AD 738698

A SOCIAL SYSTEMS APPROACH TO HABITABILITY

E. K. ERIC GUNDERSON

REPORT NO. 70-23

D D C
8 1972
A

DISTRIBUTION STATEMENT A
Approved for public release;
Distribution Unlimited

NAVY MEDICAL
NEUROPSYCHIATRIC RESEARCH UNIT
SAN DIEGO, CALIFORNIA 92152

Reproduced by
NATIONAL TECHNICAL
INFORMATION SERVICE
Springfield Va 22151

BUREAU OF MEDICINE AND SURGERY DEPARTMENT OF THE NAVY
WASHINGTON, D.C. 20390

UNCLASSIFIED

Security Classification

DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1 ORIGINATING ACTIVITY (Corporate author) Navy Medical Neuropsychiatric Research Unit San Diego, California 92152	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3 REPORT TITLE

A Social Systems Approach to Habitability

4 DESCRIPTIVE NOTES (Type of report and inclusive dates)

5 AUTHOR(S) (First name, middle initial, last name)

E. K. Eric GUNDERSON

6 REPORT DATE	7a. TOTAL NO OF PAGES	7b. NO OF REFS
1970	52	12

8a CONTRACT OR GRANT NO b PROJECT NO MF12.524.001-9003D c d	9a. ORIGINATOR'S REPORT NUMBER(S) 70-23 9b OTHER REPORT NO(S) (Any other numbers that may be assigned this report)

10 DISTRIBUTION STATEMENT

Approved for public release; distribution unlimited.

11 SUPPLEMENTARY NOTES	12 SPONSORING MILITARY ACTIVITY Bureau of Medicine and Surgery Department of the Navy Washington, D. C. 20390

13 ABSTRACT

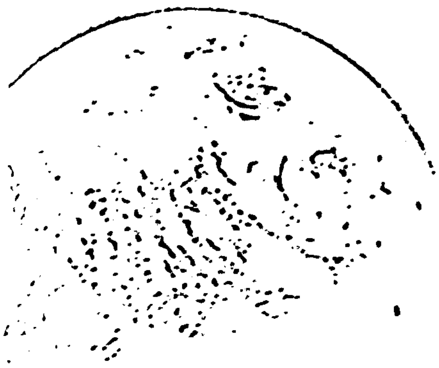
The elements of a system were described and definitions in common usage were given. The social system model developed by Sells for the long-duration space mission and other types of isolated groups was present in some detail and it was suggested that this set of system characteristics might be modified and extended and perhaps prove useful for comparative analyses of other types of small social systems, such as slum families or recently integrated work groups. It seems necessary to identify and understand those social system characteristics of families, schools, and work groups that are conducive to social health and effectiveness as opposed to delinquency and other forms of social pathology.

Unclassified
Security Classification

14 KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
characteristics model						

DD FORM 1 NOV 65 1473 (BACK)

UNCLASSIFIED
Security Classification



1ST NATIONAL SYMPOSIUM ON HABITABILITY

Reproduced from best available copy.

A Social Systems Approach to Habitability

E. K. Eric Gunderson

Navy Medical Neuropsychiatric Research Unit
San Diego, California 92152

Introduction

New developments in science in the past three decades, namely, general systems theory and research, cybernetics, and information theory have had an important impact upon the physical sciences and, to a lesser extent, upon biology and medicine. These developments have as yet had relatively little influence upon new theory or research in the social and behavioral sciences. Systems models would appear to have most to offer in those fields which require the specification and study of very complex sets of variables. The interactions and the interdependencies of physiological, psychological, social, cultural, and environmental factors present in everyday social situations, involving multilevel patterns of energy and information exchange, represent an extremely complicated array of system characteristics, which have defied adequate conceptualization and analysis.

In this paper it will not be possible to review recent applications of systems research in the social sciences, but, rather, an attempt will be made to focus on one social systems model which appears to have special relevance for the concept of habitability. The closest approximations to a general systems approach in social or organizational analysis may be found in the study of small, closed groups under conditions of isolation and confinement, such as those participating in extended space missions. Habitability considerations have become paramount in planning and designing the engineering, life support, and personnel systems required for long-duration interplanetary missions. It is emphasized that the present attempt to implement systems concepts in the area of social organization and group analysis are highly tentative. Nevertheless, system concepts appear to offer many advantages, not only for research design for complex man-machine systems such as spacecraft, but in more familiar social situations as well.

Because the word "system" has many colloquial meanings it seems desirable to describe the elements of a systems model and to limit the meaning of the term by identifying a number of basic concepts. A system may be defined very generally as a set of objects and their interrelationships. The parts or components making up the system may be physical objects or abstract entities. The properties of objects are attributes, and objects and their attributes are interconnected by relationships. This simple characterization does not adequately define the term "system" but reduces somewhat the inherent ambiguity of the concept. More complete definitions are readily available (Hall and Fagen, 1968).

A system is sometimes differentiated from its environment. The environment consists of those objects and their attributes located outside the system which affect the objects and their attributes within the system. It can readily be seen that this dichotomy of system and environment is artificial or arbitrary, and for most purposes all interrelated objects and their attributes may be studied as a single configuration. The point of view of the investigator determines whether efforts will be made to differentiate system from environment. The problem of specifying all of the factors in the environment that affect or are affected by the system may be as difficult as specifying relevant factors within the system itself. To summarize, "one includes in the universe of system and environment all those objects which he feels are the most important, describes the interrelationships as thoroughly as possible and pays closest attention to those attributes of most interest, neglecting those attributes which do not play essential roles" (Hall and Fagen, 1968, p. 84).

A distinction is often made between natural systems and man-made systems. It is clear that any given system can be further subdivided into subsystems and objects belonging to one sybsystem may well be considered as part of the environment of another subsystem. In the familiar paradigm of the man-machine-environment complex, it is useful to view persons, machines and equipment, and the surrounding natural environment as distinct subsystems, involving different types of objects and attributes, but integrated into a total process more or less compatible in design and function.

The concept "habitability" is impossible to define clearly or completely. Some notion of its meaning can be given by examples of its use in describing certain aspects of man-environment relationships. Generally, habitability refers to the effects that objects in the environment have upon individuals or groups. These effects may be defined by objective observation and measurement or in terms of subjective responses. More specifically, environmental objects may be thought of as affecting, singly or together, a wide variety of common physiological, psychological, and social variables. The concept of habitability also implies an evaluative aspect, i.e., whether human purposive behavior is facilitated or impeded by the specific features of the environment under study. It should be recognized that this aspect of the total situation is not inherent in the operations of the system but is imposed by the goals and values of the investigator or observer.

One may be interested in habitability characteristics as agents, that is, how certain aspects of the environment affect persons in the system, or as resultants, that is, how the attributes of physical objects have been determined over time by other elements in the system.

At least three separable aspects of habitability concepts seem apparent in common usage. First, habitability is frequently construed in terms of normative or cultural standards. Common examples are sanitation codes, building and safety codes, habitability standards aboard Navy ships, lighting standards in school and industry, and so on. Here habitability is a matter of definition or prescription and may have legal status or be a matter of custom. Rarely are normative habitability standards based upon systematic empirical studies.

A second version of the habitability concept may be labeled functional or operational. In this view, which is essentially the one advocated in this paper, the effects of various environmental factors upon specific groups or organizations must be determined by carefully controlled studies involving many factors. Habitability standards or requirements may vary depending upon specific personnel composition, objectives, resources, and other characteristics of particular social systems.

Finally, one could approach the question of habitability in terms of the unique subjective reactions of and meanings to the individual rather than looking for the response pattern of the group as a whole. This viewpoint, of course, is the most congenial to the cultivated sensitivities of the perceptive artist.

The focus of the discussion below will be on the application of system concepts to small organizations or groups. Katz and Kahn (1966) in their important contribution characterized human organizations as <u>open systems</u> with the common characteristics of outside energy sources, input, throughput, output cycles, steady-state and dynamic homeostatis, etc. Similar concepts have been elaborated by Berrien (1968). A major feature of the Katz and Kahn system formulation was the provision for continuing transactions with the environment which had been neglected in most earlier analyses. In their treatment, Katz and Kahn neglected the physical environment, however, which also accounts for significant variance in organizational behavior, particularly where the social system operates under extreme environmental conditions. The central unit of analysis in Katz and Kahn's formulation and in the present social system model is the organization or social group. Basically, the study of human organizations requires the specification of group members, the structure or design for operation and control of the organization, the related machines, equipment, and physical environment of the work and behavior setting. The social system model to be presented was developed to describe various types of isolated microsocieties as a frame of reference for behavioral research relevant to long-duration manned space missions. This model was originally formulated by Sells (1966) and the model is currently being revised and refined by Sells and the author.

A Social Systems Model

A social systems model specifies significant aspects of social situations that may affect human behavior, provides an overall description, and facilitates understanding of the characteristics of the system as a whole. The characteristics of the space ship system, which have been presented in detail elsewhere, will be noted here for purposes of illustration or emphasis.

The concept of a social system is inclusive and embraces all of the highly interdependent human, environmental, and mechanical components in a holistic unity which has distinctive purposes as an integrated system. The interrelationship of system purposes and the characteristics of their major components is such that, to a large extent, either can be inferred from a knowledge of the other. The model is frankly a structural one, focusing on such factors as group size, membership composition, organization, types of goals, sites of activity, equipment, skills, authority, and other dimensions that characterize distinctive social situations. This model does not include categories to describe system operations, such as the behavior patterns involved in leadership, management, and decision making. Some constraints of structure have predictable effects upon function. However, the specification of system functions (operations) for the complex man-machine-environment social systems remains as a next step in the development of a complete model.

The structural model was developed for the purpose of designing a standard set of system structural characteristics that could be applied generally as a means of ordering various microsocieties in a similarity matrix for taxonomic purposes. As indicated previously, the list of characteristics at this stage is necessarily highly redundant and makes no provisions for reflecting variations in system states at different times as the system adapts to new situations.

The system description involves eight major categories that have general relevance. These are:

I. Objectives and goals

II. Philosophy and value systems

III. Personnel composition

IV. Organization

V. Technology

VI. Physical environment

VII. Cultural-social environment

VIII. Temporal characteristics

Each of these major factors involves several subcategories that can be ordered or scaled for comparative analysis. The generalized model contains many factors appropriate for taxonomic analysis that can be omitted because of lack of variation where the model is applied within the framework of a specific cultural group.

I. Objectives and Goals.

This category should be represented by a set of variables of broad generality which might be the basis of differential description of every type of human group or organization. For the purpose of distinguishing the space ship from other isolated or confined microsocieties, the following seven variables were proposed:

1. Formally prescribed objectives
2. Mandatory vs. discretionary decisions
3. Formal authority structure
4. Goal polarization
5. Remoteness of goals
6. Clarity of success criteria
7. Success uncertainty (risk)

To these at least four other characteristics should be added to achieve broad generality. These are:

8. Unitary vs. multiple goals

9. Degree of competition with other organizations

10. Emphasis on growth

11. Planned vs. unplanned.

It is possible that this list should include some means of characterizing the content or nature of the activities to which the goals refer but at present this aspect appears to be adequately covered by other categories.

The degree of centralization in decision-making authority is an important aspect of any organization. Flexibility and discretion allowed with respect to implementing organizational objectives is a critical consideration in defining role characteristics and interrelationships.

Polarization reflects the extent to which an organization is goal-oriented with respect to one or more major objectives of importance to its sponsors and members. Remoteness refers to the time required between initiation of an activity and goal attainment. In the space program, the duration of individual missions will tend to increase and particular mission goals will become more remote. Remoteness of goals appears to be a major problem in long-duration missions. Maintenance of group integrity and motivation of group members requires filling the void of time with a richly detailed program of activities that provide meaningful interim goal achievements. Criteria of success in goal attainment may vary from confusion and ambiguity in the case of certain types of organizations to clearly defined measurable events or outcomes.

An important consideration in any group enterprise involves the amount of uncertainty in mission success, both objectively and as perceived by the participants, and the objective and perceived consequences of failure. Despite the increased confidence resulting from the Mercury, Gemini, and Apollo programs, new orbital and interplanetary programs will bring new hazards to be faced and both objective and subjective uncertainty may be expected to fluctuate as new programs and missions are activated.

With regard to multiplicity of goals, it is essential that all major objectives be clearly enunciated because of their implications for organizational structure, staffing, system operations, etc.

The likelihood of successful outcome is increased under conditions of purposeful planning, preparation, and training in comparison with unplanned, unprepared, accidental experiences.

If competition with other organizations and emphasis on growth are high, special attention must be given to public support and funding.

Goal definition is concerned with why the social system exists and what purposes it serves. Organizational goals may be well-defined and explicit or ambiguous and unclear. Groups obviously may be concerned with many different goals and purposes, but most groups are most concerned with relatively few salient objectives. Goals may be rank ordered for particular groups and the most significant identified. The usual sources for defining organizational goals are the designers, leaders, and key members. Statements of leaders do not constitute a complete account of group goals, however, because such statements may consist partially of idealizations, rationalizations, or even distortions which obscure functions. Observation of group behavior is a necessary compliment to the descriptions and definitions offered by group leaders. Generally, the larger and more complex the group structure, the more diverse will be the perceptions of goals and objectives by key group members.

II. Philosophy and Value Systems.

The philosophy and value systems of an organization generally reflect the attitudes of the controlling group with respect to considerations of ethics, concern for human values, designations of priorities in decision making, and other fundamental policies critical for system operation. Whether formal or informal, every group or organization is guided by some governing value system which may range in acceptance by members from complete concensus to considerable conflict and which may be conspicuous as in the case of religious institutions, or covert.

A definitive list of factors relating to this area has not yet been achieved, but the following six items have been specified for the space ship model:

1. Obedience to command
2. Mission emphasis
3. Respect for individual lives
4. High national priority
5. Military tradition in personnel attitudes
6. Acceptance of traditional national values (the American Way of Life).

Although a general toxonomic model requires system components of broad generality rather than the specifically tailored items listed in the space analysis, consideration of these items does indicate greater generality than may at first glance seem apparent. For example, obedience to command is an expression of control of member behavior by group authority; mission emphasis reflects the cost that the organizational management is willing to incur to assure goal attainment; respect for individual lives could be stated more broadly as the value accorded the individual, which may include other factors, but in the same general value scale; national priority could be broadened in terms of preeminence in social esteem; the military tradition reflects a set of attitudes regarding acceptance of personal hardships and austerity, masculinity, and patriotism; and similarly the "American way of life" implies conformity with the dominant mores and values of the society.

The aspect of organizational philosophy of most general interest in the present context involves the values accepted with respect to the relative importance attributed to alternative goals and alternative means, costs, and risks related to the attainment of the preferred goals. With the exception of formal religious organizations, the governing value systems are rarely available in documentary form, but must be inferred from a variety of sources, such as the record of critical decisions made, key appointments, speeches, and directives (as well as selected correspondence) by key officials.

Further study is necessary to arrive at a nuclear set of values that would apply to a wide range of organizations. Such concepts as the "golden rule"; respect for women, children, and aged persons; competitiveness, the "Protestant Ethic"; concepts of fairness, honesty, loyalty, and responsibility and the "good life"; attitudes toward wealth, power, possessions, comfort, and status are examples of important general social values.

It is apparent that many of the values suggested or specified here are interrelated with the items outlined below under <u>personnel composition</u>. And it is evident that this overlap might be reduced by multivariate analysis. Nevertheless, in specifying the model, it is desirable to distinguish explicitly between values subscribed to by organizations, in their respective formal documents or traditions, and those held by their members, even though convergence is expected in normal experience.

The culture model of the manned space program in the United States has been almost entirely that of military aviation. Although a few astronauts were recruited from civilian life, even these received their major relevant experience in military service. The concepts of crew organization and operation carried over from the military tradition have been accepted and understood by personnel throughout the organization and may be regarded as institutionally established. Unless major arguments could be presented, resistance to any proposed changes would be expected to be great. In general, these and the broader cultural values identified earlier are not expected to be amenable to or to require change in future missions, although the problems of integrating scientists, who often do not identify with the military tradition, have already become apparent.

III. Personnel Composition.

The high interdependence of system components is exemplified by the fact that optimal personnel selection tends to be guided by compatibility with goals, values, technology, and other system characteristics. The historic preoccupation of psychologists with individual differences has made the specification of characteristics of members of space crews or other organizations the least difficult task in the construction of a social system model. A comprehensive set of descriptors of individual members could include:

1. Intellectual level
2. Education
3. Extent of relevant training
4. Extent of relevant experience
5. Personality factors
6. Character and moral traits
7. Physical characteristics
8. Abilities and requisite skills

9. Motivation to participate

10. Sex

11. Age

12. Social levels or divisions

13. Rank

In addition to these descriptor items of general applicability, two others have special relevance to the space ship social system. These are: (1) heterogeneity of personnel composition on individual characteristics, particularly with reference to passengers (e.g., scientists) who are not an integral part of the crew, and (2) rank distribution or subgrouping, i.e., whether the crew is composed of officer-type personnel only, as in Gemini and Apollo, or of officer and enlisted ranks, as in naval ships and submarines.

Variables in this category might be examined with respect to the upper and lower limits of intellect, education, training, experience, specified personality and moral characteristics, motivation of members to participate, dedication to mission, physical requirements, required skills, age range, sex, marital and parental status, religious background, and the like. This inventory might properly include the entire range of individual differences and demographic characteristics. However, in the present context, it is believed that most of the relevant factors have been enumerated. The well-known bases of astronaut selection have, at least thus far, proved successful, although it is not possible to examine many of the criteria critically. To date, the astronaut group has been drawn, first from a select group of military test pilots with extensive jet experience, and more recently from a heterogeneous group of men with this or other relevant scientific training. In all cases, intellectual, motivational, emotional maturity, moral, educational, and physical standards have been exceptionally high.

Sex. Heretofore virtually every proposal to include women in the space crew has been summarily rejected and occasionally ridiculed. This position probably reflects cultural bias and is not supported by scientific assessment of performance capability. Admission of women to the space crew might create serious problems in the masculine world of space operations. However, broad trends in the 1960's, toward increased penetration of masculine occupations and roles by women, may accelerate in the 1970's to a degree that research oriented toward operations in the 1980's might well include objective review of the merits of female participation.

IV. Organization.

Eleven organizational variables are proposed for the space ship model:

1. Formal structure
2. Prescribed roles
3. Command structure
4. Centralized authority
5. Chain of command, with provision for succession
6. Back-up and support organization
7. Autonomy with respect to goals
8. Prescribed discipline
9. Prescribed social distance among crew
10. Congruence of rank and crew status
11. Group size.

The overlap among several of these items serves to emphasize salient facets and should perhaps be reduced in a working model.

It is necessary to examine organizational structure in terms of the degree of formal structure involved, organizational complexity and formal provision for authority, decision-making and direction (command). These considerations involve centralization of authority, sanctions permitted, provisions for succession, chain of command, and the power and role structure. Other factors include autonomy, control of member behavior by the organizational authorities, degree of participation of members in organizational activities, and degree of stratification of ranks or echelons.

The question of authority brings in formal documents, such as constitution, laws, directives, and the like, which may specify objectives and goals, as well as the limits of authority assigned to various offices and roles.

The organizational structure for the Mars fly-by crew will be significantly affected by overall mission constraints, such as long-term confinement and extreme remoteness from the support organization. Mission goals will be worked out in elaborate detail, and crew organization and responsibilities will be formally prescribed. The spacecraft commander would be expected to assume a great deal of authority during the mission, and formal provisions would need to be made for succession of command. Stratification in terms of authority or status among other crew members would tend to be minimal, and status leveling would be characteristic. A high degree of participation in solving organizational and technical problems would be expected of crew members, but ultimate decisions affecting the crew or mission would rest with the crew commander. Organizational rules pertaining to housekeeping duties, social activities, utilization of space and facilities, etc., would need to be clearly spelled out in advance of the mission after full discussion and participation by crew members. Crew members would have a large degree of autonomy in the practice of their technical specialties, and organizational controls would intervene only if conflicts arose in use of resources or equipment or if work performance deteriorated.

Although the organizational characteristics of the Mercury, Gemini, and Apollo programs and space crews can be fairly well described, certain changes may be expected in extended duration missions as a result of their duration and isolation. The organizational patterns of the Mercury, Gemini, and Apollo programs, with respect to overall structure as well as crew organization resemble closely those of military aviation, with much of the command responsibility held by ground command. However, onboard responsibility has gradually increased, most notably in the Apollo program. In looking ahead to the Mars mission and other extended duration efforts, there are grounds for expecting the transfer of much more authority to the space ship commander. As this transfer develops, problems of assuring integrity of command in the isolated space ship may become more acute.

The principal change affecting the social system structure for future missions in respect to the elements outlined is most likely in respect to group size. Although final decisions will involve trade-offs with many engineering considerations, it is likely that the crews of orbiting space stations and planetary space ships will range up to numbers permitting shifts (watches) and subgroups, involving considerable complication of organizational relations. The simple triad of Apollo will be inadequate as background for planning organizational patterns for crews spending extended periods in isolation. The research problems presented in this area are indeed formidable.

V. Technology.

Space technology is advancing at such a rate that planners must be ready to forecast expected developments that are not yet perfected in consideration of projects scheduled several years ahead. As space technologists think now about Mars missions in the 1980's, it is urgent that the effects of possible new propellants, such as nuclear power, new means of communication, such as lasers, improved life support systems, and the like, to be taken into consideration in conceptualizing the tasks, equipment, quarters, and other aspects of the space ship social system. The seven system characteristics related to technology are: (1) degree of technologic complexity, (2) relation to the aviation tradition, (3) use of simulators and other technical training devices, (4) degree of preparation for missions, (5) use of technical communication procedures, (6) physical preconditioning, and (7) scientific principles involved in operations.

It is almost meaningless to discuss personnel organizational behavior, and other system characteristics without taking account of the nature, complexity, characteristic operations, and traditions implied by the technology involved. The technology not only makes distinctions, such as between jet aviation and the earlier piston-propeller era, which involve differences in speeds, altitudes, schedules, and payload, but also between personnel types, traditions, training, and other significant factors assoiated with the respective technological fields. The technology of the space programs is still developing, although it follows the aerospace tradition. Among the peculiar aspects are the overwhelming significance of intensive training in anticipated emergencies as a means of insuring reliability of performance, the high level of training, experience, and skill required of crew members, the glamor associated with astronaut status (which reached new highs with the Apollo program), and the high risk associated with the very masculine (in the United States) astronaut role. The space technology has created new jobs, new vocabulary and technical jargon, and is regarded as one of the frontiers of human advancement. The type and extent of training and preconditioning provided participants are related to this section.

At any given time technology may represent constraints to be accepted rather than variables to be studied except to the extent that one has available trade-offs which are not precluded by cost priorities (values). At all times technologic complexity partially depends upon costs and available resources. Whether or not better foods, more space, etc., become realities, technology looms first in planning considerations and should be thought of as it will exist in the future rather than at present.

Changing technologies may result in subtle social system changes that need to be sought out and evaluated; for example, shifting from an emphasis on electrical engineering to automated electronic systems might reduce reliance on on-board navigational skills or on-board maintenance of communications systems.

As mentioned above, technological developments will be needed to make long-duration space-flight a reality. Although the developments expected, in fuels and power sources, life support systems (including regenerating oxygen, water, and food), food preservation and preparation, habitability, communication, and other vitally important areas, can be regarded as further elaboration of methods presently conceptualized, each may have specific implications for safety, comfort, communication, and recreation, as well as work that will require careful evaluation. There is every reason to expect that life aboard a space ship of the 1980's will be vastly different from the "primitive" conditions of the 1960's; to the extent that these developments can be taken into account in long-range planning, even subject to revision periodically, such information should be of vital importance.

VI. Physical Environment.

The rationale for each of the eight environment factors should be clear. The cultural and social environment is included as a separate major category below. The eight factors are:

1. Personnel protection, maintenance, and life support
2. Isolation (remoteness from base)
3. Presence of environmental hazards
4. Degree of space restriction and confinement
5. Endurance demands
6. Static or maneuvering situation
7. Internal and external communication permitted
8. Embedded environmental stresses.

Among the significant characteristics of various social systems are the distinctive features of their micro-environments, which have implications for the level of risk involved and the nature and magnitude of stresses encountered. The space environments are principally two, the space medium, which is unfriendly and hazardous to man, and the space ship and equipment which protect him and provide a supportive environment that enables him to function and endure in space. In extended duration missions, with prolonged enforced isolation and confinement, the protective capsule itself may be a major source of social stress, compounded by the period of time during which crew members must share the unnaturally confined quarters as work, living, recreational, and quasi-personal space. Here, again, is an unprecedented experience for man, with only fragmentary sources from which to extrapolate estimates of needs and reactions. Several additional aspects of the physical environment, which are also related to the technology, involve the distinctions between a maneuvering operation and a static environment, between extended exposure to embedded, but not intrusive stresses that lurk around the limits of system protective integrity, and occasional, insidious exposure to highly threatening conditions, and between organizations that plan and prepare means of coping with the hazards expected and those that are caught unprepared. It can be stated that the space ship is a maneuvering group, exposed to embedded, but not intrusive stresses over long periods, whose preparations for coping are exceptionally thorough and, until now, effective.

The space environment is a formidable and hazardous medium, but even in the brief span from Mercury to Apollo technological progress has produced protective garments of increasingly greater comfort and mobility, shirtsleeve conditions of flight, improvements in food and personal hygiene, maintenance and repair capabilities, photographic and communication advances, maneuverability, and power sources that encourage further efforts to invade its depths. Despite the most optimistic prospects for even greater progress in control capability in the space environment, a number of specific problems remain to be evaluated, such as prolonged exposure to zero g, and new ones can be expected. The possibilities of new requirements for astronaut selection and of new measures to support effective behavior in relation to the increased psychological stresses of prolonged exposure to isolation and confinement, have been intimated above. As engineering mastery of the capsule environment advances it appears likely that greater attention will be focused on psychological problems of the sameness and monotony of surroundings, companions, food, entertainment, and other aspects of space ship living in which variability is minimal. Approaches to the understanding of these problems and compensatory measures, possibly by exploitation of communications technology and task programming possibilities may provide new means of enriching the lives of lonely astronauts.

VII. Cultural-Social Environment.

The major utility of this section is that it calls attention to the geographic, linguistic, technologic, economic, political, scientific, religious, aesthetic, and social culture that provides a learning context and a frame of reference for the participants in a microsociety and its sponsors.

For any comprehensive analysis, it should be noted that Murdock and his associates (1961) distinguished 88 significant categories in their Outline of Cultural Materials for the Human Relations Area Files developed at Yale University. A modified list of these social cultural categories was adapted from Murdock and presented in earlier versions of the social system model (Sells, 1966). The categories include language, demography, history and culture change, total culture, communication, records, food quest, animal husbandry, agriculture, food processing, and other categories pertaining to modes of living, industrialization, economy, education, art, religion, organization, stratification, and other important aspects of cultures over the world.

Although many of these items were intended to apply to large-scale social systems and cultures, examination and refinement suggest that they may have significant analogs in a "microsociety" perspective as well. In any case, the list is instructive as a guide to the complexity of the social-cultural environment which may influence organizations and their system characteristics.

The American culture is undergoing rapid transition. Most of the astronauts eligible for Apollo missions may be too old to be considered when crew assignments are scheduled for the first Mars mission, although many of them will be available to participate in orbiting laboratories and other intermediate projects. However, assuming that crew members recruited for future missions will represent later generations of American youth, it may be wise to examine trends in culture norms with respect to significant attitudes and values relevant to participation in space activities and long-range missions in particular. Assessment of cultural changes and cautious predictions of their effects on new personnel entering the program in the future may be as important as comparable efforts, recommended above, to take into account changes expected in technology. For example, some differences in nutrition, physical standards (height and weight), and educational levels might be anticipated in later generations of astronauts.

VIII. Temporal Characteristics.

A very important aspect of every social system is its temporal character. For the space ship system model, three temporal factors are relevant. The first relates to the duration of exposure to isolation and confinement in a continuous mission. The second is the total time involved, including preparation and post-mission quarantine. Finally, the extent to which each daily cycle is fully occupied is important; on a space ship this is total, in contrast to work situations while living at home which provide many relaxing discontinuities and respites from sameness and boredom. An effect of the total environment, which may be mitigated to some extent by scheduling and by the provision of opportunities for privacy and solitude, is the magnification of interpersonal stresses generated by the enforced close contacts.

Isolation may extend from brief exposures, as in many experiments, to extremely long periods, as in certain classical cases of imprisonment. The stress of isolation is believed to increase as a function of duration. Long before the voyage of Columbus and many times since, ships' crews functioned effectively in isolation for periods comparable to those currently estimated for a Mars mission. The critical importance of duration increases, however, as the effects of close confinement and other stresses are compounded.

Research on prolonged confinement is difficult, principally because of the necessity to achieve realistic simulation, which involves implementation of the total social system in the simulation study. Too many simulation studies have fallen short of the necessary criteria of realism to produce information of significance for extrapolation to important projects. An example of an effort to incorporate a realistic approach is given in a recent paper (Special Panel, 1969) to illustrate possibilities that exist when the issues are accepted as seriously relevant and when efforts are made to secure necessary resources to accomplish the research on the basis considered necessary. While the shortcomings of this particular study may be apparent, the principles formulated might serve as guidelines for research oriented generally toward behavioral requirements of social systems of long-duration space vehicles.

The social system model presented above represents a minimal set of system characteristics, oriented principally toward description of a two-year Mars mission. The categories outlined under the Personnel Composition, Organization, and Physical Environment sections recently have been expanded in order to conduct comparative analyses of another type of isolated and confined microsociety, that of Antarctic scientific stations. Annually several small contingents of scientists and Navy men occupy extremely remote bases on the Antarctic continent in order to carry out scientific programs sponsored by the National Science Foundation. These groups constitute closed ecological systems in that no new personnel or supplies reach the stations over eight months or more of the Antarctic winter. These small isolated communities are the only available sources of research data presently pertaining to long-term individual and group adaptation to conditions of confinement, restricted activity, high social interdependency, and severe environmental threat. In the next section, habitability problems in the extended duration Mars mission and, to a lesser extent, in small Antarctic communities will be described in some detail.

Habitability Considerations for Long-Duration Space Missions

The purpose of this section is to describe the spacecraft environment for prospective planetary missions in general terms and to evaluate the implications of crew size, cabin volume, length of mission, together with isolation and confinement, and potential hazards for habitability and human adaptation problems.

Major objectives of the first missions would presumably include (1) flying in close proximity to a nearby planet (Mars) and returning, (2) insuring the health and safety of the crew, and evaluating human adaptation, and (3) gathering new scientific data concerning neighboring planets and the solar system.

Three types of missions are projected: (1) a Mars fly-by with a duration of about 500-700 days using chemical or nuclear propulsion in the last half of this decade; (2) a Mars orbiting mission of about 350-500 days duration using nuclear propulsion around 1980, and (3) a Mars landing mission with a 350-900 day duration using nuclear propulsion possibly around the middle of the next decade.

The considerations to be discussed apply primarily to the genotype of a Mars two-year fly-by mission. Space missions of such length pose a vast array of problems relating to life support, habitability, and successful human adaptation. None of the fundamental questions pertaining to man's capacities during planetary space flights can be answered with present knowledge because of the unprecedented conditions of close confinement, long duration, and zero-gravity.

The size and make up of the crew is presumed to depend directly upon the essential functions to be performed as well as upon constraints imposed by logistic and life-support requirements, including available cabin space. Crew sizes for post-Apollo orbital, lunar, and interplanetary missions are indefinite; some tentative assumptions can be made concerning crew size and composition in order to provide a framework for meaningful discussion.

For the Mars fly-by the crew will probably consist of five or six members, and these essential roles or functions probably will be represented: (1) spacecraft commander, (2) life-support systems engineer, (3) physician-biochemist, (4) physicist-astronomer, (5) electronics-communications engineer, and (6) computer-data systems specialist. The last two roles could most readily be combined if space limitations were to restrict crew size to five.

The dimensions and shape of a Mars type vehicle are not yet known. The model most frequently used for planning exercises has been the S-IVB Orbital Workshop. This vehicle would consist of a cylinder 22 feet in diameter and about 29 feet in length and would provide approximately 11,000 cubic feet of space.

Space cabin volume requirements for prolonged missions are not known at this time. Plans for space station vehicles, carrying 4 to 24 men for as long as 12 months, provide for 300 to 700 cubic feet per man. Such projected volumes are based upon rocket booster capabilities rather than on known habitability requirements for particular periods, however.

Fraser (1966) attempted to define tolerance limits for degree of confinement (free cabin space) over short periods of exposure. His analysis of space flight and simulation data suggested that confinement of an individual or group in a relatively small space (100-150 cubic feet per man) would result in detectable impairment of functioning within about 4-5 days. The Apollo crew with only about 80 cubic feet per man predictably manifested physiological problems after 14 days.

The comparatively large volume of the S-IVB Workshop would appear to provide adequate living space for a crew of 5 or 6 depending upon the space requirements for equipment and supplies. Given approximately 700 cubic feet per man for living quarters and recreational areas, proper design could result in relatively spacious, attractive, and comfortable accommodations for short-term occupancy. The adequacy of such accommodations for long-term exposure would depend upon many factors other than cabin volume per man as outlined below.

Provision of individual sleeping compartments and limited storage space for personal property would appear to be an essential requirement for extended missions. Experience in Antarctic groups and other confined situations have indicated that sharing of sleeping quarters and personal space by two individuals over long periods imposes a serious risk of escalating minor interpersonal frictions into major conflicts of unmanageable proportions. Needs for privacy, solitude, and territoriality become accentuated even in short-term confined living and tend to intensify over time.

One guiding principle in cabin design might be the creation of familiar configurations and the simulation of normal earth living insofar as practicable. Another useful principle might be the creation of as many different and distinctive behavior areas or settings as feasible, corresponding to familiar "rooms" in earth habitation. Isolated groups in other settings, such as the Antarctic, go to great lengths to preserve or create semblances of the home culture, including familiar usages of space and symbolic objects.

Modular construction of spacecraft interior surfaces (walls, floors, and ceilings), consisting of easily bolted panels, would permit flexibility in the utilization of available space. Space requirements and preferences of crew members could very well change considerably over time, and the possibility of adding, modifying, or rearranging rooms and cubicals would be highly advantageous. As food and other supplies are consumed, storage areas could be converted into useable living space.

A smaller model for space cabin volume and layout is provided by the McDonnell-Douglas space cabin simulator, which is a cylinder 12 feet in diameter and 40 feet in length (4,100 cubic feet). A 60-day earth-orbiting simulation conducted with a four man crew revealed a number of minor habitability problems in the initial configuration of living space and life-support equipment. Crowding did not appear to be an important problem for this relatively short period. Food, noise, and restricted water supply proved to be sources of minor annoyance. Improvements in cabin design for the current 90-day test in the same simulator included reduction of noise levels in crew living quarters by grouping life-support equipment and other hardware away from the sleeping area. Maximum free walking space was made possible by careful arrangement of equipment, facilities, and storage areas.

"Confinement" and "isolation" are ambiguous terms. They have many meanings in common usage and usually do not have reference to clearly denoted or standardized environmental conditions, even in experimental studies. In many situations it is difficult to know whether the behavioral effects observed are attributable to isolation and confinement or to other aspects of the total situation.

In the present context it is useful to relate confinement to the volume of free cabin space per man. Free space is that area not occupied by equipment or fixed structures within the cabin. A number of direct consequences of living in a small enclosed space are usually present to some degree; among the most important are enforced interpersonal relations, limited or non-existent privacy, reduced variety in sensory stimulation, and restricted physical activity. The extent to which these usual accompaniments of confinement can be eliminated or mitigated have an important bearing upon tolerance for confinement.

The boundaries of the spacecraft environment could be significantly extended by means of extra-vehicular activity during long missions. Extra-vehicular activity, because of high energy costs, might be restricted to essential checking and repair of equipment on the exterior surface of the spacecraft, but even this limited extension of the sphere of movement and activity would represent an important departure from routine confinement.

Isolation usually involves the notion of remoteness or distance from civilized society or time required to reestablish physical contact with that society. Psychological isolation in the present context refers to the kinds and amount of communication possible with persons outside the space capsule.

It can be anticipated that significant amounts of information will be transmitted to and from the spacecraft daily, partly mitigating the effects of extreme remoteness from earth. The information from the spacecraft presumably will consist largely of scientific data and data reflecting the status of spacecraft systems. Much of this information will be gathered by sensors and processed automatically.

It should be possible to transmit news and entertainment on a regular basis from earth for delayed television viewing aboard the spacecraft. Such communication from earth obviously would be of enormous importance in supplying variety in visual and auditory stimulation. Intimate or private personal communications with significant individuals outside the spacecraft would not seem practicable, however. This type of deprivation could have important psychological implications for crew members with strong family ties and affectional needs.

The length of time required for transmitting signals long distances would effectively preclude the intervention of the ground support organization in case of sudden emergencies aboard the spacecraft. Several minutes would be required to transmit information from the vicinity of Mars to earth and an equal time required for a response. Almost one-half hour could elapse before any response to a distress call would be received at maximum distances from earth. Thus, decisions under sudden emergency conditions could only be made by the spacecraft commander and crew.

The long period away from the earth culture would require consideration of means to facilitate "psychological re-entry." Men isolated in Antarctica for one year sometimes experience anxiety and social disorientation when returned to normal society.

Mission duration is of salient concern in the planning of interplanetary voyages because of the direct relationship of mission duration to many critical personnel and technical requirements. About one year is considered the minimum length of time for voyages to other planets. Space technology could not provide the type of high-energy propulsion necessary for such a "fast" trip in the near future. Low energy missions of approximately two years duration are considered feasible in the near future and voyages as long as 900 days are foreseen in the next decade (1980's). The most important determinant of mission length will be type of propulsion. Nuclear propulsion will offer enormous advantages in power and payload capabilities in spite of extra weight for shielding.

Mission duration, confinement, and total dependence upon life support systems, of course, compound the threat from hazards encountered in flight. In the event of catastrophe beyond a few days' travel from earth orbit, rescue or survival would appear impossible at present. In time, techniques for search and rescue of personnel from a "life raft" in outer space may be developed, but for the near future major failure in a spacecraft system or serious accident would mean certain death for all occupants. All emergency measures must be oriented toward survival inside the spacecraft.

The longer the mission, the more serious would be the problem of the build up of contaminants in the cabin atmosphere. Investigations have just begun on contaminant toxicology in long-term, closed life-support systems. Early studies[5] with animals indicated that continuous inhalation of low concentrations of ordinarily nontoxic contaminants for 90 days can adversely affect health and even cause death. Unexpected toxic contaminants have caused alarm or abortion in at least two simulation studies. Human tolerance limits for large numbers of potentially deleterious trace contaminants must be determined over long exposure periods. Severe constraints may be placed upon the kinds of materials carried on the spacecraft.

Unmanned flights will provide a great deal of information concerning hazards from meteorites or asteroids. Animals carried as passengers on long unmanned space probes could provide evidence concerning severity of radiation exposures and test radiation protective equipment. A portion of the space cabin would need special shielding for protection when higher levels of radiation were encountered. Radiation monitoring and protection would be a problem in any extended space flight.

Even with maximum provisions for safety and habitability, the crew would inevitably experience severe deprivations in many areas of personal needs and normal gratifications due to the extreme confinement for a long period. Studies at small scientific stations in Antarctica (8-30 men) have shown that the probability of irritability and depression, sleep disturbances, boredom, social withdrawal, dissatisfaction, and deterioration in group organization and cohesion varies directly with the degree and length of isolation and confinement; many other factors also are important. The usual discontinuities in social relationships which permit dissipation or displacement of normal tensions will not be possible in the spacecraft environment, and variety and novelty in interpersonal relations will be nonexistent. While recreational and educational interests and pursuits would assume greater importance in these circumstances, the likelihood of individuals initiating such activities tends to decline with long-duration confinement in the Antarctic.

Appetite, food acceptability, and adequate nutrition would represent significant problems during long missions. Weightlessness and low activity levels could have a profound effect upon caloric needs and body mass over long periods. This possibility can only be evaluated realistically by long-term exposure to zero g and confinement conditions. Food and its palatability tends to take on added significance in isolated groups, probably due to the absence of other gratifications and the symbolic significance attached to food in our culture.

Sexual needs do not appear to create overt problems in long-term Antarctic groups, although the possible contribution of sexual tensions to manifest irritability, sleep disturbances, etc., is difficult to evaluate. Interview reports tend to suggest lessening fantasy preoccupation with sexual matters over time.

Experimentation on tolerance limits for humans is severely constrained by ethical considerations. Survival limits generally are known only because of accidents. Realistic situations involving long-duration isolation and confinement, therefore, are of prime significance for defining important group adaptation problems and designing experiments to explore substantive hypotheses. Small Antarctic stations represent one such setting. Undersea experiments, such as SeaLab and Tektite, with opportunities for continuous observations of behavior under confinement and isolation stress provide important methodological contributions. Laboratory studies of 2- and 3-man isolated groups at the Naval Medical Research Institute have advanced conceptualization and hypothesis formulation.

The application of systems engineering concepts has made possible the design and efficient integration of various life support and environmental control systems -- atmospheric regulation, temperature control, water recycling, energy expenditures and metabolic exchanges, waste management, etc. --

within the total spacecraft environment. Engineering and operational factors have received primary attention in designing space vehicles to date, and habitability considerations have not received adequate attention in planning for the complete ecological system represented by the long-duration manned space mission. The preceding discussion of habitability considerations in long-duration space flight was intended to highlight the great variety and complexity of personnel, organizational, and environmental factors involved and to suggest that our knowledge is extremely limited in many of these areas. It seems clear that future research approaches to habitability problems must be holistic and programmatic rather than piecemeal in orientation, both in the space flight program and in relation to optimizing man's social and physical environment on earth.

Social System Applications in Other Settings

Social scientists in academic settings sometimes find it difficult to reconcile the prevailing pressures to "publish or perish," which favors small laboratory studies as opposed to concern with significant social problems in the real world. For example, psychologists at their national convention this past year expressed concern about lack of social relevance in their work. Hopefully, some reorientation is in progress in the behavioral sciences so that important social issues and events occurring in the real world can be integrated with scholarly and theoretical interests in order to develop useful research approaches to pressing social problems.

In surveying relevant research data on group behavior under conditions of isolation and confinement, it was necessary to turn primarily to realistic field experiments, such as SeaLab II, Tektite, small Antarctic scientific stations, and life-support system simulations. It became clear in reviewing past small group studies that the limitations imposed by the particular tasks, subject populations, and measurement techniques as well as the brevity and lack of realism characteristic of most laboratory experiments precluded their serious consideration in reference to the spacecraft crew and environment.

Studies conducted by Radloff and Helmreich (1968) in SeaLab II provided a useful paradigm for the systematic analysis of small group behavior under realistic field conditions with some exercise of experimental control. Radloff and Helmreich extended their techniques of direct behavioral observations in the Tektite experiment which provided for continuous monitoring of many aspects of psychological and physiological functioning. Deutsch (1970) has recently presented a detailed rationale and methodology for the Tektite studies.

The McDonnell-Douglas 60-day and 90-day life-support simulations were specifically designed to resemble the environment of the space ship as closely as possible. In the current 90-day simulation study, involving 4 scientist and engineer crew members who will cary out realistic and important tasks, a highly sophisticated program of behavioral study is in progress.

Several important principles relating to techniques of behavior measurement have emerged in recent years largely as a result of efforts to conduct field studies under difficult or stressful conditions. These principles include: (1) multivariate analysis and the use of multiple behavi-. indicators as independent estimates of key variables; (2) longitudinal studies with sufficient numbers of observations over long enough periods to detect long-range changes in the social system; (3) the use of unobtrusive and non-intrusive methods of measurement so that normal mission operations and behavior will not be interrupted or significantly affected, and (4) an emphasis on a systems approach to the analysis of group behavior, that is, recognition that small organizations are not only affected by a large number of internal factors but that they are in constant interaction with the surrounding physical and social environments as well.

These principles are oriented toward making observations and measurements in real social systems over relatively long periods of time; development of such principles has enhanced the feasibility of conducting meaningful research in natural group situations. Concepts and approaches are suggested which seem more compatible with research on social problems in familiar settings, such as families, schools, and work situations, than the experimental models and paradigms of the past.

The present social systems model is admittedly crude and tentative, but eventually such a framework may have potential usefulness for systematic research relating to the complex and urgent social problems confronting us. Examples might be the evaluation of the effects of poverty and family organization in the slums in terms of various forms of social pathology, integration of ghetto blacks into white schools and work organizations, and the understanding and management of social conflict.

It seems necessary to start thinking very seriously now about how to measure and study large numbers of interrelated social system characteristics, and perhaps over the next decade more effective analysis of social and family conditions and their consequences could bring more choice into the planning and development of healthy social environments. Over the long run the outcome could be to create greater possibilities for shaping social institutions and physical environments to meet basic human needs.

Two additional social system characteristics have been described in a modified version of the social systems model to provide greater generality and relevance to common social situations. These are tasks and resources. Both have been tentatively placed under the Organization category.

The tasks area refers to what must be done by members to accomplish group goals. Thus prescribed tasks are derived from and closely related to group objectives. But their definition requires careful analysis of the operations of the system and enumeration of the specific kinds and amounts of activities to be performed. In some situations, tasks can be specified with great precision and detail. In others they may be almost entirely contingent upon unknown events or implicit in broadly defined role behaviors. Tasks can be described to some degree in any social system, but a wide-range of specificity is possible. Consider the carefully planned sequence of operations performed by an astronaut as contrasted with the heterogeneous and frequently unplanned tasks performed by the housewife.

Resources refers to the money, tools and equipment, and space required for the group to perform its tasks. It represents the costs that the designers or managers of the system are willing to incur to insure the accomplishment of group objectives. Estimating costs and funding requirements is a familiar and vital concern in research organizations. In the family situation, monthly income roughly defines the organization's resources. Insufficient income to meet the needs of the family for clothing, food, transportation, normal recreation, etc., may seriously affect the performance of its basic functions.

The importance of the surrounding physical and social environment for the functioning of any social system seems obvious and unequivocal and has been emphasized repeatedly. In the Mars mission, the hostile or unknown environment of space requires elaborate life-support and ground support systems, extensive preparation and training for any emergency, and an extremely high degree of technical proficiency in crew personnel. In the slum-dwelling family, not only is there assumed to be a direct impact of crowding, poor heating, lighting, ventilation, sanitation, etc., upon health and self-perceptions, but the brutalizing effects of slum neighborhood attitudes and behavior patterns may be presumed to directly contribute to social pathology.

It may be useful to further conceptualize slum-dwelling families in terms of some of the social system characteristics outlined earlier. Slum families are not only disadvantaged in terms of resources, but they are typically disorganized, have little awareness of objectives and related tasks, and evidence value systems that are delinquency producing. For those who have studied slum families it has been striking that a large percentage offer no stable father figure. Furthermore, even where there is a father in the home, he often appears to shift responsibility for training the children entirely to the mother. The mothers in these families tend to see themselves as helpless and overwhelmed by the children's demands. An essential element lacking in these families is apparently what has been called "executive guidance." There is no one in an executive role to provide direction and control in relation to the family's internal needs and in relation to dealings with the outside world. Frequently in these families, authority and responsibility tend to fall upon the oldest sibling whose principal involvements usually are not within the family.

The therapeutic approach found to be effective with slum families was not the traditional individual psychotherapeutic relationship. Rather the more successful therapeutic strategy was to work with the family-as-a-whole in meeting its day-to-day problems while attempting to strengthen the internal capacities of the family to cope with everyday stresses and demands. Therapeutic goals were described in one extensive study of slum families by Minuchen, et al (1967) as: (1) restoration or institution of executive functioning in the head of the family, (2) increase effective communication between parents and children, and (3) modification of the value systems and role functions of siblings. This way of describing essential family functions appears to agree well with the systems approach outlined earlier.

Integration of Negro citizens into our schools, work organizations, and general social processes is of vital concern today. Unemployment and low income are basic problems facing black Americans. In terms of the social systems analysis model, solving the problems of unemployment could have profound effects upon the structure of the black family. In a recent study by Fleisher (1966), regression analyses of delinquency rates in 100 cities across the United States were conducted using as independent variables income, unemployment rates, racial composition, residential mobility, family stability, and region. Fleisher's results indicated that in "delinquency prone" groups a 1% rise in income was associated with a 2.5% reduction in delinquency and a 10% rise in income with a 20% reduction in delinquency. Extrapolation would suggest that black families given equal resources or income to that of white families would not have excessive delinquency rates. Even though such extrapolation is not justified, this study provides an illustration of the extent to which one family system parameter, income, may relate to social pathology.

The problems of integrating black Americans into the work force involves much more than simply providing job openings. The Negro worker may bring in personal values and perceptions of his situation which are quite different from those of his coworkers, and a period of social and cultural assimulation may be needed to achieve the necessary understanding and cooperation. There are many problems in black-white social relations that are as yet poorly understood, and much more research knowledge is required if low status blacks or other disadvantaged ethnic groups are to be successful in making the transition to stable employment and full social participation. Specific kinds of training appear to be required for socially and economically disadvantaged citizens in order to facilitate the needed communication and interaction in new cultural settings. Careful analysis is needed of customary behaviors, attitudes, and values of those groups of citizens who are moving into new social situations. Special problems exist in the area of motivation, in suspicion and distrust of white institutions, and in understanding the social norms and behavior expectancies of other cultural groups in concrete terms. The traditional approach in this area has been to try to change the new employees to adjust to the existing environment. Some thought should be given to changing the social environment, that is, training employees already on the job in the acceptance of new employees and in understanding their temporary difficulties in modifying long-established behavior patterns.

Successful on-the-job and school integration for black ghetto residents will depend upon finding ways to bridge the large differences in values and goals in relation to predominantly middle class values. Ghetto residents tend to be highly suspicious of white authorities, and their social behavior tends to be characterized by mistrust, low cooperation, and overtly hostile acts when in conflict with others. Low self-esteem, short-range time perspectives, and irregularity in job attendance lead to perceptions by middle class blacks or whites that ghetto blacks are unreliable. Ghetto blacks tend to be high on needs for affiliation and socializing which may be perceived by middle class individuals as avoidance of work. A systems analysis of the employment situation might show that it would be easier and less costly to change the values and expectations of middle class employers and coworkers until new work habits and normative influences can be gradually established in trainees from the ghetto.

The relationships of ghetto blacks with government agencies in many major cities are unbelievably bad. Training of police, welfare workers, and government officials in understanding the black culture would beem to be must more expedient for the time being than trying to train blacks in middle class values. Violence and fighting has a different meaning in the ghetto from that in the middle class neighborhoods, and, in fact, it is the behavior norm.

It is of great importance to institute large-scale research efforts oriented toward understanding the values, beliefs, and logic of ghetto residents in relation to the behavior of police and government officials. Ransford (1968) in a study undertaken after the Watts riots found that willingness to use violence to further Negro rights among ghetto residents was highly related to three factors: (1) little social contact with the outside community, that is, isolation; (2) feelings of being treated unfairly because of race; and (3) feelings of powerlessness or inability to change one's position. Education level played a part in this relationship in that feelings of unfair treatment and powerlessness did not relate significantly to willingness to use violence among college educated Negroes.

Finally, those social system characteristics in families, school groups, and work groups which are conducive to social health and effectiveness as opposed to delinquency, drug abuse, and other forms of social pathology need to be explicitly defined and carefully documented by extensive research. If we are serious in doing something about the plight of disadvantaged Americans, we must know much more about these social problems and intensively investigate the social system characteristics that produce such conditions and the characteristics that prevent or alleviate them.

References

Berrien, F. K. A general systems approach to taxonomy. In Indik, Bernard P. and Berrien, F. K. (Eds.), People, Group, and Organizations, New York: Teachers College (Columbia University) Press, 1968, pp. 110-127.

Deutsch, S. Personal communication, 1970.

Fleisher, B. The effects of income on delinquency. American Economic Review, 1966, 56, 118-137.

Fraser, T. M. The effects of confinement as a factor in manned space flight. NASA CR-511, prepared under Contract No. NAsr-115 by Lovelack Foundation for Medical Education and Research, Albuquerque, New Mexico, July 1966.

Hall, A. D. and Fagen, R. E. Definition of system. In Buckley, W. (Ed.), Modern Systems Research for the Behavioral Scientist, Chicago: Aldine Publishing Co., 1968, pp. 81-92.

Katz, D. and Kahn, R. L. The Social Psychology of Organizations. New York: John Wiley & Sons, Inc., 1966.

Minuchin, S., Montalvo, B., Guerney, B. G., Jr., Rosman, B. L., and Schumer, F. Families of the Slums: An Exploration of Their Structure and Treatment, New York: Basic Books, Inc., 1967.

Murdock, G. P., Ford, C. S., Hudson, A. E., Kennedy, R., Simmons, L. N., and Whiting, J. W. M. Outline of Cultural Materials, (4th rev. ed.), New Haven, Conn.: Human Relations Area Files, Inc., 1961.

Radloff, R. and Helmreich, R. Groups Under Stress: Psychological Research in SeaLab II., New York: Appleton-Century-Crofts, 1968.

Ransford, H. E. Isolation, powerlessness, and violence: A study of attitudes and participation in the Watts riot. American Journal of Sociology, 1968, 73, 581-591.

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

Special Panel convened by NASA Langley Research Center. Principles of crew design, organization, and selection for isolation-confinement simulations related to long-duration space flight and undersea operations. Institute of Behavioral Research, Texas Christian University, Fort Worth, Texas, 21-22 May 1969.

Dr. Gunderson

In the paper distributed prior to the conference I described a tentative social system model that has been used to compare the Mars space mission situation with a number of other types of isolated and confined groups. It was suggested that this set of system characteristics might be extended and modified and perhaps prove useful for comparative analyses of other types of small social systems, such as slum families or newly integrated work groups. This suggestion was made hesitantly because much more work needs to be done on the model to make it generally applicable to a variety of social situations and problems.

I would like to use my time this morning to elaborate on the theme: how does one conduct meaningful social experimentation as a means for developing sound social planning and policy? This is a timely and important question. If the governing body of a community or an organization can agree on what changes in their system are desirable, how can they best insure that actions taken will accomplish desired ends? To answer, we must consider some aspects of statistical theory. (I am indebted to my colleague, Dr. Ardie Lubin, for suggesting basic ideas presented here.)

The first observation is that social and environmental changes occur all the time and have some effect on community life. New laws, new educational, medical, or social programs, new community facilities, etc., presumably affect the population concerned in some way, or they would not have been instituted. Yet we usually have no way of knowing what these effects are.

In order to assess the effect of some environmental or social change by means of the classical experimental model of R.A. Fisher, control groups are needed. The assignment of social units to the control group or the treatment group must be truly random. The impracticability of applying Fisher's rigorous paradigm to social experimentation has led D. T. Campbell and others to propose "quasi-experiments," where the requirement of random allocation to control and treatment groups is relaxed or the control group is eliminated altogether. In the quasi-experiment, the emphasis is on the use of the treatment group as its own control. The argument is that if you know what the status of the group was before the social or environmental change was introduced, and measure the group after the change, then the before-and-after difference is an estimate of the effect of the change. A serious technical difficulty in this design is that social units will rarely be stable prior to the treatment. They will show a variety of complex trends, some cylical (such as monthly or seasonal cycles), and some long-term (such as growth and development or change in technology). Therefore, the "before" measure should include an estimate of where the group is going as well as where it is now. This permits the elimination of so-called "trend" effects from the estimate of the effect of the social change. Campbell has termed such analyses "interrupted time series."

Let us assume for purposes of illustration that a community, say the city of Los Angeles, tentatively plans to build some parks and playgrounds. Someone in the city government objects and insists that the money should be spent for something else, such as smog control.

Proponents of parks and playgrounds claim that the community would benefit considerably from their program. How should the available resources (tax dollars) be used? The only sound approach to such a question would be systematic evaluation of the effects of various policies and innovations by empirical testing. The next step for the Los Angeles City Council in our example would be to evaluate the proposal that building parks have favorable effects on community life. For proper evaluation, a portion of Los Angeles should be divided into number of clearly defined districts. These would represent possible treatment areas, that is, areas where parks might be installed.

Three possibilities for conducting such an evaluation will be considered: (1) formation of treatment and control groups with random allocation, a true Fisher experiment; (2) formation of treatment and control groups without random allocation, a quasi-experiment; (3) formation of a treatment group with no control group.

The first problem would be the selection and measurement of social indicators or criteria that represent the desired effects of building parks. These indicators might be rates of juvenile delinquency and attitudes of satisfaction toward the community. We will assume that the aforementioned criteria were selected and found to be measurable. (We ignore many practical and theoretical difficulties of finding such social indicators.)

In order to implement the Fisher design with random allocation of treatment and control groups, we would need a number of neighborhood areas or administrative units (districts). We would gather data on the selected social indicators -- juvenile delinquency and citizens' attitudes -- before treatment is applied, i.e., before the parks are established.

Time series analysis would be applied to the social indicators to find out what models and parameters will describe each set of values. Ideally, this pre-treatment measurement and analysis should continue until we are satisfied that we have equations that will fit the observed values.

Now we use the derived equations to predict a key social indicator, say delinquency rate, for each district. The prediction should be made for the same time period that we anticipate analyzing for the effect of the treatment. Then we would stratify the districts in pairs by predicted delinquency rate, and allocate each member of the pair, at random, to the treatment or control group; that is, the two districts that have the greatest predicted delinquency rates would be selected and a coin tossed to determine which district would be allocated to the treatment group. Then we would take the next two districts that are highest in the predicted delinquency rate, toss the coin, and allocate the pair, etc. When applied to all districts in the experiment, this procedure is called stratified random allocation. It is an optimal form of the Fisher experimental design.

Suppose there is no possibility of stratifying the sample of districts by a key social indicator before the treatment begins. Then the districts should be allocated at random to the treatment and control groups without stratification. Although this procedure is not optimal, it still meets the basic requirements of a Fisher experiment, i.e., random allocation.

After the onset of the treatment period the social indicators will be measured periodically, in the same way, in all treatment and control districts.

It will be recalled that we have predicted the social indicators during the treatment period from the pre-treatment time series. The crucial step in the analysis is the subtraction of the predicted values from the values actually observed during the treatment period. If these deviations sum to zero within each district, then the overall effect of the treatment is nill. If these deviations have an average positive or negative value, then there is an effect of the treatment above and beyond the changes due to pre-treatment trends.

Random allocation is often completely unrealistic in situations of social change. Ordinarily the location of parks, or other projects, is determined by financial, social and political factors completely outside the scope of any planned experiment. A rational alternative in the neighborhood parks situation is to find a district or set of districts that will not be treated and to select control districts from this untreated set. These control districts are selected so as to match the to-be-treated districts.

Again, the notion of baseline measurement combined with time-series analysis to match our groups is used. Baseline measurement and analysis of the to-be-treated districts continues until we can fit the observed data with explicit time-series equations. Then predictions for each social indicator are made for the projected treatment period.

The untreated districts are measured and analyzed during the baseline period until a satisfactory time-series fit has been obtained. Predictions are then made for the time interval to be covered by the treatment period.

For each to-be-treated district, a control district is found whose predicted social indicators most clearly match those of a to-be treated district.

When the treatment period is over, the deviations from the time-series prediction are summed, divided by their standard deviation, and used as scores for each district. For each social indicator, one-way analysis of variance can be used to test the difference between the control and treated groups.

The procedure just described is a quasi-experiment. Non-random allocation of the districts to the control and treatment groups makes it impossible to use the usual inductive inference. With random allocation for a large set of experiments, a treatment with no effect would lead to a zero difference between the control mean and the treatment mean. Without random allocation, there is no effective way of guarding against the possibility that there are systematic differences between the control group and the treatment groups other than those introduced by the treatment.

Now consider the third case, treatment group but no control group. In this extreme case, the treated districts may be unique or the necessary measures of the social indicators may be obtainable only from the treated districts. In these situations, it may be necessary to give up entirely the idea of a controlled study; even the non-random-allocation matched-groups design may not be possible.

We are left with the basic two-phase design: baseline measurement of the to-be-treated districts until a satisfactory fit has been obtained, then calculation of the deviation from baseline prediction during the treatment period. As before, the average of the deviations, divided by their standard deviation, becomes the score for each district. Under the null hypothesis of no treatment effect, these district scores have an expected value of zero.

In the worst case, there is only one treated district, and the question is whether the deviations from prediction (during the treatment period) differ significantly from zero. Several time-series analyses have been suggested for this case. Severe difficulties of a statistical nature arise, however; in particular, if the deviations from prediction show serial correlation, the proposed tests are inappropriate.

To apply Campbell's Interrupted Time Series Analysis to any of the three cases given above, a time series equation must be fitted to the baseline data. Two dynamic time-series models have been developed for use by engineers, industrialists, and economists: the Moving Average Model and the Auto-regressive Model. Both of these assume that an observed value at time t is some function of previous observations at time t-1, t-2, t-3, and so on. If one knows the order of the model, that is, the number of past observations that must be considered, then a prediction for time t can be generated from the past observations.

A time-series equation of either type can be generated for each district.

A test for serial correlation among the residuals is directly incorporated into the fitting of the autoregressive model.

One distinct advantage of the autoregressive function is that it can be used to estimate the "transfer function." The transfer function of a system is, roughly speaking, the ratio of the output of the system to the input. Given the transfer function for a system, it is possible to calculate what will happen as various inputs are fed into the system. Unfortunately, this is only possible if the autoregressive equation is completely linear.

Nevertheless, this raises the possibility of conceiving of each social unit (district, county, city, etc.) as an integrated system, with a set of social indicators that are dependent upon each other in a feedback manner so as to preserve homeostasis for the social unit. This approach demands a multiple time-series method in which every time-series for a social indicator is a function of its own past behavior and of the behavior of all other social indicators. Methods have been given for the analysis of suchmultiple time series.

To summarize, Campbell and others have proposed that environmental or social changes be regarded as quasi-experiments and that pre-treatment measures as well as during-treatment measures be taken. At the end of some trial period, perhaps three to five years, the feedback from the time series analysis is used to help us accept or reject the social reform or environmental change on a quasi-statistical basis.

The time series model recommended by Lubin, the Autoregression Model, raises the possibility of considering social units as systems and applying the control theory that is customary in engineering. This can be done if the fitted autoregression equation is an adequate representation of the transfer function, i.e., the ratio of the system output to input.

This may sound very complex to the uninitiated, and indeed it is. Yet the fact that there is a possibility of using time series in certain types of social experimentation is considered very significant and encouraging.

(More detailed discussion of these issues may be found in the following sources:)

Campbell, D.T. and Stanley, J.C. Experimental and quasi-experimental designs for research. Chicago: Rand McNally, 1966.

Lubin, A. The use of time-series in social experimentation. Unpublished paper, Navy Medical Neuropsychiatric Research Unit, San Diego, California 92152.)