15. Supplementary Notes
Prepared for Manned Space Flight Center, Houston, Texas 77058

16. Abstract

Guidelines and recommendations for habitability design are formulated to facilitate individual and group stability. These findings are based on reviews of previous studies involving persons in various terrestrial environments. Considerations were given to the NASA group model and properties of such a group.

17. Key Words	18. Distribution Statement
Habitability Design Confinement Restricted environment	Unclassified - Unlimited

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	53 + 10 front matter	$3.00

ABSTRACT

This study defines the basic habitability system environmental requirements and design guidelines to be considered when designing for group stability in confined environments. Such environments are to be found in the proposed space stations and space bases of the mid to late 1970's and 1980's.

In performing this effort, consideration was given to the organizational model and group characteristics of the NASA teams manning such facilities. It was recognized that crews of the space station and space base will differ, the distinguishing factors being: primary areas of interest; crew composition; and crew size. For the space station the crew will consist of a relatively small number of "professional" astronauts whose primary interest is in testing the feasibility of such facilities, with completion of some experimental programs being a secondary goal. A mixed team of astronauts and scientists will inhabit the space base, and their primary concern will be the accomplishment of scientific investigations rather than establishing the habitability of the life support environment.

While such differences will exist, a generalized NASA team model was developed that allowed for these "divergent" groups to work together. The model was essentially "pyramidal" in nature for both the professional astronaut and astronaut-scientist groups. In defining the group model, consideration was given to the functional and demographic properties of such groups. It was believed that an understanding of specific group component characteristics would assist in determining design recommendations. Nine specific variable "group properties" were identified and explained.

Data from research programs utilizing isolated or confined environments were evaluated. These included the Sealab II exploration, Antarctic research projects, and laboratory studies conducted in controlled environments.

Certain nominal discrepancies were noted which were minimal when compared with the similarities underlying the study results. The importance of experienced leadership, compatible personality types and organizational structure were underscored in all such "stressful" operational environment situations.

A review of the literature was conducted in order to ascertain the effects of the environment upon social interaction. This consisted of a review of proximetics theory and various other observational studies. The theory and studies indicate that task relevancy and status in the group (leader, no-leader) interact significantly with environmental parameters to determine seating patterns, separation distances, etc.

All aspects of the study were considered for developing the finalized listing of environmental requirements and design guidelines. The specific problems that might arise from various group sizes, crew mixes, and personality incompatibilities are not defined. Rather, general principles that should reduce some of the stressful conditions found in isolation and restricted environments have been presented.

FOREWORD

NASA is currently investigating various aspects of establishing a space shelter that will have the capability of sustaining groups of individuals, ranging in size from six to one-hundred men, for periods of up to six months. Studies are investigating various aspects of such a shelter, such as food preparation, waste elimination, and other factors relating to "habitability" within this environment. Ultimately, it will become the responsibility of NASA and the designers for the contractors constructing the vehicle/shelter to integrate these studies in a meaningful manner so that an optimal environment is produced.

One aspect of space shelter research still requiring investigation is the degree to which social science findings relating to the man/environment interaction can be integrated with the design process. The present effort attempts to bridge this void by establishing habitability system environmental requirements and design guidelines which will serve to facilitate the group stability of the inhabitants. In order to accomplish this goal, the following tasks were undertaken:

- Identification of the psychosocial and interpersonal characteristics that may affect the individual crewman's behavior in a group under long-term confinement conditions appropriate to a space station mission.
- Definition of a model that is representative of the social process to be found in groups representative of the space station crew composition.
- Identification of important group properties that relate to the maintenance of group stability.

- Determination of the potential effects of a space station environment on the group properties in light of potential design parameters and alternatives available to NASA designers.
- Development of a set of environmental guidelines and requirements, properly weighted and in a format that would be usable by NASA designers.

ACKNOWLEDGEMENTS

The time that Dr. Benjamin Weybrew, Dr. Erik K. Gunderson, Harry Watters and Charles C. Kubokawa spent, either in discussion with the authors or in review of the preliminary document, is sincerely appreciated. Their experience and insight into the problems facing men in unusual environments is extensive and was of great assistance.

Mr. Armand Fiorenza participated in this study by conceptualizing and executing the creative design concepts and artwork. The authors are grateful for his efforts.

Dr. Robert Campbell proved to be an invaluable friend and associate who shared his information concerning man/environment interactions freely.

For the structure and guidance given to this report, the authors are indebted to Mr. Earl La Fevers and Dr. William Fedderson.

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CHAPTER I: INTRODUCTION

The majority of studies performed to evaluate habitability aspects of confined space have been typically concerned with single individuals rather than with the needs of groups of people. Thus, consideration of food preparation, waste elimination, internal free volume, and even the less commonly considered habitability factors such as illumination, decor and color have been approached from the individual rather than the integrated group level. This approach appears throughout the NASA literature, especially in the shelter-related studies such as STEM (1965), LESA (1964), MOLAB (1966), and Fraiser (1968).

An area that has not been systematically reviewed is the literature pertaining to architectural/design factors as they might affect members of groups. In other words, the present study attempted to consider the effects of various physical configurations upon the internal stability of the group. While most of the present efforts in this area relate to individual reactions, these reactions have been obtained from group situations and, as such, yield insights into group interactive processes.

The need for "group" considerations has been suggested by numerous authors and in NASA reports including: Preliminary Technical Data for Earth Orbiting Space Station (1966), (LaPatra et al., 1968), Radloff and Helmreich (1968), LUNEX II Report (1966), Tektite and the Benjamin Franklin drift report (1970). It is recognized that shelters serve several functions. The primary function is to protect and sustain the crew members by supplying the required environmental control/life support needs, including:

- shelter from hostile environments
- habitat atmospheric and thermal regulation
- operational and physical maintenance facilities.

However, as space mission time periods are extended for the astronauts in space and the number of personnel on each flight increases, greater emphasis will have to be placed on the social and psychological factors that affect these groups.

With more extended space voyages and with the establishment of habitability shelters in space, larger numbers of space travelers will be living together in groups of varying sizes. For these individuals to perform at an optimal level, mission planners will have to consider all aspects of the environment that these space "adventurers" will live and work in. An aspect of the environmental evaluation, notable by its absence in NASA documentation, is the area of group dynamics and the potential effects of shelter design on behavioral and performance characteristics of the shelter inhabitants.

The present study was conducted in order to provide NASA and NASA contract engineering groups with information concerning characteristics of groups and environmental parameters which might affect the stability of groups subjected to long time periods of extremely close contact. Inputs include a review of the literature concerning group dynamics, results from field studies, and laboratory findings.

The objectives of this investigation were:

- To identify and define a set of environmental guidelines and requirements, presented in a manual format that will be usable by NASA habitat designers.
- A preliminary system of weighed rankings for the guidelines and requirements so that NASA designers can apply and generalize the results of this study to a number of habitats.

To accomplish these objectives, Concept Applications, Ltd., scientists have viewed the group, the individual crew members, and the shelter environment as interacting components of a habitability system. The systems approach toward developing group - environmental requirements implemented by Concept Applications, Ltd., involved the identification of important group properties via a study of the variables influencing group dynamics, and an analysis of environmental features which have interacting effects on these properties. In reviewing the problem, it became apparent that not all requirements or guidelines have an equal impact on group stability. In the review of the literature and in discussions with persons working in the area, the various properties and related environmental characteristics important for group stability received a preliminary set of weighed rankings for each of the environmental requirements and design guidelines. In this manner, basic information was derived from which an evaluative system was then developed.

The worksteps accomplished in completing this study are presented below, and correspond to the various chapters in the report. They include:

- The development of a group dynamic model representative of the behavior and structure of future long-term NASA space missions.
- An identification of important group properties related to the model of anticipated interactions between NASA personnel inhabiting their shelter.
- The identification of psychosocial and interpersonal characteristics of individuals who have undertaken long-term confinement conditions similar to a space station mission.
- A definition of the effects of the shelter environment on the various group properties.
- The development of guidelines and requirements for designers.
- An assignment of preliminary weighed rankings for the guidelines and requirements.

CHAPTER II: NASA GROUP MODEL

The "pyramidal" model of group behavior best characterizes the initial NASA explorations using small groups and relating to missions of relatively short duration. The utility of this model in situations where potentially larger numbers of personnel, with more varied backgrounds, are assigned to habitability structures for long duration missions, must be examined also. An example of this model can be seen in Figure 1 below:

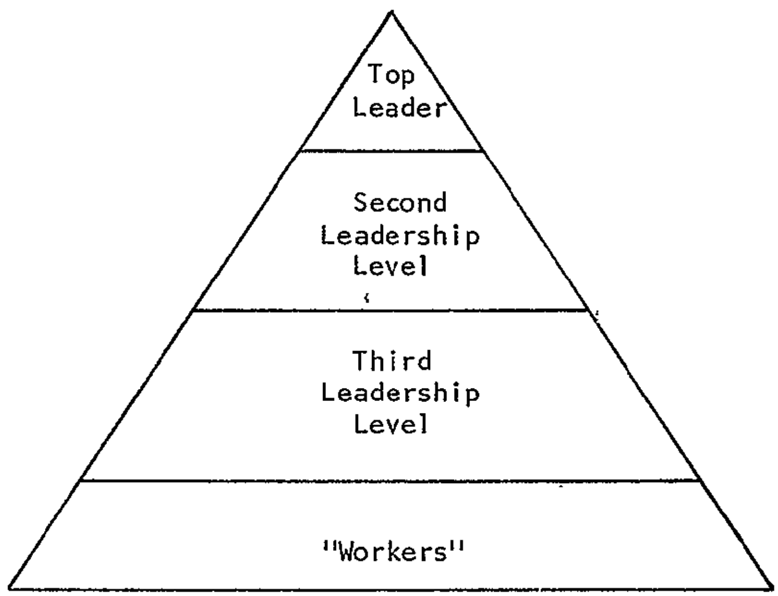

Figure 1. Pyramidal Model

The levels of leadership in this model consist of discrete tasks and reporting sequences. Similar "chains of command" are seen in the family trees or reporting sequences of many industrial complexes. It is anticipated that in the earlier space missions, requiring fewer personnel and of shorter durations, the pyramid representing reporting and leadership levels will be of a restricted nature. Each crew member will have specific and assigned tasks. Generally, it is anticipated that one crew member will be in the top leader position (commanding officer) and the other crew members will report directly to him.

With the advent of longer duration missions requiring greater numbers of personnel, the interactions between the various crew members will require a much broader base to allow for the required command structure. A generalized pyramidal model for the longer duration missions is presented in Figure 2.

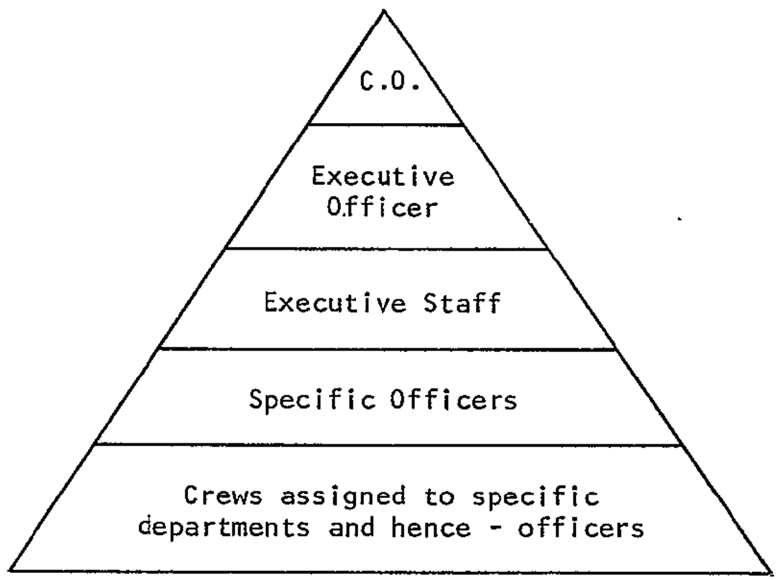

Figure 2. Generalized Pyramidal Model

As can be noted, there is great similarity between Figures 1 and 2. Leadership levels have been defined in terms of title designations that might be anticipated. The potential complexity of the reporting structure can be seen in Figure 3. Here, we represent some of the positions anticipated in a space base containing 60 persons.

While the models presented represent the command reporting structure anticipated in NASA groups, additional models are required to adequately describe the NASA group. A slightly broader behavioral and interactive model that incorporates the salient features of NASA teams and duty mission is called for. Such a model is found in the concept of the work group.

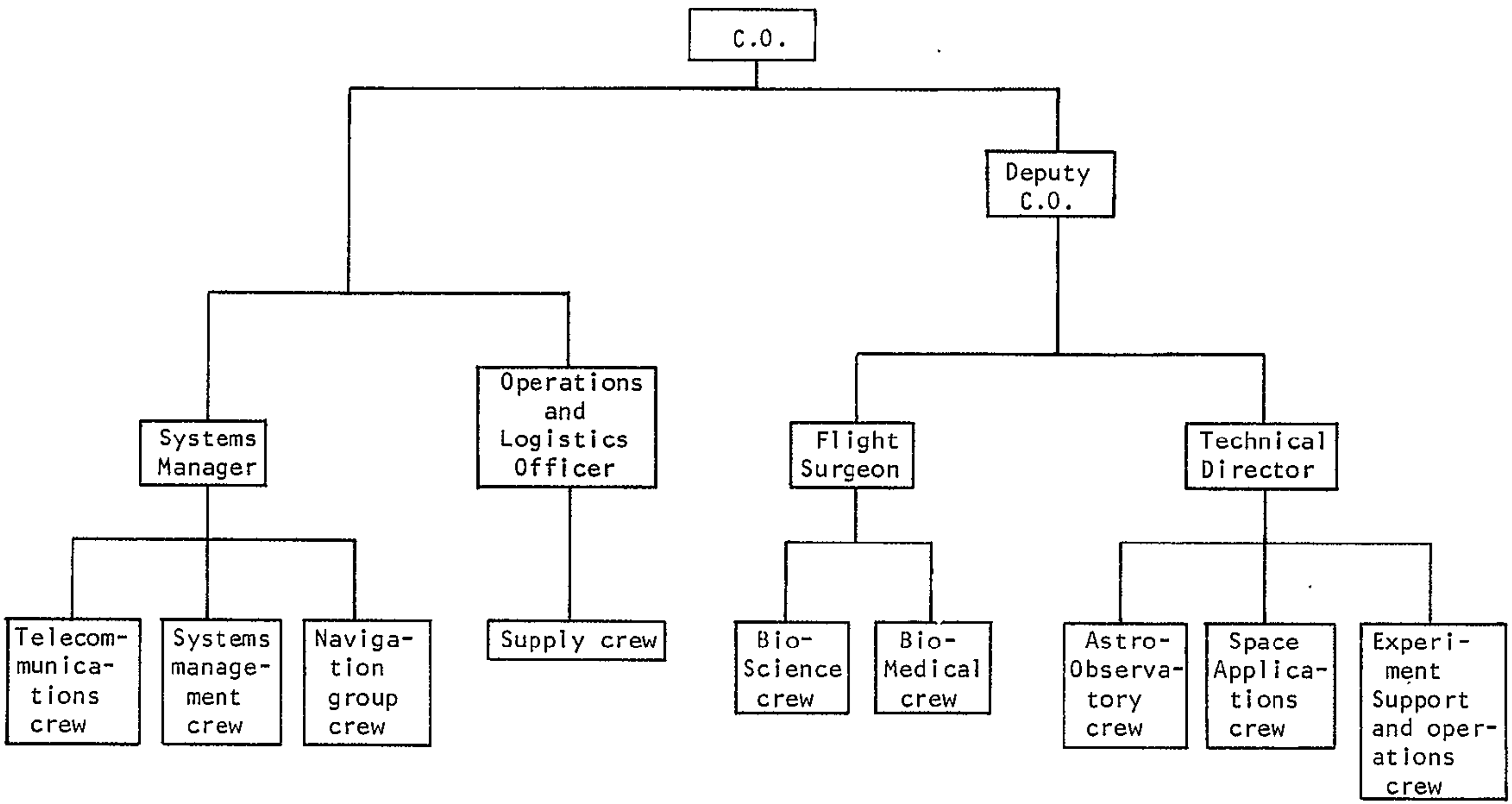

Figure 3. Generalized Space Base Organization

Cartwright and Zander (1968) describe the work group as one of non-spontaneous formation where the "basic condition for the deliberate creation of a group is the judgment by one or more people that a collection of individuals can accomplish some purpose (or do so at a level of efficiency) not otherwise possible." Work groups are formed "to perform some task more efficiently through the pooling and coordination of the behavior and resources of a collection of individuals ... . An example is the formation of an expedition to explore the Antarctic, to climb Mount Everest, or to land on the moon." To a large extent, the member's rank in the group and the importance of his specialized skills to the ultimate goal, i.e., successful completion of the mission, initially define and determine the roles, the expected behaviors, and the interactions for this paradigm. To the degree each member has a unique and valuable contribution to make, status differences may be negligible.

However, while the work group model may be the most suitable one for NASA team interactions in a task oriented milieu, long missions with large crews confined to spatially limited, if not stimulus limited environments will provide numerous opportunities for non-task or non-mission oriented interactions to occur. These interactions, revolving about off-duty activities, might best be depicted in terms of a social group model of spontaneous formation. Here the basic composition of the group is determined by processes of mutual consent with each member wanting to be in the group. Role functions and behaviors are less directly related to rank or status per se.

To summarize, two types of group paradigms are most likely needed to account for the kinds of work and social interactions that will occur among NASA personnel confined to habitability structures for extended periods of time. In order to ensure the success of the missions and the safety of the crew members, a deliberately formed work group conforming to a pyramidal-leadership model is essential. At the same time, interactions of a less formal, more spontaneous nature conforming to a social model of group behavior are expected to develop during off-duty hours.

Table I summarizes various group models applicable to the functioning of NASA teams in space.

TABLE I. GROUP MODEL SUMMARY

Model	Formation Condition	Structure	Primary Group Function	Types of Groups	Societal Examples
I	Deliberate (non-spontaneous)	Formal	Accomplish group goal or mission	work	explorations expeditions manufacturing concerns
				military	armed services police
				problem solving	research teams
				social action	commissions political parties lobbies
				mediating	courts UN committees
				legislative	senates boards of directors
				client	T groups Topic House

TABLE 1 (Continued)

Model	Formation Condition	Structure	Primary Group Function	Types of Groups	Societal Examples
II	Spontaneous	Informal	Meet psycho-social needs of members		friendship cliques informal groups within a formal organization social clubs gangs
III	External	Perceptual	None to perceived members	Cognitive and perceptual stereo-types	hippies teenagers "the poor" eggheads Negroes/Jews

As can be seen from Table I, it is likely that the NASA crew will conform to some aspect of all three types of groups. During mission operation time periods conformity to the work-group model will dominate. During off-duty periods, model two should prevail. The degree to which the third model develops is contingent upon the personality and background characteristics of the selected crew.

CHAPTER III: GROUP PROPERTIES

In the past several years there have been a number of experimental programs investigating the effects of confined, restricted and isolated environments upon individuals. These studies have typically been interested in environmental effects upon individual persons rather than groups of individuals. Perhaps the greatest potential effect of the stresses associated with, or generated by extended duration missions in confined environments is upon the stability of the group engaged in the mission. Group stability will affect the potential success of the mission since harmonious and stable interactions between crew members will enhance the probability of optimal performances by all crew members. While physical separation or withdrawal from the group is nearly impossible due to the spatial limitations imposed by the habitability structure, psychological withdrawal or "cocooning" can occur. This has been observed in both field studies in the Antarctic and in laboratory situations where "members" of the group were incompatible in terms of various personality variables.

A member is attracted to, or held by a group because the group has properties which are more significantly related to the positive reinforcement of that member's needs than some other available group. This would hold for any one of the previously mentioned types of groups described in the preceding section. Four interacting factors that influence the attractiveness of the group to an individual include:

- individual motives and needs for affiliation
- reinforcements offered by the group
- individual expectancies of beneficial or detrimental consequences of membership, and

- comparison level of possible outcomes resulting from membership in one group as opposed to another.

These four factors appear to be influenced by a larger number of variables forming the basis of group attractiveness and cohesiveness. Table II summarizes these variables as well as research findings related to each variable, and indicates the significance of these data for extended flights or prolonged exposure to limited environments.

TABLE II. FACTORS INTERACTING WITH GROUP PROPERTIES WHICH AFFECT GROUP COHESIVENESS

Variable	Hypotheses from Data	Significance
1. Member attractiveness	If persons interacting like one another, interactions increase the liking; if persons dislike one another, increased interactions increase antipathies.	Environment must allow for "privacy" or opportunity for non-interaction with other crew members at times.
2. Member similarity	While attraction to a group can increase with increasing similarity (homogeneity) among members, dissimilarity sometimes enhances attractiveness.	Provisions must be made for interactions between members of the crew with different assignments or backgrounds.
3. Group goals	Distinctive group goals or purposes attract people with similar motives, fostering interpersonal bonds and group identification.	Feedback should be fostered so that group goals and achievements can act as a group reinforcement.
4. Group activities	Where group standards in various activities exceed a member's ability to meet them, dissatisfaction increases and group attractiveness decreases.	A variety of recreational activities should be provided. They should fulfill the needs of the crew.

TABLE II (Continued)

Variable	Hypotheses from Data	Significance
5. Leadership and decision making	Participatory leadership rather than supervisory leadership produces greater satisfaction and feelings of group efficiency.	While seating arrangements can reinforce the sense of leadership (i.e., head of the table) a circular grouping fosters or can encourage greater participation.
6. Communication	Average level of satisfaction in a group is positively related to decentralized communication networks.	Circular seating arrangements provide maximum opportunity to communicate with others.
7. Hierarchal structure	Satisfaction increases as a function of job status. Group members serving in high stress positions or having a chance of moving from low to high status show greater attraction to other members of the group.	Rectangular seating arrangements allow for a greater display of status levels.
8. Group size	Size affects attractiveness by its effect on other properties. If they become less satisfying, as size increases, satisfaction decreases.	The environment should be flexible enough to allow for alterations in apparent group size.
9. Affective climate, atmosphere, milieu	While a "friendly" and accepting atmosphere tends to increase attractiveness, outlets for antagonisms are necessary.	Recreational facilities should provide amusement and therapeutic/emotional outlets.

A possible threat to the cohesiveness of any group as a whole is the formation of "cliques" or sub groups within the larger organizational unit. As crew size in a mission increases, it appears that greater opportunities for sub group formations will be afforded. While this may be unavoidable, the environment should be structured so as to allow for maximum communication between members of various sub groups to offset, to some extent, the increased communication between members within sub groups.

CHAPTER IV: POTENTIAL EFFECTS OF ISOLATED OR CONFINED ENVIRONMENTS UPON INDIVIDUAL AND GROUP PERFORMANCE

There have been a number of situations that have allowed scientists to study the effects of isolated or confined environments upon individual and group performance. This section will review the findings of three such situations; Sealab II, Antarctic research projects, and laboratory studies, respectively. These studies differ in terms of levels of stress, crew stay time, and "naturalness" of the situation. They do, however, yield insights into behavior in "unusual" environments.

Sealab

In the Sealab II mission, crew members were faced with the physical dangers inherent in existing at a depth of over 200 feet beneath the sea and with the discomfort related to the necessity of living and working inside a 12-foot by 57-foot capsule which was uncomfortable, crowded, and stressful. This shelter provided scant privacy and space for personal effects. In addition, it had a six degree tilt in two directions, a communication disrupting helium atmosphere (prohibiting smoking), and high heat and humidity conditions which fostered infections. These, then, were the environmental conditions which were the major sources of discomfort to Sealab's crews.

The results of investigations of three crews that inhabited this shelter for extended periods of time indicated that:

- There were significant increases in the cohesiveness of the teams, with little or no evidence of overt friction.
- The hypothesis that "under conditions of common fate, individuals will develop interpersonal attraction," (Collins and Guetzkow, 1964) reflected by an increase in group cohesiveness, was strongly supported by sociometric data.

- Observed group differences were considered slight, and in no cases were instances of overt bickering observed in any group.
- Task orientation, emotional stability, and social compatibility proved to be highly intercorrelated criteria of adjustment.
- Paper and pencil tests failed to find significant relationships between personality factors and success in stressful situations.
- Territorial behavior was not observed in Sealab II.

This last finding is somewhat surprising in that numerous reports dealing with behavior in isolation and confinement emphasize the emergence of this trait. A number of reasons are offered to account for the lack of evidence of territoriality; the major ones being the extreme conditions of crowding so no spot could be consistently occupied, and the crudeness of the measurement instrument. The aberrant forms of social behavior associated with high population density (Calhoun, 1963) were also not found to occur in the Sealab II habitat. This might be a result of the recognition that, due to the "eyeballing and elbowing" nature of the habitat, cooperation and compatibility were imperative.

The important consideration is that group harmony may not have been achieved without effort, but that the necessary effort was expended. Censorship and restraint in expressing irritations and hostilities occurred in the interest of overall good relations. These excellent group relations, even if somewhat "pseudo-cordial" served to enhance and maintain performance so that a high level of accomplishment of mission goals was achieved.

Antarctic Studies

The principal characteristics of groups of men wintering over a scientific stations in Antarctica were:

- persistent difficulties in keeping essential station equipment operating

- repeated open conflicts between group members
- low motivation or morale reported at the end of the year by observers at the scene.

Gunderson and Nelson (1965) found that exposure to long-term isolation from the outside world produced a measurable deterioration in social relationships and work effectiveness during the latter part of the confinement period. Interestingly enough, individual adjustment and satisfaction did not consistently show a similar decline. This could mean that individual adjustment and satisfaction measures were not sensitive to change or that group processes are affected (in this situation) by variables not affecting individual members of the group.

In a review of other similar field conditions research it was concluded that all in all, while maintaining group organization, harmony, and efficiency during periods of long term isolation and confinement may be a difficult task, it is not an impossible one; and that the identification and measurement of those variables related to social processes and group interactions occurring at exceptional environments is an obtainable goal.

Laboratory Studies

In a series of laboratory experiments, Altman and Haythorn, et al., found that social isolation is stress-inducing and that the stress is a function of interpersonal needs. Dominance and achievement appear to be more stressfully influenced by isolation conditions than do affiliation or dogmatism needs with the effect related to high levels rather than homogeneity for achievement. These authors interpret their findings as indicating the "importance of group composition to functioning in isolated environments and, perhaps, to other stressful situations."

Additional research by Altman and Haythorn indicated that individuals in isolated dyads revealed more about intimate topics to partners than did controls, but less than would be revealed to a best friend. In control dyads, the level of disclosure was about comparable to that of average persons. Isolates were found to reach a depth of disclosure similar to that achieved with close friends, although the magnitude was small. The overall disclosure profile of isolated partners is described as " ... somewhat intermediate between that associated with average persons in a general reference group and close friends, whereas the disclosure profile of control partners reflected an even more casual relationship than that achieved with average persons in a reference group." (1965)

In the final project performed by this research team only one of 35 groups terminated the study early. This was in sharp contrast with early studies in which up to 54 per cent of the subjects aborted, with shorter (7- to 10-day) mission durations. This finding was attributed to the more mature experienced subjects, traditional military structure with a clearly defined leader, better diet, and a monetary incentive for participation.

After an intensive analysis, the authors feel that the data provided clear support for the seven conclusions which follow:

- The use of mature subjects in a structured setting produced less stress.
- Subjective stress and anxiety were significantly elevated, and feelings of happiness were depressed during confinement.
- Compatible groups manifested less hostility towards partners, but were more annoyed with physical features of the rooms.
- In difficult situations, i.e., incompatible three-man groups, senior leadership was generally more effective than junior leadership.

- A significant reduction in the frequency of alpha rhythms of ten subjects who underwent EEG recordings occurred. This was consistent with earlier sensory and perceptual deprivation studies and with Russian simulation studies of space cabins.
- Performance of a task involving rapid reasoning was impaired by the group incompatibility condition, while performance in a vigilance task was maintained at a high level of effectiveness.
- Crowding did not appear to be a powerful variable in and of itself, but did interact in a significant manner with group size and seniority of leadership.

Perhaps the most important findings of these studies for extended duration missions is that the traditional pyramidal model with experienced leadership operated relatively efficiently in the worst experimental conditions possible in this study. The finding that hostility was internalized or directed at physical features of the room suggests that the inconveniences inherent in space habitats may serve to reduce aggression within the group by focusing anger upon an obvious source of irritation.

CHAPTER V: MAN-ENVIRONMENTAL INTERACTION

The relationship between man and his environment have come under increasing scrutiny in recent years. This is true, not only for the external environment, but also for the environment found within various architectural structures. The reason for this interest is suggested by Fitch's (1970) statement:

> "The boundaries of all architectural volume are delimited by surfaces (floors, walls, ceilings) which constitute the second interface between man and the macrocosmic world of nature.. These surfaces play a decisive role in the way we respond to and behave in the spaces they enclose ... "

While the percentage of variance of human behavior accounted for by this variable (architecture) has never been quantified, it is of significance in that it can facilitate or hinder the social development of a group.

The area of proxemics (Fitch, 1970) has a limited history, ("proxemics: the study of behavioral consequences of spatial relationships for interpersonal relationships of all scales and types."), in that it has been considered and studied by the social scientists for a little longer than the past decade. As such, it has a small but growing literature pertaining to man's utilization of space and the effect that spatial arrangements have on individuals and groups.

Hall (1966) has noted that different cultures conceive of space in various ways. What is conducive to social interaction in one culture will hinder it in another. In a similar manner, what is conceived of as a "normal" distance for conversation in one culture will be considered excessively close by a second culture, and excessively distant by still a third culture. In the definition of social distance, Hall distinguished four major distance zones.

These are the intimate, the personal, the social-consultive, and the public. Each of these zones is divided into a close and far category.

When considering social interaction in terms of the distance zones, the interplay of the auditory, visual, thermal, kinesthetic and olfactory receptors are considered crucial. These modalities interact with cultural anticipation to prescribe specific separation distances between individuals in specific situations. A modification of Hall's chart indicating the interactive effects of sensory receptors and proxemic perception is seen in Table III.

While Hall's anthropological background is apparent, social and clinical psychologists have also examined man's interactions. Much work has been done in the study of communication nets and problem solving. Four typical nets can be seen in Figure 4. The efficiency of such communication networks progresses in order from A (the circle) through D (the wheel), with the wheel being the most efficient. It is believed that, if satisfaction measures were derived from such studies, the flexibility of the wheel arrangement would lead to the choice of this as being most desirable from the subject's self-satisfaction viewpoint.

While the communication studies do not attempt to analyze the spatial factor in such groups, the circular or wheel arrangement was shown to be an important configuration in the speech patterns of discussion groups. Steinzor (1950) noted that seating patterns in a discussion group could be a determinant in patterning conversation between group members. He discovered that "in a small group seated in a circle, the greater the seating distance between two people, the greater the chance that they will follow one another verbally."

TABLE III. INTERACTIVE EFFECTS OF SENSORY RECEPTORS AND PROXEMIC PERCEPTION

Receptor	Separation Distance			
	Intimate	Personal	Social-Consultive	Public
Kinesthesia	Allows for the deliberate or accidental touching of others	Allows for contact within these ranges: two people barely have elbow room, out of interference distance	Allows for contact if both parties participate	No physical contact
Thermal	Limited awareness	None	None	None
Olfactory	At very close distances, some body odor may be considered desirable. In American culture, if this is not a masking aroma, it is usually undesirable	If not a "masking" odor, this is usually considered objectionable	Usually none	Usually none
Visual	Vision is distorted. Use scanning and head movement to see the person	Some enlargement of features. Use of scanning and head movement to see the person	Person appears "normal"	Person begins to appear "small"
Auditory	Whisper or soft voice	Soft voice to conventional or modified voice	Casual or consultive style to a loud voice	Loud voice

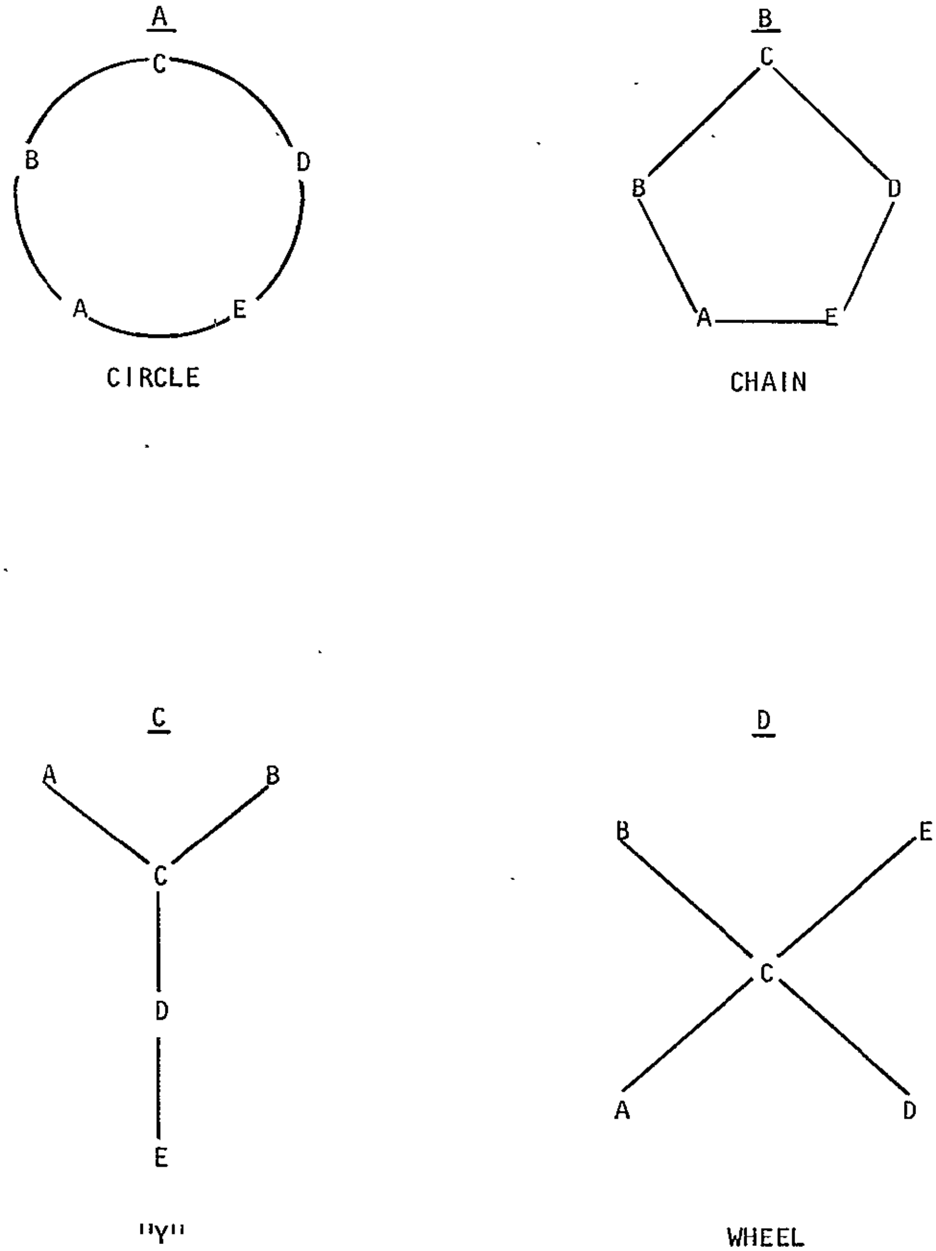

Figure 4. Typical Communication Networks

In a somewhat similar study, Charles Winick and Herbert Holt (1961) noticed that an analysis of the seating position taken in a therapeutic group session yielded insights into the effects of the analytic session(s). The variability of such seating choices and arrangements expressed the subjects' needs for privacy, territorial behavior, feelings of cohesiveness and unity with the group, and many other behaviors noted by researchers in proxemics and of persons in confined and isolated environments.

Some of the most extensive research has been conducted by Robert Sommer. This has occurred under "field" observational and relatively controlled conditions. In a number of related studies, Sommer (1959, 1961) found that "neighbors" tend to interact more than more "distant" persons. When the "subjects" were seated at a table such as the one seen in Figure 5, the interactions between persons seated next to each other, in a corner to corner relationship (E-D, E-F, or A-B, A-H) were greater than could be anticipated by chance. With three subject groupings, the subjects once again selected corner seating arrangements (A-B, A-H, E-D, E-F, or E-D-F, A-B-H) more than any other seating pattern.

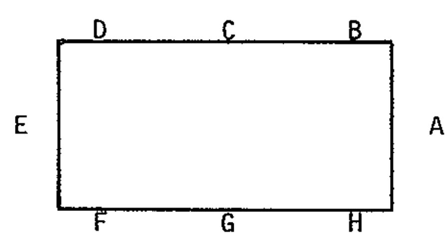

Figure 5. Table and Seating Arrangements Available

When group size increased and a leader was included in the group, people still tended to sit near each other and close to the leader. The results of this research can be seen in Figure 6.

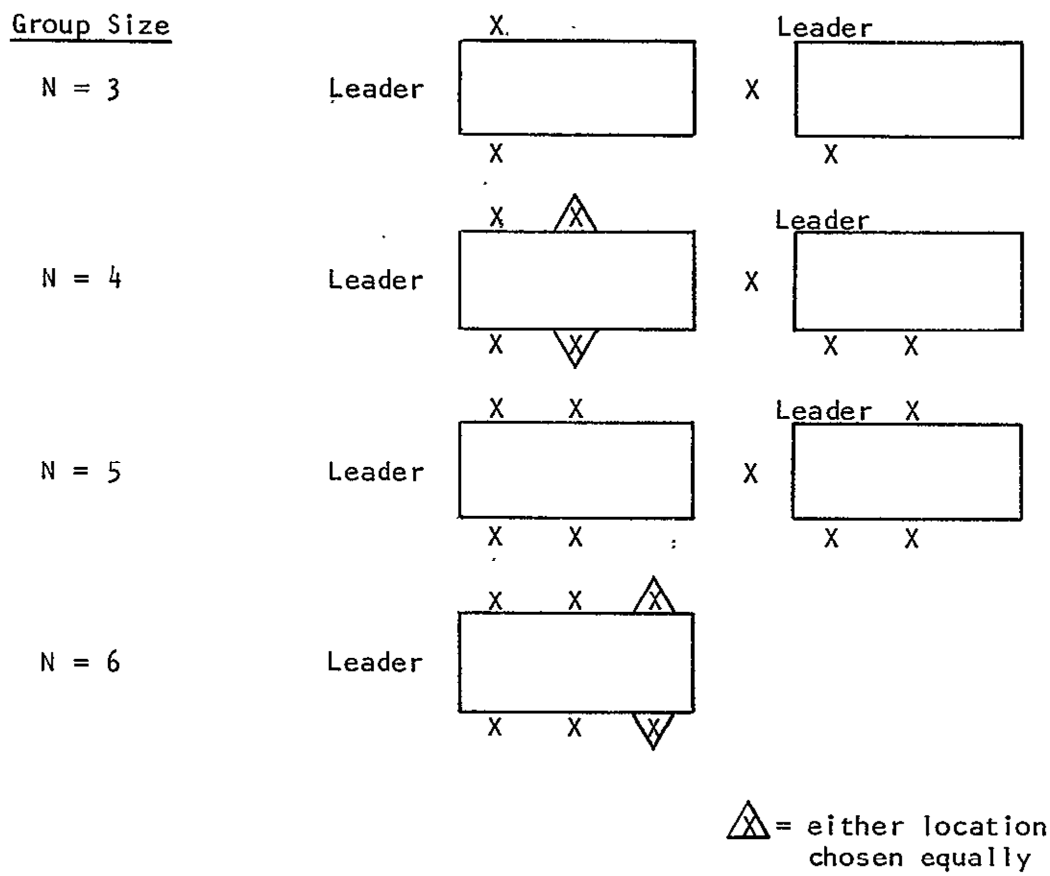

Figure 6. Most Common Seating Patterns of the Various Size Groups

Sommer (1961) also measured interpersonal seating distance between pairs of subjects. He found that once the separation between couches on which the subjects could be seated reached three and a half feet the subjects, overwhelmingly, chose to be seated on the same couch. When the separation distance was less than three and a half feet the subjects selected individual couch seating patterns. Sommer concluded that:

> "Our subjects began sitting side by side when there were five and a half feet between persons. Under the particular conditions we used, this can be assumed to be the upper limit for comfortable conversation."

This finding is supported in the composite data shown in Table IV.

TABLE IV. SEATING PATTERNS BETWEEN PAIRS OF SUBJECTS AS A FUNCTION OF THE DISTANCE BETWEEN SUBJECTS

Distance Between Couches	Number of Pairs of Subjects Sitting: Opposite	Side by Side
1 to 3 feet	31	12
3-1/2 to 6 feet	4	32

In later studies performed on a college campus, Sommer (1965) once again examined seating patterns under various conditions. The tables used in these studies were either square or rectangular. These arrangements can be seen in Figure 7. The results of the seating patterns of the students, contingent upon the nature of the activities to be performed, can be seen in Table V.

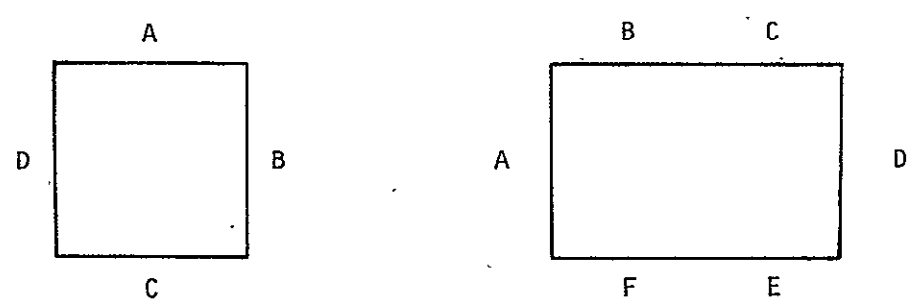

Figure 7. Seating Arrangements

TABLE V. SEATING PATTERNS AS A FUNCTION OF TABLE SIZE AND STUDENT BEHAVIOR

Seating Arrangement	36" x 36" Interacting	36" x 36" Co-acting	36" x 54" Interacting	36" x 54" Co-acting
Corner to corner	66%	10%	54%	0%
Across from each other	34%	90%	36%	32%
Side by side			6%	0%
Distant			4%	68%

The results were similar to those of earlier studies (1961). Interacting individuals prefer corner to corner seating most, followed by across-table seating patterns. Co-acting individuals preferred arrangements that allowed for geographical as well as visual separation.

Students were further requested to complete a questionnaire concerning their seating preference under conditions of conversing, cooperating, co-acting and competition. They could select seating arrangements from the rectangular and circular patterns seen in Figure 8. The results of this survey can be seen in Table VI.

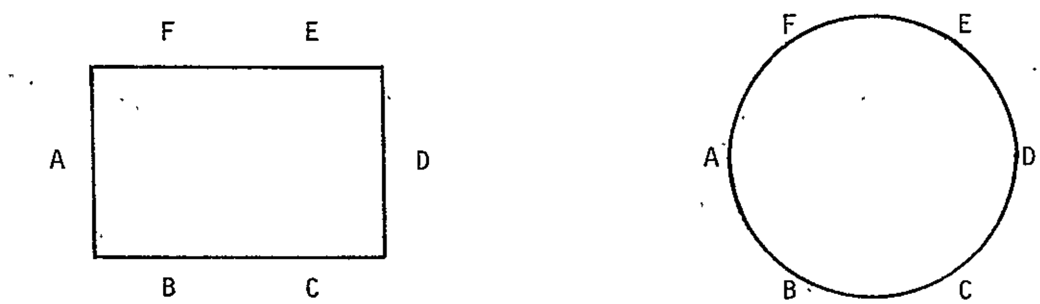

Figure 8. Potential Seating Choices from which the College Subjects could Choose

TABLE VI. PER CENT OF SUBJECTS CHOOSING SPECIFIC ARRANGEMENTS

Seating Arrangement	Conversing		Cooperating		Co-acting		Competing	
	▭	○	▭	○	▭	○	▭	○
A-B	42	63	19	83	3	13	7	12
B-F	46		25		3		41	
B-E	1		5		43		20	
B-D	0	17	0	7	3	36	5	25
B-C	11		51		7		8	
A-D	0	20	0	10	13	51	18	63

The research findings presented in this chapter and the works of Patterson (1968), Willis (1966), Shiff (1968) and Brookes (1970) confirm the belief that the environment helps to structure personal-social interactions. Apparently, the visual and auditory perceptions have primary functions in this process. However, the other sensory modalities are also deterministic in this process but usually to a lesser degree. Additionally, task performance and the nature of and physical patterning of artifacts present in the environment are also critically important interacting variables.

CHAPTER VI. GUIDELINES AND RECOMMENDATIONS

The major intent of this report was to review the literature that would indicate important variables affecting group stability. In particular, its objectives were to derive guidelines and recommendations that could be used by NASA designers when considering habitats that will confine crew members for long periods of time in isolation and/or confinement. This section presents the guidelines and recommendations derived during the course of this study. They represent generalizations that concern the environment of "confining," isolated habitability enclosures, such as those anticipated in the next generation of space endeavors. It is believed that these guidelines and recommendations will be valid for terrestrial habitats where the users will encounter isolation and confinement because of unusually hostile environmental conditions.

One of the initial premises was that the guidelines and, in particular, the recommendations derived from this study, would be weighted in accordance with the impact that they might have on the crew's stability. A review of the literature does not warrant such a weighting factor at this time. An analysis of the literature does not allow the investigators to assign a percentage to the amount of variance accounted for by any one specific guideline or recommendation. For this reason, all guidelines and recommendations have an equivalent weight in this report. It is believed that additional research into this area would be of great assistance to designers, but this is a problem for future study and investigation. Where items of specific importance have been isolated they have been noted. In this regard, it is recognized that there are many interactive aspects of the guidelines and recommendations presented herein. These relationships will be noted and integrated to the greatest extent possible.

The following is the listing of the guidelines derived. They are presented in capital letters with any explanatory information in normal type face:

SPACE HABITATS SHOULD IMPLEMENT INDIVIDUAL AND GROUP ACTIVITIES

Previous NASA studies have placed a major emphasis on the individual. It is realistic to investigate the mobility patterns of individuals under a weightless condition, and then to generalize to a larger population. In the same light, it is meaningful to calculate the amount of food ingested by the "average" astronaut, and assume that "x" numbers of astronauts living for an extended period of time should consume some multiplicative function of the initial amount of food. This type of experimentation and calculation is valid for many aspects of future long duration space flights. As noted earlier, however, such flights will necessitate larger crew sizes, living together for longer periods of time. For this reason it is believed that NASA should investigate the needs of both individuals and groups under comparable conditions. The interactive forces present in groups of individuals, living and working together for long periods of time, might differ from such groups under shorter periods or under differing "hostile" environments. The various requirements for group stability should be studied further, and any additional information pertinent to habitat design and group stability should be incorporated into the future habitat structures.

SPACE HABITATS SHOULD REPLICATE AS CLOSELY AS POSSIBLE THE ENVIRONMENTS FOUND IN THE ASTRONAUTS "NORMAL" ENVIRONMENTS

In the earlier space flights in particular, crew members will be living in a particularly hostile, stressful environment. Any failure of the EC/LS or other critical systems could result in the death of the crew members. In latter space ventures, there is the reality that "tested" systems can fail, with similar results. This is particularly evidenced in the Apollo 13 flight where the "normal" mode of flight had to be aborted and the Grumman LEM used as a backup "life raft" system. This knowledge can be extremely stressful to crew members.

In addition, confinement with no possible means of vacating the environment, even for a short period of time, will add an additional measure of stress. For this reason, the internal environment of the habitat should not induce any further stress upon individual crew members or on the crew as a group.

One method of reducing any potentially additional stress is by configuring the environment in a manner that is familiar to the crew members. In a zero "g" environment, man has certain capabilities that should be utilized when designing the habitat. It is believed that in the initial phases of the flight, such an environment might prove to be a greater source of amusement and entertainment than it can be a detriment. As the flight continues, and the stresses of confinement and isolation begin to summate, relief might be gained (to some degree) by providing the astronauts with "familiar" surroundings. These "familiar," "homey" features might help reduce the subjective and group stresses perceived.

SPACE HABITATS SHOULD SUPPORT INDIVIDUAL AND GROUP EXPERIENCES AND ACTIVITIES

The environment within the habitat should enable the individual or the group to perform activities that are desirable for the maintenance of individual stability. Additionally, group activities that will foster cohesion within the group should be provided. The design of the habitat and the supplies therein should assist the individual growth of the astronaut, if this is desired. It should also be capable of "giving" such assistance to the group if this is deemed desirable or necessary.

SPACE HABITATS SHOULD BE ADAPTABLE, ALLOWING FOR AS MUCH VARIABILITY AS POSSIBLE

It is recognized that the space within future habitats will be restricted in terms of the size of various compartments. Since the area configurations in terms of walls and furnishings might be best suited for one particular activity and not for another one that might be performed in the same general area, the crew members should have the ability to reconfigure the environment as they consider it necessary or desirable. This reconfiguration might take place as a function of the change of activities within the area, or the development of particular group processes over a period of time. By allowing this capability, the following can occur:

- Sleeping areas can be varied to allow for greater or lesser numbers of individuals to share a given compartment. This is performed by altering the total area allocated for this function as well as by altering the internal configuration of the furnishings.
- An area can serve multiple purposes. Reconfigurations of the area can allow change from one function to another, depending on the needs of the crew members.

SPACE HABITATS SHOULD NOT HAVE STERILE LEVELS OF SENSORY STIMULATION

The results of sensory deprivation studies indicate that this condition can be debilitating to individuals. While a space habitat will not have sensory deprivation qualities, in the experimental meaning of the term, it might have a minimal amount of sensory variability. Little is known about the effects that this condition might have on crew members performance or psychological stability. From a review of the literature, however, it would appear that limited sensory stimulation levels is an undesirable characteristic for habitats. For this reason, it is considered desirable for the astronauts to be able to vary the level of sensory inputs available to them.

In the visual realm, the ability of the crew members to vary lighting intensity, area configuration and furnishings are methods of varying visual stimulation. This should be available to the crew members to a limited degree, since the lighting intensity desirable for sleeping, resting (socializing), and working conditions differs. Some variability to accommodate performance under these differing conditions must be made available to the crew members. In addition, the light intensity, "room" coloring and shading can be altered to combat visual/perceptual boredom.

Auditory stimulation levels can be varied in several ways. A crew member can leave one area to go to a more quiet or noisy environment. The movement away from, or toward a sound source (within the same area) can also alter the sensory input level for this modality. This can be accomplished by "the closing of a door," or the movement of a chair to a new seating location within the confines of a room.

SPACE HABITATS SHOULD ALLOW FOR PRIVACY AND/OR SOCIAL INTERACTIONS WHEN EITHER OF THESE ARE DESIRED

While the habitat should allow for and enable social interactions, it is recognized that there will be times when the individual crew member(s) will desire privacy. The habitat should be designed to facilitate either of these behavior patterns. If the furnishings of an area are "portable" or movable, and if the area is of sufficient size, then an individual can isolate himself from other members of the group who might be in the area. This can be done while not leaving the group totally. In other instances, the individual might desire total privacy. In this case, he might be able to isolate himself by partitions, or by "cocooning" if he has a "private" sleeping area.

SPACE HABITATS SHOULD ALLOW FOR BOTH CASUAL AND MORE FORMALIZED SOCIAL CONTACTS

It is anticipated that normally, most individuals would use the "social" area of a habitat for casual interactions. This area would be desirable for use in more formalized activities initiated by the habitat commander or by specialized groups within the crew. By having movable furnishings (chairs, tables, etc.,) this area could be reconfigured to allow for both types of interactions. If a crew member was displaced by such a meeting, it would be desirable that another area of the habitat served his needs.

SPACE HABITATS SHOULD ALLOW FOR INDIVIDUAL AND GROUP NEED FULFILLING ACTIVITIES

By having a flexible environment the crew members would be able to adapt the environment for individual recreational activities such as reading, etc., or for group activities such as card playing, darts, movies, etc. The need for the flexible environment extends to the furnishings in the "social" area, so that smaller tables can be joined in order to enable larger group activities, or separated to enable individual activities. The sleeping areas should also enable individual activities.

SPACE HABITATS SHOULD ALLOW FOR COMMUNICATIONS ON BOTH FORMAL AND INFORMAL LEVELS

This guideline is somewhat similar to that recommending flexibility to allow for casual and more formalized social contacts. Within formalized communication patterns, the ability to alter the environment would enable various levels of "rigidity" within the communication structure. Depending on the nature of the structure desired, the group might be able to form into such patterns as the classical "wheel" or "circle" arrangements studied in many laboratories.

The guidelines presented on the previous pages suggest several general requirements for designing habitats for astronauts undertaking long duration missions. Each requirement will be presented on a separate page. Where possible, graphic presentations indicate the potential design features that will allow for implementation of the specific requirement.

THE ABILITY TO RECONFIGURE PHYSICAL AREAS

The ability to reconfigure areas appears to be a primary requirement. This reconfiguration requirement applies to both personal and social areas. An example of the effects of reconfiguring of both personal and social areas can be seen in the accompanying figures. While these figures do not represent current NASA concepts, they are presented since they represent the concept of the ability to reconfigure an area and demonstrate the impact this has on the habitat. These presentations represent spatial reconfiguration ability and are not representative of currently conceived spatial allocations.

The ability to reconfigure sleeping areas would allow for isolation if this was considered a desirable feature of "dormitory" areas. It would also allow for the grouping of two, three, or four crew members into an expanded, larger "sleeping" area. Such multiple dwelling arrangements might be required during periods of transition from one crew grouping to the next. Such a sleep area can be seen in Figure 9.

This requirement would be useful in the social area as well. Reconfiguring areas (spatially) allows for more optimum multiple use of space by allowing for segmentation of the area to meet the needs of various individuals/groups at specific time periods.

Figure 9. Single and Multiple Sleep Areas

THE ENVIRONMENT SHOULD BE FLEXIBLE

This concept implies more than just changeable spatial configurations (changing of the sizes of areas). It suggests that the internal furnishings should also be variable. As was noted in the presentation of the guidelines a flexible capability with regard to the furnishing of an area allows for:

- separation of a crew member from the group (if he so desires) without isolation from them,
- facilitation of multiple uses of an area,
- alteration of "private" quarters in order to facilitate changing needs of crew members.

In the crew members' sleeping area, the reconfiguration of the internal furnishings will allow for the individuality and territoriality noted in other habitats. This is accomplished by allowing the crew member to introduce "personalized" artifacts into the environment and to arrange these in a manner satisfactory to the individual. (See Figure 10.)

The social area requires an internal environment that is flexible. The concept of multiple use of specific areas requires that these areas be reconfigured for differing uses. The arrangement of seating patterns will differ if the crew members are engaged in movie viewing, discussing operations of the habitat, or small group recreation. If the same area is to be used for exercising, the area would once again require reconfiguration.

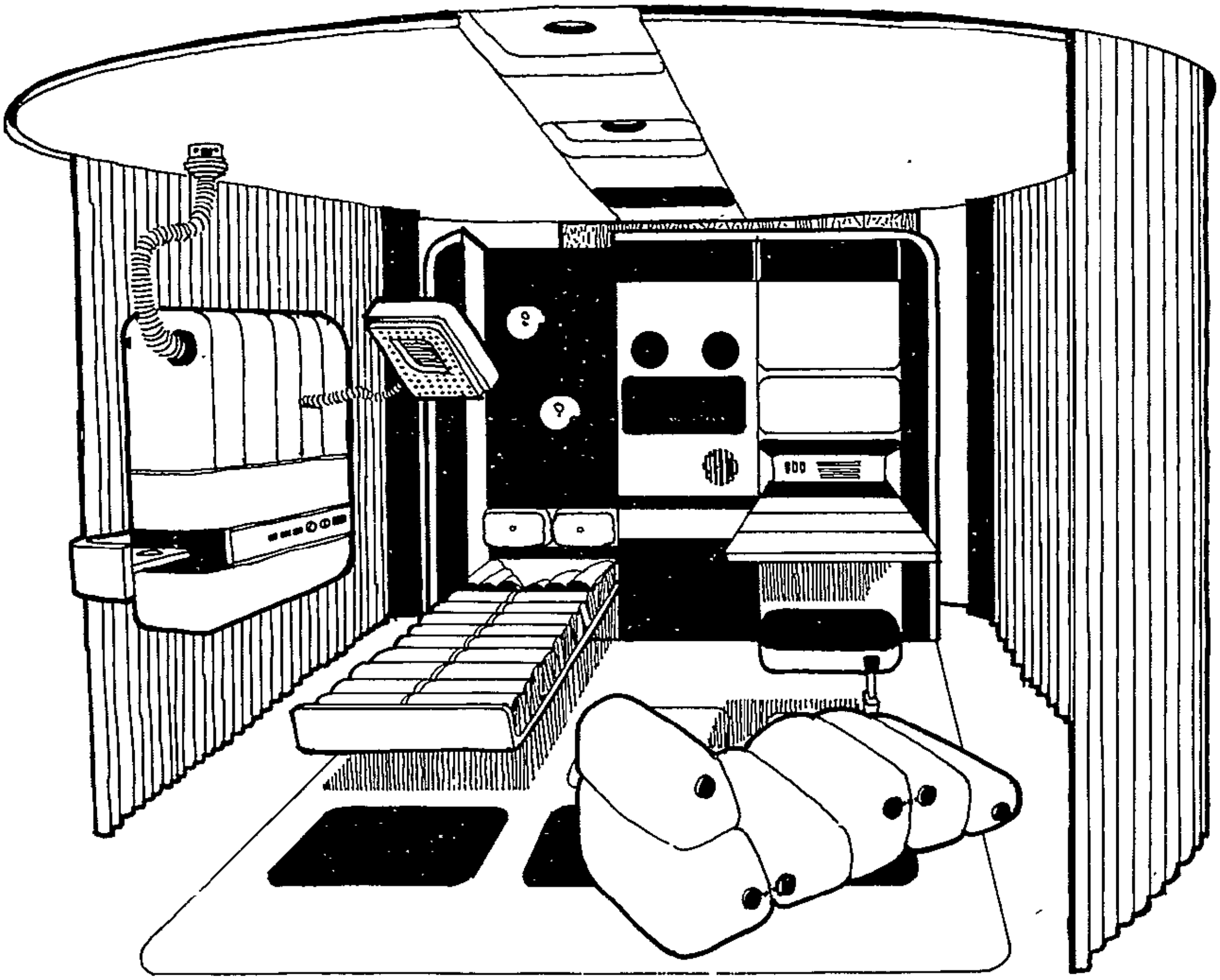

Figure 10. Individual Sleep Area

THE ASTRONAUTS SHOULD BE CAPABLE OF VARYING CERTAIN STIMULUS PARAMETERS

This requirement will enable the astronauts to combat the effects of stimulus monotony which can summate and produce, over time, debilitating reactions in crew personnel. As noted earlier the areas most amenable to stimulus change are the visual and auditory areas. For this reason, changeable visual and auditory characteristics of the habitat are presented in the following diagrams. While these diagrams do not indicate the color potentials fully, the importance of color must be recognized. By using multiple colored panels (one color on one side and a different color on the opposite side), the astronauts will be capable of altering the color scheme of specific areas. This requires movable wall panels. Similar effects can be obtained by the use of colored lighting. In this case the walls would be white and the changing lighting would produce varied colors and tonal qualities in the surrounds. These effects would also vary the lighting intensities of the environment.

The habitat must allow for generalized ambient lighting and localized lighting sources. While the light intensity required for card games (in the social area) might be the intensity for the general area, a person reading or performing some hobby task would most likely require increased lighting intensity. This should be available to the crew members. (See Figure 11.)

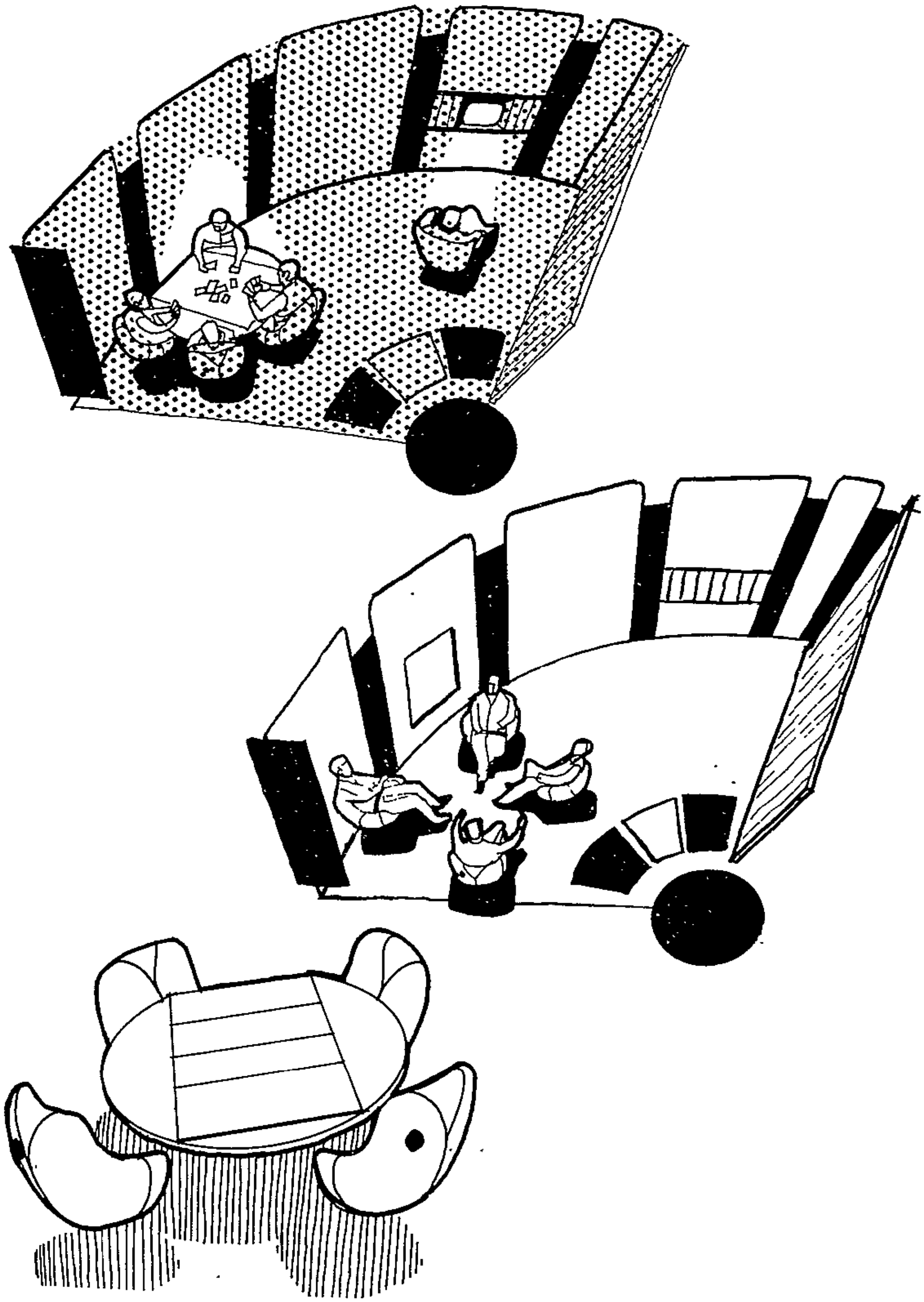

Figure 11. Illumination of the Social Area

THE ENVIRONMENT SHOULD ALLOW FOR A VARIETY OF ACTIVITIES PER AREA

While this is an extension of several requirements listed earlier (the ability to reconfigure physical areas and the environment should be flexible), it is an entity unto itself. The requirement for multiple use of areas necessitates that material used for any reconfiguration of the area be present or located in close physical proximity. This will require a detailed analysis of the uses to which areas might be put. An example can be provided by the sleeping areas of the habitat. The literature indicates that individuals under the conditions of long term confinement and isolation, tend to withdraw from social interactions. The design of the habitat should allow for such behaviors. The sleeping quarters should allow for its prime function of sleeping. In addition, it should facilitate inhabitant behaviors such as reading, individual recreation and two-man activities such as studying or card playing, etc. It might well serve as the area from which inhabitants can communicate with loved ones while in the terrestrial environment.

The social area might be used for group recreational activities, food preparation and ingestion, meetings, and exercise requirements. The location and storage of materials that facilitate these activities will strain design concepts but storage, and potential arrangements for these activities, must be considered and accounted for in the final design of the habitat. For maximum multiple usage of an area it must be capable of being reconfigured rapidly and with a minimum of effort. (See Figure 12.)

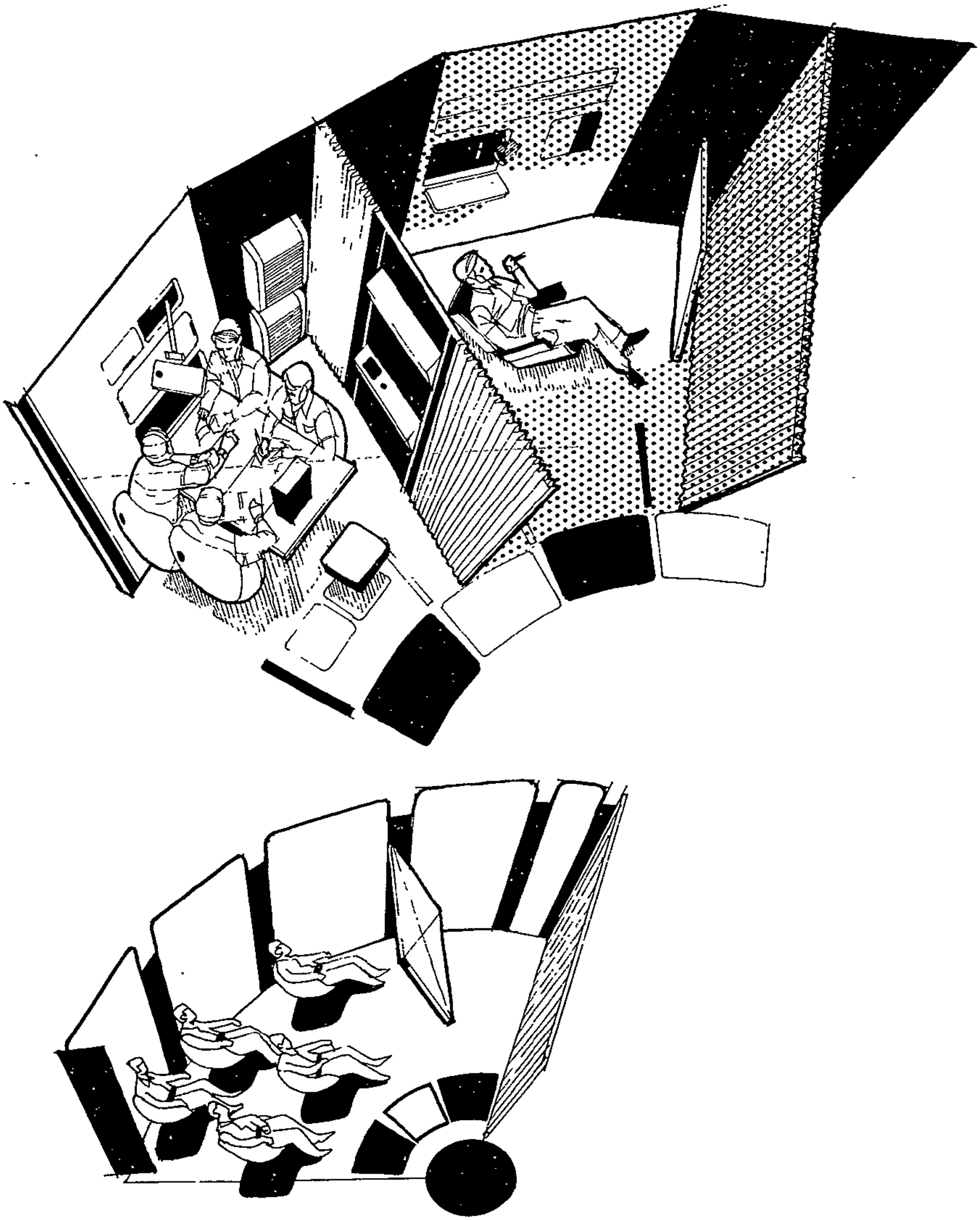

Figure 12. Multiple use in the Social Area

ANY HABITAT MUST SATISFY GENERAL PHYSIOLOGICAL REQUIREMENTS (EC/LS)

It is self evident that the safety of crew members is a prime requirement of any habitat. This necessitates that the habitat supplies all of the EC/LS requirements of all crew members. In the design of the habitat, partial control of these functions should be under the control of the crew members. Such control functions might include temperature, air flow, etc.

An additional area that requires further study and definition concerns the maintenance of physiological conditioning of the crew members. Equipment and exercise techniques must be developed in this area and incorporated into the design of the habitat. It is desirable for these activities to be pleasant (enjoyable) and of a nature that requires a minimum amount of external motivation for crew member participation. (See Figure 13.)

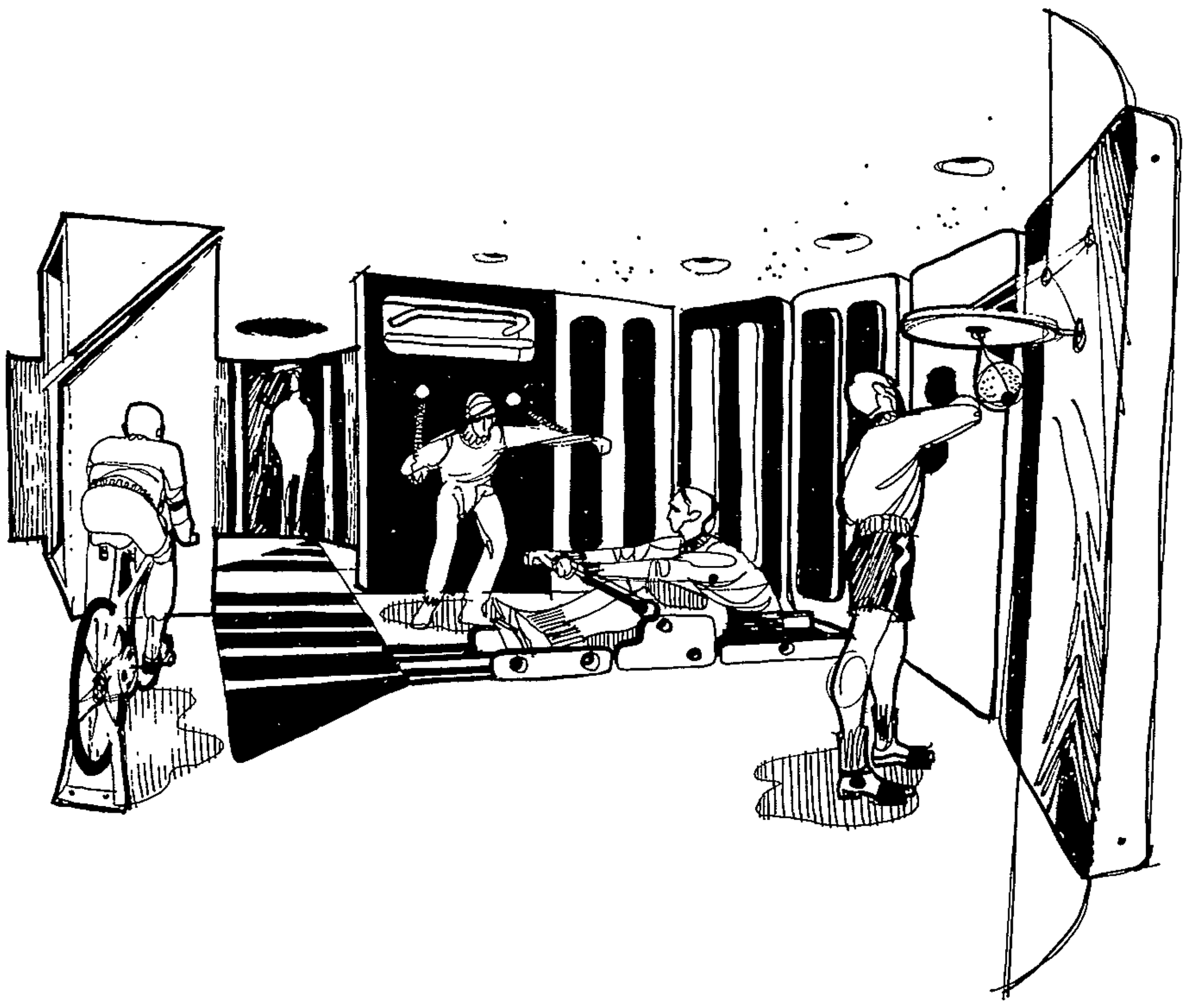

Figure 13. Crew Exercise Configuration

LARGER AREAS IN HABITATS SHOULD ALLOW FOR INDIVIDUAL USE AS WELL AS GROUP USE. INDIVIDUALS SHOULD NOT BE FORCED INTO INTERPERSONAL CONTACT IF THIS IS NOT DESIRED

Excessive rigidity in the internal design of a habitat might force individual crew members into situations where they must join in the activity of others, or isolate themselves from such activities by "cocooning" in private quarters. In many instances, these crew members might desire a "middle of the road" approach, that is, to be a non-participating observer of group activities. As was noted earlier, a flexible environment (walls and furniture) will allow for such individualized behaviors. This is particularly true when considering the social area of the habitat. By reconfiguring the furniture arrangement and varying the lighting intensity of specific areas of the room, it is possible to allow the crew members "privacy" while they are still members of the larger group. It is believed that this ability is more desirable than forcing the individual from the location into isolated surroundings. By being present, the individual may become interested in the activities and, after a short period, join in them. If this does not occur he might join or initiate other activities of interest to himself and, possibly, others. The more exposure the individuals have to other crew members the greater the potential for friendships to be established. While the formation of cliques can be disruptive to the organization and discipline required in these habitats, friendships between various crew members can assist in the development of cohesiveness of the group. The greater the exposure of crew members to one another, the greater the potential for such cohesive bondings to be formed. (See Figure 14.)

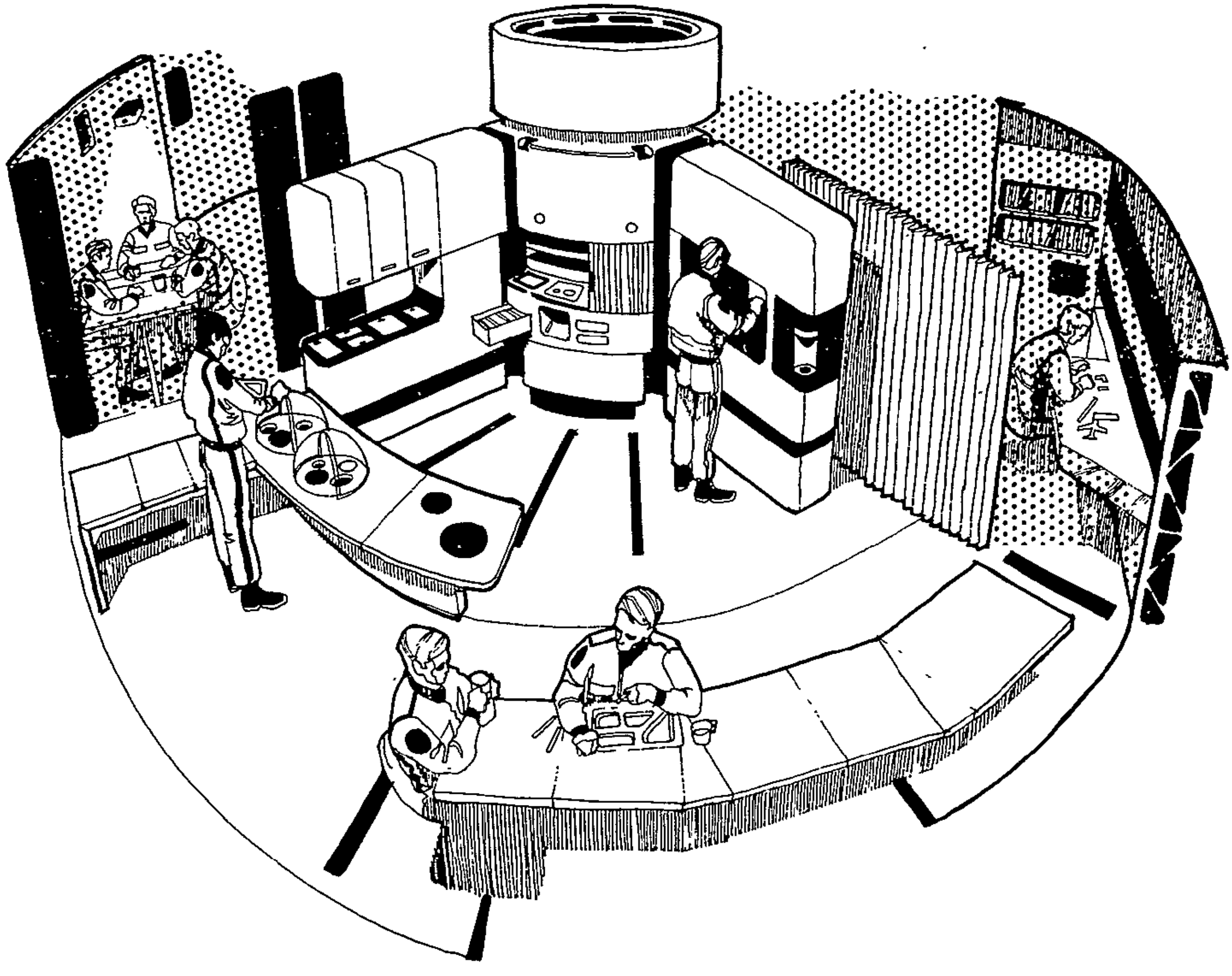

Figure 14. Flexible Social/Nutritional Area

HABITAT DESIGNS SHOULD ALLOW FOR THE DISSIPATION OF IRRITABILITY (AGGRESSION) IF THIS BECOMES BOTHERSOME TO CREW MEMBERS

A review of the literature indicates that isolated and confined groups in the terrestrial environment tend to suppress hostile feelings towards other individuals in the group. This is done in order to maintain a semblance of group stability. It is believed that designers and NASA personnel interested in recreational and physical conditioning activities can incorporate these activities so that they can serve to dissipate aggression. This might necessitate the design of more strenuous activities which allow crew members to "work off steam." The desirability of this requirement can be seen in the clinical literature. Persons capable of shedding aggressive feelings tend to perform allotted tasks with greater efficiency over longer periods of time. The dissipation of these feelings will also reduce the possibility of "cross currents" being established between various group members. Such a reduction will be beneficial to the development and maintenance of stability within the group.

An additional method for dissipating hostility or channeling aggressive feelings towards constructive goals is via "rap" sessions between the groups or individuals concerned. Here, the environment should support the formation of such group sessions. Particular activities would depend upon the design of the habitat as well as the skill of the leader in conducting such sessions. It is believed that either or both of these methods would be beneficial to group stability and individual performances over extended periods of time.

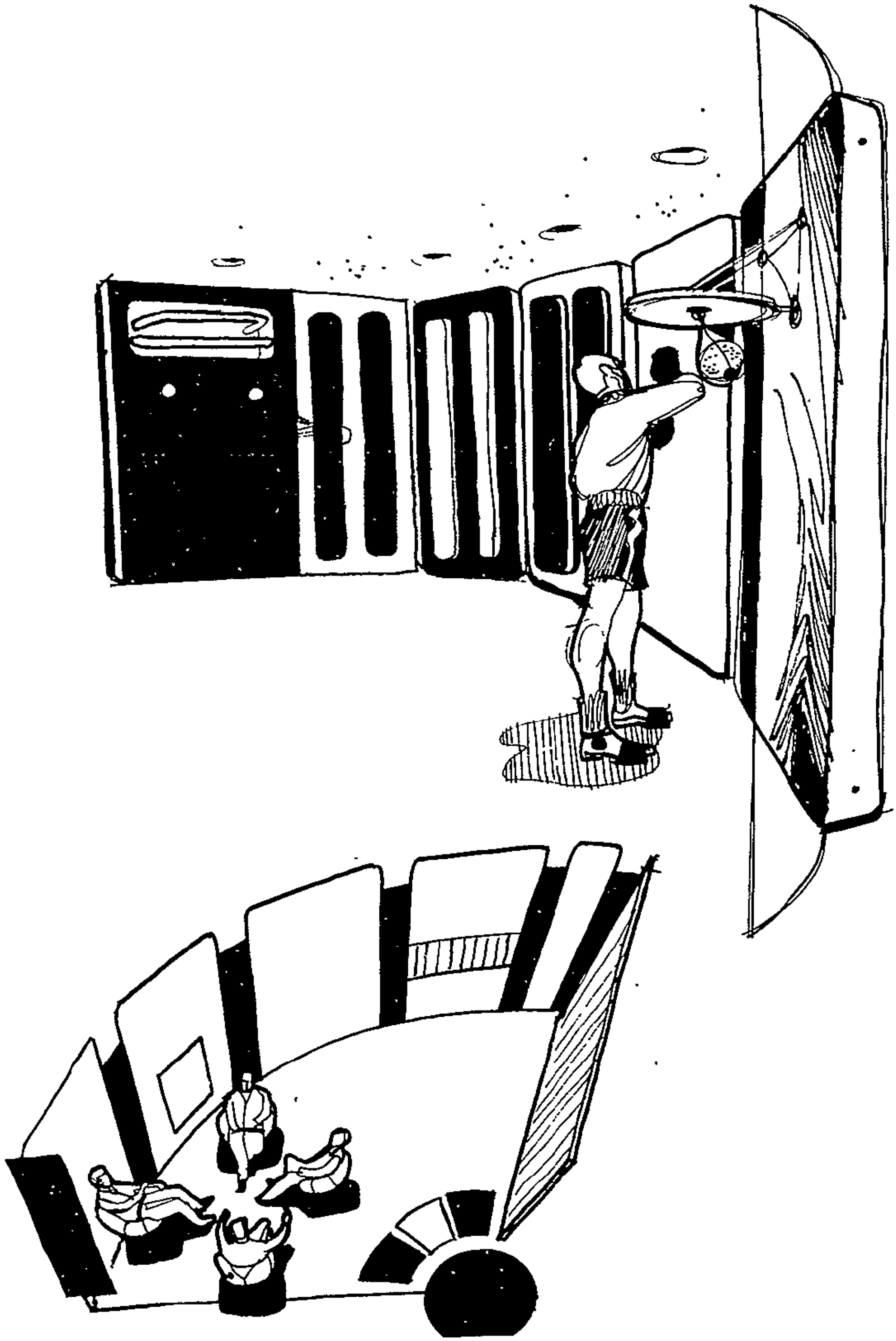

Figure 15. Social Area

SPACE HABITATS SHOULD REPLICATE AS CLOSELY AS POSSIBLE THE ENVIRONMENTS FOUND IN THE ASTRONAUTS' "NORMAL" ENVIRONMENTS

It was noted earlier that the design of "normal" environments is desirable for individual as well as group stability. Each crew member will be under a great deal of stress and the "normal" environment might assist in reducing the tensions produced under these stress conditions. Any such reduction would assist the stability of the group itself. Consideration must be given to sitting and sleeping positions and the hardware required for accomplishing these functions. The interactive effects of a zero gravity and the psychological well-being produced by familiar objects must be evaluated and considered in the design process.

CHAPTER VII. REFERENCES

Alpaugh, David. Design and community. North Carolina State University, Raleigh, 1970.

Altman, Irwin, and Haythorn, William W. The ecology of isolated groups. Behav. Sci., 12: 1967, 169-182.

Altman, I., and Haythorn, W. W. Interpersonal exchange in isolation. Sociometry, 28(4): 1965, 411-426.

Blake, R. R., et al. Having architecture and social interaction. Sociometry, 19: 1956, 133-139.

Blau, Peter M. Formal organization: dimensions of analysis. Amer. J. Sociol., 63: 1957, 58-69.

Brookes, Malcolm J. A maze of contradictions. Progres. Architect., 1969, 130-131.

Brookes, M. J. Changes in employee attitudes and work practices in the office landscape. Human Factors Design and Research, Inc., New York, 1970.

Bryne, D., and Bouehler, J. A. A note on the influence of propinquity upon acquaintanceship. J. Abnorm. Soc. Psychol., 51: 1955, 147-148.

Burns, T. The reference of conduct in small groups. Cliques and cabals in occupational milieux. Hum. Relat., 8: 1955, 467-486.

Calhoun, J. B. Population density and social pathology. Sci. Amer., 206: 1963, 139-148.

Campbell, Robert D., et al. Planning the man/environment interaction. The Matrix Research Co., Alexandria, Va., 1970.

Cartwright, D., and Zander, A. Group dynamics - Research and theory. Harper & Row, New York, 1968.

Doll, Richard E., and Gunderson, E. K. Eric. Hobby interest and leisure activity behavior among station members in Antarctica. Navy Medical Neuropsychiatric Research Unit, San Diego, Calif., 1969.

Doll, Richard E., and Gunderson, E. K. Eric. Group Size, occupational status and psychological symptomatology in an extreme environment. Paper presented at Amer. Psychol.Assoc., meeting, 1970.

Donaldson, J., et al. Psychological aspects of confinement in fallout shelters. J. Psychol., 47: 1959, 163-170.

Donenfeld, Ira. Project RIM: Observational data collection. Naval Medical Research Institute, Bethesda, Maryland, 1970.

Dubin, Robert. Human relations in formal organizations. Rev. Educ. Res., 29: 1959, 357-366.

Eberhard, J. W. The problem of off duty time in long duration space missions. Volume 1: Summary and research recommendations. Serendipity Associates, 1967.

Eisman, B. Some operational measures of cohesiveness and their correlations. Hum. Relat., 12: 1959, 183-189.

Esser, H. The psychopathology of crowding (human pollution). Presented at Amer. Psychol. Assoc. meeting, Miami Beach, 1970.

Felipe, N. J., and Sommer, R. Invasion of personal space. Soc.Probl., 14(2): 1966.

Festinger, Leon. Architecture and group membership. J. Soc. Issues, 7: 1951, 152-163.

Festiner, L., Schachter, S., and Back, K. Social pressures in informal groups: A study of a housing project. Harper, New York, 1950.

Fiedler, Fred E. A note on leadership theory: The effects of social barriers between leaders and follows. Sociometry, 20: 1957, 87-94.

Fiedler, Fred E. Perception and psychological adjustment of group members. Univ. Illinois, Urbana, 1967.

Fitch, James Marston. The architectural manipulation of space, time, and gravity. In Sanoff, H., and Cohn, S. (Eds.), EDRA 1, Proceedings of the 1st Annual Environmental Design Research Assoc. Conference, 1970.

Ford, K. A., and Gunderson, E. R. Personality characteristics (EPPS) of Antarctic volunteers. Navy Medical Neuropsychiatric Research Unit, San Diego, California, 1962.

Fraser, T. M. The intangibles of habitability during long duration space missions. Lovelace Foundation for Medical Education and Research, 1968.

Garrett-Airesearch Manufacturing Co. Human factors and environmental control - life support systems for LESA. Report SS-3242, Los Angeles, 1964.

Gross, N., and Martin, W. On group cohesiveness. Amer. J. Sociol., 57: 1952, 533-546.

Gundersen, Robert I. Earth-orbiting space-base crew skills assessment. NASA, Washington, D.C., 1970.

Gunderson, E. K. Eric. Adaptation to extreme environments: The Antarctic volunteer. Navy Medical Neuropsychiatric Research Unit, San Diego, California, 1966.

Gunderson, E. K. Emotional symptoms in extremely isolated groups. Navy Medical Neuropsychiatric Research Unit, San Diego, California, 1963.

Gunderson, E. K. Eric. Personal and social characteristics of Antarctic volunteers. J. Soc. Psychol., 64: 1964, 325-332.

Gunderson, E. K. Selection for Antarctic service. Navy Medical Neuropsychiatric Research Unit, San Diego, California, 1966.

Gunderson, E. K., et al. Biographical predictors of performance in an extreme environment. Navy Medical Neuropsychiatric Research Unit, San Diego, California, 1965.

Gunderson, E. K. Eric, and Mahan, Jack C. Cultural and psychological differences among occupational groups. J. Psychol., 62: 1966, 287-304.

Gunderson, E. K., and Nelson, P. D. Criterion measures for extremely isolated groups. Personnel Psychol., 19(1), 1966 (Spring).

Gunderson, E. K., and Nelson, P. D. Measurement of group effectiveness in natural isolated groups. J. Soc. Psychol., 66: 1965, 247-249.

Haaland, J. E. Man system criteria for extraterrestrial roving vehicles: Phase IB - the Lunex II simulation. Honeywell Inc., Systems and Research Division, Minneapolis, Minnesota, 1966.

Hagstrom, Warren O., and Selvin, Hanan C. Two dimensions of cohesiveness in small groups. Sociometry, 27: 1965, 30-43.

Hall, E. T. A system for the notation of proxemic behavior. Amer. Anthropol., 65: 1963, 1003-1026.

Hall, E. T. The hidden dimension. Doubleday and Co. Inc., Garden City, New York, 1966.

Hare, A. P. Interaction and consensus in different-sized groups. Amer. Sociolog. Rev., 17: 1952, 261-267.

Hare, Paul; Borgatta, E. F., and Bales, Robert F. Small groups: Studies in social interaction. Alfred A. Knopf, New York, 1955.

Haythorn, W. W., Altman, I., and Meyers, T. I. Emotional symptomatology and stress in isolated pairs of men. J. Exp. Res. Personality, 1: 1966, 290-306.

Haythorn, William W., and Smith, Seward. Terminal report on NASA-NMRI contract for project RIM. Naval Medical Research Institute, Bethesda, Maryland, 1970.

Hereford, K. T., and Huber, S. E. Relations among school design, utilization, personnel, interaction, and attitudes. Michigan State University, 1963.

Heron, W. The pathology of boredom. Sci. Amer., 196: 1957, 52-56.

Himes, H. W. Space as a component of environment. In C. T. Larsen, (Ed.), Environmental evaluations, Ser. 2. University of Michigan, Ann Arbor, 1965, 57-91.

Honigfeld, A. R. Group behavior in confinement: Review and annotated bibliography. Human Engineering Laboratories, Aberdeen Proving Ground, Aberdeen, Maryland, 1965.

Ladds, J. E. A study of Air Force personnel problems associated with remote or isolated assignments. Nebraska University, 1965.

LaPatra, J. W., et al. Moon lab: Preliminary design of a manned lunar laboratory. A Stanford/AMES summer faculty workshop study, NASA, 1968.

Lipman, A. Building design and social interaction. Architects J., CXlVII: 1968.

Nelson, P. D. Structural change in small isolated groups. Navy Medical Neuropsychiatric Research Unit, San Diego, California, 1965.

Newmiller, C. E. Psychological factors related to tolerance of confinement. HRB-Singer, Inc., State College, Pa., 1967.

Olmsted, Michael S. The small group. Random House, New York, 1967.

Parr, A. E. Psychological aspects of urbanology. J. Soc. Issues, XXII(4): 1966, 39-45.

Patterson, M. Spatial factors in social interactions. Hum. Relations, 21(4): 1968.

Radloff, R., and Helmreich, F. Groups under stress: Psychological research in Sealab II. Appleton-Century-Crofts, New York, 1968.

Scott, W. A. Values and organizations. Rand McNally, Chicago, 1965.

Seaton, R. W. Small group experimentation in the Arctic. Presented at annual meeting of The American Psychological Association, St. Louis, 1962.

Seitz, C. P., and Goldman, A. Use of the Ben Franklin submersible as a space station analog. Vol. II: Psychology and physiology. Grumman Aerospace Corporation, Bethpage, New York, 1970.

Sells, S. B. A model for the social system of the multiman, extended duration space ship. Aerospace Med., 37: 1966, 1130-1135.

Sells, S. B., and Gunderson, E. K. A social system approach to the long-duration space mission. Texas Christian University, Institute of Behavioral Research, 1970.

Sherif, M., and Sherif, C. W. Groups in harmony and tension: an integration of studies on intergroup relations. Harper & Bros., New York, 1953.

Smith, W. M. Observations over the lifetime of a small isolated group structure; danger, boredom and vision. Walter Reed Army Institute of Research, Washington, D.C., 1966.

Sommer, R. Further studies of small group ecology. Sociometry, 28: 1965, 337-348.

Sommer, R. Leadership and group geography. Sociometry, 24: 1961, 99-110.

Sommer R. Personal space: The behavioral basis of design. Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1969.

Sommer, Robert. Man's proximity environment. J. Soc. Issues, 22(4): 1966, 59-70.

Sommer, R. Studies in personal space. Sociometry, 22: 1959, 247-260.

Steinzor, B. The spatial factor in face to face discussion groups. J. Abnorm. Soc. Psychol., 45: 1950, 552-555.

Sullivan, Walter. Crew that gets along is called important on long space flight. New York Times, New York, N.Y., 1970.

Taylor, Dalmas A., et al. Stress relations in socially isolated groups. J. Person. Soc. Psychol., 9: 1968, 369-376.

Teichner, W. H., et al. Predicting human performance in space environments. NASA, 1969.

Theodorson, G. A. The function of hostility in small groups. J. Soc. Psychol., 56: 1962, 57-66.

Trumbull, Richard. Environmental modification for human performance. Office of Naval Research, Washington, D.C., 1965.

Tuckman, Bruce W. Personality structure, group composition, and group functioning. Sociometry, 27: 1964, 469-487.

Walker, C. R., et al. Workers and the social group. In The man on the assembly line. Harvard University Press, Cambridge, Mass., 1958, Chapter 5, p. 66-80.

Walsh, J. M., et al. Project RIM: Design and implementation. Naval Medical Research Institute, Bethesda, Maryland, 1970.

Weybrew, Benjamin B. Prediction of adjustment to prolonged submergence aboard a fleet ballistic missile submarine. U.S. Naval Medical Research Laboratory, Submarine Base, New London, Conn. 1964.

Wilkins, J. R. Man, his environment and microbiological problems of long-term space flight. NASA, 1967.

Winick, C., and Holt, H. Seating position as nonverbal communication in group analysis. Psychiatry, 24: 1961, 171-182.

Woods, W. A., and Boudreau, J. C. Design complexity as a determiner of visual attention among artists and non-artists. J. App. Psychol., 34: 1950, 355-362.

Wright, G. H., et al. The psychological environment of protective shelters. HRB-Singer, Inc., State College, Pa., 1966.

Zuckerman, Marvin. Perceptual isolation as a stress situation. Arch. Gen. Psychiat., 1966.