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THE PROBLEM OF OFF DUTY TIME IN LONG DURATION SPACE MISSIONS

Volume I
SUMMARY AND RESEARCH RECOMMENDATIONS

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Prepared by

John W. Eberhard

Prepared under Contract No. NASw-1615

SERENDIPITY ASSOCIATES
McLean, Virginia

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FOREWORD

This report is the first of three volumes dealing with the off duty time problem in long duration space flight. The report summarizes the off duty time and activity findings presented in the final report (Volume II). It also presents detailed research requirements necessary to obtain design criteria for time and activities in long duration missions. The report can be used in conjunction with the annotated bibliography (Volume III) to obtain background literature sources to further comprehend and extend the research requirements. This work was performed by Serendipity Associates under Contract No. NASw-1615 for the National Aeronautics and Space Administration, Washington, D. C.

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CHAPTER I
SUMMARY

PROBLEM

This study was performed to determine to what extent man's off duty time should be considered in the development of long duration space flights. Mission constraints such as the extended time period (one to three years), total commitment to the spacecraft for life sustenance, and the psychological and social problems related to constant contact with the same small crew (three to twenty people) warrant careful consideration of off duty time. Therefore, an analysis was performed of the amount of off duty time available in long duration missions and a determination of the effective utilization of this time was made.

APPROACH

The approach utilized to evaluate the off duty time period reviewed and analyzed the available literature in order to: (1) determine how much off duty time was available in the long duration space missions, (2) establish criteria for evaluating off duty time by determining how much off duty time is available both in relatable general populations and in special populations, (3) evaluate the available off duty time in mission studies in light of the time available in the general and special populations, (4) generate principles related to off duty time developments for anticipated space flights. Suggestions for reducing the extensive off duty time were also generated. A similar approach was employed in evaluating the discretionary activity possibilities to be employed in advance space flight. In addition, an extensive list of potential discretionary activities was generated. Finally, research requirements which should be effected before definitive answers concerning time utilization are possible were developed.

OFF DUTY TIME CONSIDERATIONS

This section defines off duty time in mission studies, determines the amount of time available, establishes criteria for evaluating the time, evaluates the time, gives suggestions for handling excessive off duty time and presents principles for incorporating off duty time in mission planning.

Definitions

In order to appreciate the problem of off duty time we must first distinguish between scheduled off duty time and unscheduled off duty time. Scheduled off duty time is that time allocated on a mission time line that enables crew members to engage in activities of their own choosing. Unscheduled off duty time is time available during the course of a mission due to excessive time allocation to scheduled activities. Excessive amounts of unscheduled off duty time can have a serious deleterious effect on mission performance and success because frequently there will be inadequate off duty activities to keep the crew members from becoming disturbed and bored. Therefore, a careful analysis of the unscheduled off duty time possible in some representative long duration space missions was performed. In estimating the adequacy of the off duty time in long duration missions, both the scheduled and unscheduled off duty time were taken into account.

Mission Studies

The amount of off duty time was obtained by reviewing representative long duration mission studies (3, 6, 7, 8, 10, 11, 12) and obtaining estimates of their scheduled off duty time and time allocated to work, sleep and contingencies. Unscheduled off duty time was obtained by analyzing scheduled operations to determine how much of the time allotted was not required. The best estimates of time required for work and sleep, particularly during deep space, were applied to these mission studies in order to obtain unscheduled off duty time estimates. The results of the analysis indicated that there were inadequacies in the allocation of time in different phases of long duration missions and, thus, excessive off duty time may result.

Time required for contingencies, sleep and work as determined in this study together with estimates from mission studies are presented in Table 1. The table also presents the scheduled off duty time allocated in the mission studies which varies from 1.5 to 3 hours. There tended to be a consensus of opinion that activities within the off duty time period should be the free choice of individuals. One shortcoming found with relationship to scheduled off duty time was that in some of the mission studies the time periods did not coincide for some of the crew members, reducing or eliminating social interaction.

The basis for deriving the current estimates of time required for sleep, work and contingencies are:

1) Overallotment of sleep time. The results of the Gemini VII mission, particularly the second week of that mission, would tend to indicate that five hours a day may be sufficient sleep in the weightless environment (5). Also, the data from confined groups and work/rest simulation studies tend to indicate a reduced sleep requirement. When the five hour sleep time estimate is contrasted to the 7.2 estimate from the mission study average, it is seen that there is an excess of 2.2 hours allocated for sleep that would be unscheduled off duty time.

2) Inadequate work opportunities. Based upon an analysis performed by Serendipity of the work opportunities during the deep space portion of a Mars mission, an estimate

TABLE I

Summary of Scheduled Off Duty Time, Contingency Time, Sleep Time, Work Time and Days for Each Crew Member Per 24-Hour Day for Long Duration Space Flight

Source	Time Allocation: Scheduled Off Duty	Contingency	Sleep	Work	Work Days/ Week
Douglas MORL (3)	1.5	2.4	8	9.3	7
Douglas MARS (7) Contingency	1.5-3	1.5-2	7	10.3-10.8	7
Serendipity Long Term Mission (10, 11)	2.75	----	7.6	5.6-7.7	7
Lockheed Early Manned Inter-planetary (12)	1.9	----	7.2	8	7
NAA Mars Landing and Return (6)	Indeter-minate	----	5.5	12.8	7
AFSC 30-Day Low Orbited (8)	3	2	8	11	7
Average Mission Estimate	2.1-2.4	2.0-2.1	7.2	9.5-9.9	7
Current Estimate		0-2.1	5[a]	4[b]	5.5
Unscheduled Off Duty Time		0-2.1	2.2	5.5-5.9	

TOTAL OFF DUTY TIME 9.8 - 12.6 Hours per 24-Hour Day

[a]Represents approximate number of hours of sleep from day 7 to day 14 for Gemini VII (5).

[b]Represents upper estimate of time for scientific and operational work requirement during interplanetary (deep space) phase of Serendipity Mars mission analysis (10).

of approximately 4 hours per day per crew member was obtained. This is to be contrasted with the 9.5 to 9.9 average for the mission studies and to the mission design objective of keeping the crew members meaningfully occupied as a control of boredom. It should also be noted that the deep space phases account for more than 99% of mission time; however, crew size is generally based upon work required for the remaining 1% of the mission

3) Lack of contingency time utilization. In some mission studies a time factor is allotted for contingencies. By definition a contingency time period may or may not be used and when not used becomes unscheduled off duty time. Furthermore, it would seem likely that certain equipment failures may occur which may further reduce the working opportunities after an initial surge of maintenance operations trying to repair the failed equipment. The lack of contingency time utilization could contribute on the average up to 2.1 hours a day additional off duty time. Thus, the available off duty time summing scheduled off duty time and unused work, sleep, and contingency time can range somewhere between 9.8 and 12.6 hours per day on the average. This is a lengthy time period for highly confined crew members with limited outside activity possibilities on a one to three year mission.

Off Duty Time in Relatable Populations

The off duty time patterns of both general and special populations were reviewed. A summary of key facts about time utilization found in this review are presented in Table II. Time utilization surveys presented

TABLE II

Summary of Facts about Time Utilization
(Hours)

Source	Free or Off Duty	Sleep	Work	Eat	Work Days per Week
General Population					
Robinson (14)	5.0	7.6	5.8	1.2	
Ward (in deGrazia (4)	4.5[a]		6.0	1.2	5.5
Special Populations					
Gemini VII (5)		5			7
Antarctica					
Pole Station (9)					
Summer	8.4[b]	8.05	9.03	1.58	
Early Winter	10.56[b]	7.92	6.41	3.00	
Late Winter	10.22[b]	8.19	6.99	2.92	
Simulator Studies					
Lockheed (1)	4.33	5.5			7
Rathert (13)		5.1			7
Boeing (2)	2	7[c]			7[d]
Shelter Studies					
Strope (15)	4-5				
Mission Studies					
Serendipity Deep Space (10)			2.4-4+		

[a]Underestimate due to curtailing sampling at 11 p.m.

[b]Represents an extensive over-estimate since participants could be engaged in more than one activity simultaneously, e.g., eating and talking.

[c]Two split 3.5 hour periods allocated for sleep.

[d]Suggested simulating Sunday.

in de Grazia (3) and Robinson (10) were the principal data sources for the general population. These surveys indicate that men in general have approximately 5 hours a day for off duty or free time and that over 3.5 hours of this time are spent at home or in activities that could readily be performed in space. The Ward survey (see de Grazia) also indicates that off duty or free time is distributed around breakfast, lunch, and, for the most part, in the evening. Also, there are indications that men in general work a five and one-half day week.

The special environments studied included Antarctica, remote aircraft and warning sites, Naval ships and submarines, space simulator studies, air raid shelter studies, and laboratory studies. The intact group studies consistently indicate that off duty time is a problem for isolated individuals. There is a tendency for the isolated groups to have less off duty time than that found in the general population -- somewhat less than 5 hours a day. None of the studies reviewed had even half as much off duty time as was available in the mission studies reviewed, and only one of the studies, namely, Boeing's Manned Environmental System Assessment (1) had less off duty time scheduled than was scheduled in the mission studies.

Evaluation of Off Duty Time

Thus, in light of both the general and special populations reviewed it can be said that the available off duty time in long duration missions is much in excess of that which is preferred or available in relatable groups. Work opportunities are sought by groups in isolation, and the men are unwilling to share their work load with others whose work opportunities may have been reduced. Also, groups in isolation who have adequate work opportunities have lower incidence of abnormal symptoms such as sleeplessness, depression, anxiety, etc. Thus, the design goal of keeping men meaningfully occupied as a control of boredom or monotony is an appropriate one, if feasible. In light of the above analysis principles related to incorporating off duty time considerations in long duration missions were generated. These principles are presented in Appendix A.

DISCRETIONARY ACTIVITIES

As a further evaluation of the off duty time period, the discretionary activity possibilities for long duration space flights were determined. Activities from the mission studies and the general population were combined and evaluated in light of long term confinement on activity patterns as determined in special environments, particularly Antarctica.

Definition

One final definition is required in order to place the study in perspective, namely, the definition of discretionary activities. Discretionary activities are those activities provided for or created by the crew members who may use the activities at their discretion; that is, the crew member has free choice in considering whether to engage in the activity or not.

Findings

The results indicated that the off duty time and activity patterns of isolated groups differ from those of the general population; furthermore, the activity patterns of individuals in confinement change over time. Men in confinement talk more, read more, and watch more movies and/or television than men in general, and they also take twice as long to eat. Confined men also tend toward more individual activities, e.g., increase reading time as a function of their time in confinement. There is relatively little interest in painting, playing cards, chess, and checkers by most of the individuals studied. Education, a frequently mentioned activity, was found to be highly individualistic and infrequently sought by most individuals. In general, the recreational facilities in most of the remote groups studied have historically been the source of significant morale problems.

In light of the review of discretionary activities, a list of potential activities of an intellectual, physical, religious, and social nature that could be performed by individuals and/or groups was prepared (Appendix B). In the final report, some indication concerning the anticipated frequency and probability of use of each of the activities is suggested. Furthermore, guidelines for the design of discretionary activities are given in light of available off duty time, crew psycho-social problems and spacecraft constraints (Appendix C).

REDUCTION OF OFF DUTY TIME

In light of the excessive off duty time determined for deep space, factors which could reduce real or apparent off duty time were suggested. These factors were crew size and composition, mission duration, mission day and work week time and structure, crew selection requirements, use of pharmacological agents in depressing time, and hardware and energy requirements for the spacecraft. The mission studies reviewed indicated that crew size was generally based upon the heavy work portions of the missions, for example, flying by Venus or Mars or the Mars Exploration Phase. In some instances, this time represented less than 1% of the total mission time. Thus, suggestions relative to reducing crew size and skill levels to permit a more uniform work load throughout the mission were developed. Emphasis was placed on changing the working or worker requirements during the heavy work portions such as recommending automatic and semi-automatic systems to aid in collection and analysis of relevant information, and scheduling short periods of intense work for the crew. Consideration was also given to reducing the length of a mission day particularly during deep space. A rationale for reduction in day length in light of lack of evidence to the contrary was presented. Furthermore, suggestions were presented for (1) reducing the work week from seven days (as was found in all missions studied) to 5.5 days to correspond more to work weeks in most of the situations studied, and (2) to increase the work load during the work portion of the week. Suggestions relative to individual differences of potential candidates in their ability to cope with the free time were presented. Finally, directly attacking the excessive off duty time of the deep space flight by increasing the spacecraft energy requirements, and thus reducing flight time was discussed.

CHAPTER II
RESEARCH REQUIREMENTS

Research requirements resulting from this study could be directed solely to the problem of off duty time and the design of discretionary activities. However, it is our belief that this problem is more properly solved in the broader context of design criteria for including man in long duration space missions. Objective crew design criteria can only be established after some definitive research has been performed in the areas of:

(1) Work opportunities during all phases of potential missions.

(2) Sleep requirements as a function of gravity and other conditions.

(3) Impact of gravity on sleep, work opportunities, and human support functions.

(4) Time considerations (day length, work day and week) related to sleep, work opportunities and off duty time in the design of missions.

(5) Development and assessment of discretionary activities in light of available off duty time, mission length and crew characteristics.

Once the above areas of study are in various stages of completion we will be in a much better position to establish design criteria relative to crew requirements for all phases of intended missions. The criteria should permit a determination of crew size and composition including skill levels for performing the required activities during all phases of the mission. Furthermore, criteria relative to work opportunities and crew well-being, leadership patterns for work and non-work activities, mission time line requirements in light of activity possibilities, psychological characteristics, pharmacological requirements, habitability considerations and definitive estimates of activity possibilities in light of available time and gravity conditions could be presented.

Research requirements will be presented in each of the areas listed above. The point of orientation as well as the most crucial consideration in the development of the research effort will be presented. Consideration will also be given to possible places where required results can be obtained, such as Antarctica, laboratory studies, space simulation studies, mission planning efforts, study contracts, and direct space experience.

WORK OPPORTUNITIES

Because of the fact that work is the most frequently sought activity by men in long duration confinement and yet there may be inadequate work opportunities, an initial study effort should detail the work opportunities possible in all phases of intended missions. The study should establish as many work tasks or requirements as possible during the various phases of representative potential missions. This should be done from a work requirement point of view as opposed to initially considering the means to effect the given tasks. Once a reasonable population of work opportunities or tasks has been established in a given phase, then consideration should be given to the means required to effect the tasks. Alternative means should be detailed down to the level where a decision concerning allocation to man or machine can be made and that the skill and experience requirements for men in performing the task can be determined. The end product of this work effort would be a data bank of work opportunities together with the required skill levels to effect the given work requirements with the means detailed. The end product would be extremely useful in giving due consideration to the crew size and composition characteristics throughout all phases of the intended or planned missions. Crew work opportunities in a given mission could be then designed around both the time requirements to effect various work opportunities as related to the available work and the skill level of the crew members. It would also enable mission time lines to be developed around the work requirements of the specific crew for the total mission. For example, if a high level of skill is required in decision making concerning types of Martian surface to collect, then, the work tasks during deep space should also be selected from the work data bank to require high level decision making. The current study would also impact hardware developments since it would point out phases in the mission in which advanced technology might be required in order to level the crew skill requirements to permit a more uniform crew size and skill level composition for the total length of the mission. The work opportunities study should also impact or be interdependent with all of the other study areas which follow, particularly if it is shown that it will be difficult to develop meaningful work opportunities during the deep space phases of the mission. Some of the areas in which this impact will be directly relatable are:

(1) Establishing the number of hours of work available during different phases of the mission.

(2) Giving inputs into establishing exercise requirements as a function of work opportunities that produce the effects similar to those expected of exercise.

(3) The determination of an optimum work schedule as a function of work opportunities.

(4) A determination of available off duty time as a function of work opportunities.

(5) Providing data concerning the need for a reduced work week or a reduced mission day.

(6) Providing inputs into determining sleep requirements as a function of the physiological characteristics of movement in work actions.

SLEEP REQUIREMENTS

Another conclusion of this study is that there is evidently a marked reduction in the number of hours sleep required in the weightless environment than on Earth; however, there are many aspects to the sleeping requirements that are unsolved.

The initial area of work should be concerned with sleep and the gravity field of the spacecraft during different phases of the mission. A graph indicating number of hours of sleep required as a function of the amount of gravity would be desirable. This would particularly be helpful in establishing sleep times as a function of the aritficial gravity field and the gravitational field on the surface of the various planets that might be explored. Furthermore, there is a requirement to determine the influence of exercise and work opportunities on the sleeping process. Sleep changes as a function of the physiological and psychological aspects of exercise and work are required. Possibly a hypodynamic environment could be considered as the test site for determining the physiological influences brought about by exercise and work type activities on the sleeping process. However, it is felt that ultimately the impact of exercise and sleep can only be adequately determined from space flight opportunities where controlled or at least accurate measurement of the exercise and work opportunities can be obtained.

There is a serious question concerning whether the reduced sleep requirements in the weightless or reduced gravity environment is desirable. One area that has received little, if any, attention to date is the psychodynamics of crew members as a function of a reduction in the dream time because of reduced sleep time. If reduced dream time is in fact a serious problem, then it behooves us to uncover the problem before we send crew members on long duration interplanetary flights that can produce many psychological and social problems of their own right. Furthermore, if there are limited work opportunities there may already be too much off duty time and additional time as a result of reduced sleep requirement may not be desirable. Studies of the reduced sleep and dreaming characteristics might be performed in the laboratory by reducing the sleep time available. However, problems that might develop would be difficult to differentiate as a function of sleep debt versus dream time reduction.

Consideration may be given to the use of pharmacological agents that would extend the sleep period; however, an insufficient amount of information is known about extending the sleeping period beyond that which is physiologically required. The influence of drugs on sleep time requirements would appear to be most appropriately performed under laboratory conditions with some verification in either the hypodynamic or spacecraft environment.

If consideration is given to reducing the day length and additional time available as a function of reduced sleep, then there is the further consideration of determining the sleep requirements as a function of length of day. A graph of hours of sleep versus hours in the day might be developed to give further guidelines relative to the sleep time required as a function of mission day length.

In conclusion it might be added that although we can probably anticipate a fairly marked reduction in numbers of hours of sleep, there are many interactive elements; i. e., gravity condition, day length, exercise effects, dream effects, work effects and psychological effects, that are unknowns in the establishment of the number of hours or the influence of sleep in long duration space flights. It is anticipated that work in this area should help in the establishment of:

(1) The number of hours of sleep required as a function of gravity and other conditions.

(2) Determination of the influence of reduced sleep on the psychodynamics of dreams.

(3) Determination of the influence of drugs in the control of the sleep requirements.

(4) Determination of the influence of work and exercise on the sleep requirements.

(5) Determination of the influence of length of mission day on the sleep requirements.

(6) Determination of the influence of sleep time available and the influence on crew monotony and boredom.

(7) Determination of the sleep requirements on other aspects of the human support system such as eating requirements, hygiene requirements and psychological and medical requirements.

GRAVITY CONDITIONS

One of the most complicating factors for man in space flight is the gravity condition. As we have seen, it reduces his sleep time requirements, it changes his work habits, it has a decided influence on his exercise requirements, makes difficult his eating and personal hygiene, and changes and reduces his discretionary activity possibilities. The gravity condition could be the one single influence that pushes man's acceptance of long duration space flight from the bearable to the unbearable. As we have already indicated, we know so little about the impact of the reduced sleep requirements on crew well being that it is impossible to say what influence the side effect of gravity will have. In the area of exercise the forecasting is a little clearer. As we have seen in the study, exercise is a generally infrequently performed activity by most adults. In addition, physiologists are still unclear concerning how to exercise all of the various body processes that are dependent upon gravity for natural exercise. This fact alone may require the spacecraft to include some minimal gravity field. Thus, there is a need to determine the influence of various amounts of gravity on sleep requirements, work opportunities, eating techniques and requirements, hygiene techniques, and exercise requirements.

In light of the rather extensive level of deprivation expected on most long duration space flight, considerations of the impact of gravity conditions on crew member deprivation is required. As was seen in the

Antarctic studies, eating is a more sought after activity than it is for men in general. In the reduced gravity condition, eating techniques to date have been marginally acceptable although they may have been extremely nutritious. To expect crew members on long duration missions to employ the same techniques that our current astronauts employ in eating or in hygiene would be suspect from an acceptance point of view. Therefore, research is required to determine what acceptable eating and hygiene techniques can be developed in gravitational fields anticipated during long duration space missions. Though eating techniques may initially be determined in a food laboratory, and can be pretested in space simulations, the ultimate test can only be performed under fairly extensive time periods in a weightless or reduced gravity environment. Some consideration to their acceptance during long periods of confinement might be obtained as a function of having sample diets and eating techniques presented to crew members in remote sites, e. g. Anarctica. However, this could also create obvious problems because individuals are unwilling to put up with less than optimum conditions if they know that optimum means are readily available for their particular environment.

Physical exercise, though obviously required, will produce its share of hardships to crew members during the lengthy mission. If a gravitational field is not provided in the spacecraft, the result will be the onerous task of exercising for 2. 5 hours a day.[1] Therefore, some alternatives to exercise programs as we currently know them are required. Possibly an onboard, manually operated centrifuge might solve parts of the problem. If an extensive regime of exercise is required, consideration should be given to development of both co-operative and competitive group exercise programs. These programs

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1 As suggested by the Lovelace Foundation for the Serendipity long duration space flight mission.

should be pretested and have a high amount of validity and crew acceptability--they should be extremely interesting and motivate the crew members to be willing to perform the exercise over an extended period of time. If such activities cannot be developed, then consideration should be given to the development of spacecraft capabilities which incorporate a gravity field.

TIME REQUIREMENTS

One dimension that can be considered to solve some of the problems of crew members in long duration space flight is time. The mission studies reviewed indicated that there was inadequate or no consideration given to the manipulation of time to solve the problems that might be encountered during deep space. Some of the time factors that might be analyzed include: the establishment of the length of work week, length of work day, mission day length related to work, sleep time, human support and off duty time functions as well as an accounting system for actual time utilization during total mission development.[1] People who have successfully completed long term confinement experiences, particularly unplanned for experiences such as shipwreck, report that a regime which permitted passage of time was highly desirable. Therefore, an analysis is required which would permit the development of guidelines for mission time lines that permit crew members to observe and anticipate the passage of time.

Although all the mission studies reviewed were based upon a 7 day work week, the current study shows that there is no good reason for considering this length for the work week. Consideration should be

[1] One of the difficulties uncovered in the current study was in trying to compare activities and time as presented by the different mission studies. There were inadequate definitions of the activity requirements during the space flight studies as well as the allocation of time to the various activities. Therefore, one of the areas of research required is the generation of guidelines relative to the development of mission time lines.

given to what the impact would be on system performance as a function of a 5 or $5\frac{1}{2}$ day work week; particularly during the deep space portions of the mission where work opportunities are reduced. Conversely, can men meaningfully employ a day, day and a half, or two days of consolidated off duty time in the limited environment of the spacecraft. This will probably depend upon the ability of mission planners to present phenomenologically equivalent experiences to those that are normally possible if the crew members were on Earth during the weekend period.

One of the more critical considerations for reducing excessive off duty time is reducing the mission day length. Since there is limited data on this phenomenon available, there is need for extensive study on the feasibility of the reduced day length, particularly considering the reduced sleep requirements and work opportunities. Whether such an experiment can be performed on Earth is somewhat questionable. The best Earth oriented test site for reduced day length would be the hypodynamic type experiment in an area in which the lighting conditions were made comparable to those that can be anticipated on the spacecraft. Ultimately, such reduced day lengths should be tested in the space environment.

Since calculated off duty time in the mission studies exceeded all Earth oriented groups studied, there is need to determine how men will adapt to the excessive time if this time cannot be reduced. However, consideration should be given first to reducing the time as a function of lengthening the work opportunities, possibly varying the sleep time requirements or the mission day length. Studies relative to crew composition characteristics as a function of excessive off duty time would appear warranted. The end product of such studies would be the establishment of criteria for selecting crew members who would be able to handle the available off duty time and activities for the extremely long periods of confinement and boredom expected in the missions. Laboratory studies to determine the influence of certain of the criteria on intact groups such as Antarctica or other remote military or civilian sites are possibilities. Ultimately, the off duty time and discretionary activity possibilities for excessive off duty time should be tested in the Earth orbital environment.

In summary, there is a need for:

(1) The development of specifications concerning the development of mission time lines.

(2) Establishment of an optimum work week for long duration space flight.

(3) Establishment of the length of mission day.

(4) Evaluation of man's ability to handle excessive off duty time.

(5) The establishment of criteria for the selection of crew members who can adequately cope with excessive off duty time.

DISCRETIONARY ACTIVITY REQUIREMENTS

Some additional discreet studies are required although their priority is dependent on performance of the studies just discussed. For example, if the off duty time period is reduced to an acceptable level, that is, below 5 hours a day, and if crew selection criteria for handling the off duty time period are developed and employed, research specific to off duty time may be reduced.

Some of the off duty time study areas include:

(1) The development of discretionary activities as a function of gravity field.

(2) Determination of the acceptability of special means required as a function of the spacecraft environment. For example, the manner of presenting reading material.

(3) A determination of the possibility of the currently listed discretionary activities to adequately fill the time available for off duty time.

(4) Determination of the availability and suitability of the suggested discretionary activities.

A review of the literature indicated that there was an almost total lack of advanced thinking in the development of discretionary activities that took advantage of the gravity field expected for interplanetary travel. There was some mention of a three dimensional tennis sport by Ericke in Walter Cronkite's 21st Century; however, this is almost the limit of advanced thinking given to the problem. As has been mentioned, there may be an extreme problem in having the crew members exercise throughout the duration of the mission; therefore, consideration should be given to the development of interesting space sports and space exercise alternatives. These probably would have to be evaluated in the space environment before being ultimately incorporated into interplanetary travel.

Will a crew member curl up with his microfilm reader? This question and similar questions should be raised concerning the means for presenting discretionary activities. Does reading a Bible from a microfilm reader give the crew member the required support that normal Bible reading might provide? The means of providing reading material, learning material, and other discretionary activities by type of activity or material should be examined and possibly tested either in a laboratory, space simulator or space environment.

APPENDIX A

Principles Related to Off Duty Time

Individual Considerations

1. The amount of free time for each crew member should be determined in light of scheduled opportunities and contingencies.

2. Approximately five hours a day of off duty time appears to be the upper limit desired in view of reduced activity possibilities in space.

3. Meaningful work opportunities are preferable to excess off duty time possibilities; however, sham tasks should not be the basis for these opportunities.

4. Off duty time periods should be designed around the personal preferences of the crew members.

5. Three off duty time periods per day are recommended -- two short ones around the breakfast and lunch periods and an extended period around and after the dinner hour.

6. A 5 or $5\frac{1}{2}$ day work week is recommended when feasible.

7. The mission time line should be designed to insure that social interaction is possible among the maximum number of crew members during the off duty period. However, in special instances, interpersonal conflicts can be reduced by reducing the interaction possibilities for conflicting members during the off duty time period.

8. Discretionary activities should be included that permit crew members to observe the passage of time.

Mission Planning Considerations

9. If time is allocated for contingencies, consideration should be given to what would be done with the time should contingencies not arise.

10. Task rotation should be considered as a normal routine to curtail the unwillingness of crew members to share their limited work opportunities should contingencies arise which limit a crew member's work opportunity.

11. Staffing for heavy work portions of interplanetary missions should be based upon the fact that motivated individuals can extend themselves for long periods when performing meaningful work.

12. Estimates of number of hours of sleep required per day should be based upon space experience or estimates related to the gravity situation for the specific phase of the mission.

APPENDIX B

Potential Discretionary Activities

Intellectual Activities

Individual

- Mission related
  - Preparation for operation
  - Preparation for experiment
  - Analysis of data
  - Update mission requirements
- Personal improvement
  - Advancement in grade
  - Course work for (advanced) degree
  - General course work
  - Writing dissertation
- General communication
  - Mission reporting
  - Personal diary--personal use
  - Personal diary--public use
  - Write articles relative to mission
- Personal communication
  - Private communication
  - Family stereo theatre
- Entertainment
  - Watching television
  - Watching movies
  - Listening to radio
- Musical activities
  - Listening to music
  - Making tape (voice or music)
  - Playing a musical instrument
  - Music arrangement and composition
  - Electronic music composition
- Reading
  - Reading books--fiction
  - Reading magazines
  - Reading newspaper equivalent
  - Reading books--non fiction
- Professional activities
  - Reading journals, technical books
  - Writing technical papers, books
  - Presenting technical papers

Intellectual Activities

Group

- Mission related
  - Discuss mission objective
  - Discuss failures
  - Writing books and articles
  - Group diary
- Musical Activities
  - Writing
  - Arranging
  - Band
  - Listening
  - Criticism and discussion
- Educational
  - Tutorial - on board expert
  - Pre-programmed courses
  - Developed during mission
- Communications
  - Mission control
  - Personal interest group
  - Professional organization
  - Technical paper presentation
  - Writing books and articles

Religious Activities

Individual

- Reading material
- Religious articles
- Special religious communications
- Religious rites handbook
- Religious exercise
- Radio/TV religious exercise

Group

- Denominational service
- Non-denominational service
- Inter-faith discussion periods
- Crisis services--death, sickness
- Bible and religious reading

Potential Discretionary Activities (Continued)

Social Activities

Individual

- Personal communication
- Personal reflection
- Family activities
- Video shopping tours
- Doing nothing
- Cat nap
- Ham radio
- Games
  - Solitaire
  - Puzzles
  - Autobridge

Group

- Talking sessions
- Parties
- Special events
- View and discuss sports
- Discuss viewed material
- "Happy Hour!"
- Contact with Earth organizations
- Shows and skits
- Gambling
- Clubs
  - Stock market club
  - Literary discussion club
- Games[1]
  - Acey Ducey
  - Bridge
  - Cards
  - Charades
  - Checkers
  - Chess
  - Cribbage
  - Crossword puzzles
  - Electronic shooting range
  - Electronic sports games
  - Intellectual games
  - Monopoly
  - Puzzles
  - Scrabble

Physical Activities

Individual

- Personal effects
  - Store for personal articles
  - Personal living area change
  - Reconfigure
  - Redecorate
  - Repair
- Personal belongings
  - Keeping things in order
  - Clean house
- Exercise program
- Space walk
- Manual
  - Handicraft
  - Art: Paint - draw

Group

- Living quarter habitability
  - Sleeping quarters swap
  - Reconfigure group activities area
- Exercise
  - Cooperative exercise
  - Competitive exercise
  - Group space walks
  - Space sports
  - Special eating--holidays, etc.

[1] The list is not intended to be exhaustive.

APPENDIX C

Principles in Designing Discretionary Activities

Individual Considerations

1. Selection of discretionary activities must take into account personal preferences of crew members and the influence of long duration confinement on these preferences.

2. Use of discretionary activities should be the crew's free choice.

3. Crew member acceptance is critical in the selection and design of discretionary activities.

4. The discretionary activity patterns of crew members will differ as a function of their being in isolation and as a function of the time they are in isolation; therefore, the activity preferences of crew members must be adjusted for these factors.

5. The discretionary activity value of eating should not be overlooked since men in confinement take almost twice as long to eat.

6. In considering educational activities, previous habit patterns relative to education is a better predictor than lofty goals crew members might anticipate for their confinement period.

7. Activities that reduce or alleviate the abnormal symptoms frequently found in remote groups should be selected and developed; e.g., earth oriented activities such as participation in family affairs and organizations.

8. Activities which can produce interpersonal conflicts, for example, differences in musical preferences, should be handled either in the selection of individuals or in the manner of presenting the activities.

9. Discretionary activities should be selected that tend to reduce the anticipated monotony and increase sensory stimulation.

10. Discretionary activities should be custom designed both for the individual and the group.

11. Wherever possible and practical, existing onboard equipment should be employed as the means for discretionary activities.

12. Where onboard equipment is employed consideration of excesses such as additional logistic requirements, impact on reliability, storage and power as a function of use for discretionary activities must be taken into account.

13. Estimates of spares and expendables required for selected discretionary activities should be made based upon frequency of use of the total crew and length of mission.

14. The design must take into account the weightless environment and other characteristics of materials such as their flamability, toxicity and odiferousness.

Group Considerations

15. In considering group activities it is necessary to determine whether there is sufficient ability and interest among crew members to meet the group size requirement for the activity.

16. Since men in confinement withdraw from direct confrontation with incompatible crew members, there should be a provision for privacy in both crew quarters and discretionary activity possibilities.

17. Rules relative to activity performance should be considered in the design, integration, and use of activities in the space craft.

18. Discretionary activities should not accentuate pre-existing crew composition differences that are likely to lead to interpersonal conflicts.

19. Activities should not be selected that enhance concern about total committment, limited abort capabilities or the operations of the life support system.

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