NASA Contractor Report 3942

Human Performance Issues Arising From Manned Space Station Missions

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SUMMARY

Ten former NASA astronauts were interviewed to provide information for use in planning future space flight missions. Although no statistical analysis of the material was performed, the responses do provide insight into numerous aspects of space flight, including psychological aspects, training, command structure, health and comfort, physical aspects, and many others. The responses by the Astronauts to the questions are presented together with comments by the researcher, himself a physician with long experience with the space program. Additionally, spontaneous matters that came up in the questioning periods are reported upon together with the researcher's comments on these as well. The results, which maintain the strict confidentiality of the individual respondents, contribute to the basic information required by those planning future missions in space.

INTRODUCTION

This is a report of information obtained during the course of separate interviews with ten former NASA astronauts that took place during the first half of 1984. The purpose of the interviews was to elicit information that had not been previously reported and that might open leads for fruitful research endeavors applicable to the United States Space Station program.

There are many reasons why this information might not have been reported. It might have been forgotten during the Astronaut's post-flight debriefing, or he might not have felt that it was important at that time. There may have been personal reasons why he did not care to mention some items. Some material may have developed in his mind as a result of reflections since his flight and of his observations of flight activity that have occurred since his own mission.

Every effort has been made to safeguard the confidentiality of the inquiry, as described in the section on confidentiality.

METHOD

A list of fifty-one questions (Appendix A) was formulated by the investigator. Published documents, discussions with NASA personnel, and the investigator's own personal knowledge of space flight human factors entered into the formulation of the questions. Some changes were made in the list of questions as insights were gained during the course of the interviews.

The original thought was that each subject would be asked each question on the list, but it soon became apparent that this approach would not be the best way to proceed. Some of the questions clearly referred to specific programs, Project Apollo for example, and would be of little use in interviewing a person whose experience was restricted to an earlier program. Further, it was seen that strict adherence to the list of questions would result in stilted, stereotyped replies - the questions became boring rather than stimulating. After the first two or three interviews, it was decided to use the questions only to stimulate discussion. Although some questions were given to all ten contacts, some were only given to one or two, with each question being presented to an average of 6.2 contacts. This is somewhat misleading because in certain instances questions would stimulate answers to later questions, and the responses were combined. (See Question 4)

Ames Research Center provided the investigator with a letter of introduction (Appendix B), which described the program and its goals, and which reviewed the background of the investigator. The letter gave absolute assurance that the information given would be safeguarded in such a manner that no statement could be attributed either to an individual or to his specific flight.

The contacts were each paid a consultant's fee of $50.00 per hour.

It was originally intended for Mr. Donald K. Slayton to be present at each interview so as to take advantage of his background, training, and knowledge of manned space flight operations. It proved nearly impossible to coordinate the schedules of the investigator, of Mr. Slayton, and of the contacts,

without delaying the progress of the project to an unacceptable degree; Mr. Slayton, therefore, was present during only two of the interviews.

The first interviews were with people known personally to the investigator or to Mr. Slayton (or both). These individuals made suggestions for subsequent interviews.

MECHANICS

The contacts were first called by telephone and the purpose of the study was explained to them. If they consented to being interviewed (and some declined because of their busy schedules), an appointment was made, and a copy of the letter of introduction was mailed to them in sufficient time to allow them to review it before the interview.

Because of the preconceived opinion of the investigator that the presence of a tape recorder would be inhibitory to the free flow of information, the original plan specifically excluded the taping of the interviews. When the first individual was contacted, and when it was explained to him that a tape recorder would not be used, he said he felt the taking of handwritten notes would be distracting to him. He then asked that a recorder be used in his interview. When subsequent contacts were made, each person was given his option of using a tape recorder or not. None expressed even the slightest reluctance to being taped. One even asked for a copy of the tape for his children.

In all cases the investigator traveled to the community where the contact lived. The interviews took place in the contact's office on three occasions, in his home on three occasions, and in the investigator's hotel room on four occasions.

The environment was very informal. As stated earlier, the questions were used only to stimulate discussion. When the conversation lagged, another question was selected and asked. This usually resulted in a great deal more spontaneous conversation.

SAFEGUARDING CONFIDENTIALITY

Each contact was assured at the time of the initial telephone conversation that anything he said would not be traceable to him or to his flight. The letter of introduction contained these same assurances, and they were repeated in the investigator's letter that forwarded the NASA letter of introduction. Finally, the subject was given the same assurances orally at the time of the interview. It was apparent that most of them appreciated the assurances of confidentiality and were probably more open in their discussions as a result of those assurances.

After each interview the tapes (12 in all) were brought back to the investigator's residence, where they have remained stored in a safe location. They are identified only with a numerical code number. The contact's name does not appear on the cassette label. The investigator transcribed the material verbatim in most instances. Paraphrasing was rarely used and then only when it became necessary to clarify syntax that was peculiar to the oral interview situation. There are a few portions of the tape that have not been transcribed because they referred to the personal social relationships of the contact and the investigator.

The investigator transcribed all the recorded material on an Apple IIe personal computer in his home, using the Apple Writer II word processing program. No secretarial assistance was used in either transcribing the taped material or in the preparation of this report. No other person has heard the tapes of these interviews. To facilitate preparation of this report, the transcribed interviews were printed on 104 single-spaced sheets. No one other than the investigator has seen these typed pages. When not in use, they are kept in a combination-locked safe in the investigator's office.

Each transcription is saved on a magnetic disc, and duplicate discs have been made and stored separately.

GENERAL FINDINGS

The subjects were, without exception, extremely cooperative. No animosity towards the investigator or the project was expressed. The investigator could detect no evidence of conscious withholding of information.

A broad range of experienced people were interviewed, including persons who had flown on all NASA programs, with the exception of the Space Shuttle. Interviews were conducted with crew members from Mercury, Gemini, Apollo, and Skylab. The Apollo contacts included men who had participated in the Earth-orbiting phase of the project, and in the lunar landing phase. One of these latter contacts landed on the moon and another was a Command Module Pilot who remained in lunar orbit alone during a lunar landing mission.

No meaningful statistical evaluation can be made for several reasons:

1. The list of questions was not rigidly adhered to. All subjects were not asked all questions.
2. Answers to questions were subjective in nature.
3. Many spontaneous questions generated by the subject's comments evolved on the spot. Some of these were not really applicable to subsequent interviews. On the other hand, some of these spontaneously generated questions were asked at subsequent interviews, but no effort was made to contact earlier subjects to ask them to answer the newly generated questions.
4. Only ten people were interviewed.

In this report the questions will be stated, and in cases where the question was presented to several individuals, an evaluation of the replies will be attempted.

Spontaneous statements of importance and answers to spontaneously generated questions are included at the end of the answers to the list of fifty-one questions.

NOTE: After the answers to each question, there is a section labeled "COMMENTS". This section contains the investigator's own subjective remarks

and evaluation of the statements made by the contacts. A COMMENTS section will be found after each spontaneous comment as well as after the answers to the prepared questions.

ANSWERS TO PREPARED QUESTIONS

1. Opinion of the Crew Health Stabilization Program.

Surprisingly, only 2 of 9 who were asked this question were opposed to the program. All stated either spontaneously (5) or upon questioning (2) that they thought it was helpful in keeping the crews insulated from annoying contacts.

"I thought it was kind of fun. It kept the world away from us."

"It allows the crews to concentrate on what it is they have to think about. They are not being pulled in a number of directions just before the flight. It allows them to focus on the task and the training ahead."

Comments: Inasmuch as the Crew Health Stabilization Program is no longer practiced with as much rigidity as it was in the early Apollo flights, it might be wise to develop some policy for providing a similar degree of privacy and seclusion for future missions.

2. Thoughts on Space Station maintenance activities.

NOTE: Because of the similarity of responses to this question and Question 4 regarding tools, the responses to both questions have been combined here.

This question was presented to all the contacts. Two had no comments on the subject.

One man said that multipurpose tools were important. He urged the inclusion of files, wrenches, and other common tools. He stated that his Swiss Army knife was especially valuable. He also suggested providing sticky tape with the adhesive on both sides. This would be useful in restraining small parts to the workbench surface when making repairs.

One man commented that the Apollo tool kit was very good.

Another urged that maintenance should be kept simple - at the "black box" level.

One respondent thought that neutral buoyancy training was good practice for maintenance, but another stated that it was misleading at best. He urged that any procedures developed in a neutral buoyancy tank be checked out in the zero-g aircraft before being adopted for use in space flight.

Only one person mentioned the importance of foot restraints.

One recommendation was to project maintenance instructions, and even diagrams, on the inside of the helmet visor in the manner of a Head-Up Display (HUD).

A quotation from one of the contacts might prove interesting:

"You design things for routine maintenance done there by people with tools in order to keep the system simple, and with simplicity you gain reliability. You get the reliability through that route rather than through redundancy and automation."

Comments: The most significant response to this question is contained in the last quotation. The recent remarkable successes in satellite recovery operations add emphasis to the quotation. Future satellites and future Space Station equipment should be developed with the plan in mind that crew members are capable of performing routine bench-level maintenance.

3. Alarm Systems.

This question was presented to seven contacts. Two of them mentioned that they noticed a decrease in the loudness of sounds somewhat proportional to the reduction of pressure in the helmet. Another denied that he had had that experience. Other comments included the recommendation that the volume of the alarm be proportional to the severity of the situation; that for critical

emergencies there should be simultaneous visual and audible alarms; and that audible alarms should be a "warble tone" as is used by some European police cars.

Two individuals mentioned the great importance of eliminating false alarms. One suggested that a study of the characteristics of false alarms might reveal a "signature" for false alarms. This signature could be incorporated into a computer, and alarms could be evaluated against these signatures before being sounded.

Comments: The suggestion to investigate the "signatures" of false alarms might be worthy of further investigation.

4. Tools for on-orbit repair and maintenance.

Inasmuch as this was covered adequately in Question 2, relating to maintenance activities, the answers to this question have been combined with those obtained in response to Question 2.

Comments: None.

5. Food and meals.

Of the ten persons interviewed, one had no comment; three suggested that meals be selected from a menu in-flight; and five advised that all individuals eat the same thing at each meal with no selection. Mention was made by these individuals that the military chow line had much to recommend it. One of the five suggested that snack items be provided for free selection from a pantry, but he still did not recommend that there be item selection for the main meals.

One person said he felt a menu determined ahead of time by crew interviews was of little value because people lose some of their ability to taste when in zero-g. He attributed this to loss of convection currents carrying aromatics into the nose. He said this could be helped by providing strong condiments - pepper in oil solution, hot mustard, and so forth.

One contact suggested the investigation of foil-packaged foods that are marketed under the brand name of RETORT FOODS. These are not freeze dried, and may be eaten hot or cold.

One contact urged that more attention be paid to the nutritional aspects of the diet. He distinguished between those aspects of food preparation that are conventionally performed by a dietician and those performed by a nutritionist. He suggested NASA pay more attention to the latter aspects of menu and diet selection.

Comments: Those who advocated the military chow-line approach have probably not seen today's chow line. In present-day military dining halls, there is a remarkably broad selection of items available. One of the contacts suggested that each crew member be asked about his dislikes rather than his likes. The disliked foods would not be provided in his menu. This seems like a reasonable approach.

6. Trash disposal.

This question did not stimulate much discussion in the early interviews so was eliminated later on. Two subjects suggested that trash be pyrolized - convert trash to energy. Two others who were asked had no comment. Five were not asked.

Comments: None.

7. Clothing design.

The overwhelming opinion was for a two-piece garment with lots of pockets (seven out of nine, with two "No Comments"). The advantage of being able to shed the upper garment for comfort in warm areas was commented on twice. All agreed that many pockets were a necessity, but pocket closure should be with Velcro rather than with buttons, which could catch on things. Two unusual comments included the suggestion that a "dress" uniform be provided for special occasions- this for morale purposes. Another was that a variety of colors and styles was important for morale. One individual stated the need

for strict dress-code enforcement as an aid to maintaining discipline. One subject stated he had had some experience with polypropylene outdoor clothing and thought it might be worthwhile investigating. He said it was quite comfortable, but brought up the question of its fire resistance.

One suggested a different garment for wear during exercise periods.

One man suggested that two-piece uniforms have some means of fastening the shirt/jacket to the waist of the trousers to prevent uncomfortable gapping at that point. He suggested Velcro.

There was a need expressed for a place to carry an emergency checklist at all times.

Free choice of underwear was suggested.

One man suggested that slippers be provided for off-duty wear.

Comments: As might be expected, there was a wide range of suggestions regarding clothing. When some of the more extreme suggestions are eliminated one reaches the conclusion that the basic in-flight uniform should be a two-piece garment with many pockets. The suggestion for the provision of a place to keep an emergency checklist available at all times is a good one.

8. Personal hygiene equipment.

Three contacts had no comments, and three were not asked. The remainder had comments that did not fit any pattern:

One wanted to use an electric toothbrush and an electric razor. Another preferred manual toothbrushes and a blade razor.

One man said that all on board should use whatever turned out to be "issue" equipment. He also mentioned that he would insist on daily shaving as he felt it to be good for mental discipline. He felt it establishes a good mental set.

Although not really classed as personal hygiene equipment, one man commented that showers were important but he felt a sponge bath might do as well.

Comments: One might question the advisability of providing electric razors, what with the possibility of producing "whisker dust" in the vicinity of the face of the user. Since electric razors seem to be more practical in the Space Station environment, it might be worthwhile to conduct studies on the Shuttle to determine whether or not whisker dust really is formed in the vicinity of the external nares in a zero-g environment. One might also perform animal studies to determine whether or not dust produced from that animal's own guard hairs produced any lung pathology when inhaled on a daily basis for extended periods of time.

9. Aids to transfer of massive objects.

The question was asked of only four people, and two of them had no comments. One person said, "Put a loop of rope around it and snub it down." Another suggested the use of a "Brooklyn clothesline". This is a continuous loop of rope strung between two pulleys. Objects could be attached to the line with clips. On the other hand, another contact mentioned, in response to a different question, that he had tried such a device in the Weightless Environment Training Facility (WETF) and found it worked very well, but when he tried it in the zero-g aircraft it became tangled to such an extent as to prove useless.

Comments: None.

10. Identification of "Up" and "Down".

Because of the special interest of this question, a great deal of time was spent on it. Of the ten subjects questioned, nine were very definite in stating that there was no need to take any particular pains to identify up and down. Several commented that down was always where their feet were. There appeared to be no difference between the answers from individuals who had flown in confined spacecraft and answers from those who had flown in spacious

vehicles. One individual said he himself was not bothered by the lack of up and down, but stated he felt it would be wise to ensure that everything in a given volume have the same orientation.

One contact related that one of his colleagues had spent "hours and hours" in the simulator, then went into flight and became ill even before he had gotten out of the seat. The point of this observation is that this person had excellent up and down references but became ill anyway.

In response to a direct question, one man said that even seeing his colleagues in an orientation different from his own did not disturb him.

Two men commented that the use of a simulator may drive the configuration of the Space Station, at least in areas where simulator training is extensive. The simulator will have to be constructed with an up and down orientation because it is used in a one-g field. The Space Station area must match the simulator for training if it is to serve any purpose.

The following quotations are presented:

(1) "Before I came into the space program I tended to have a great amount of familiarity with mathematical techniques of rotation and translation of axes systems...I tended to look at something and just figure that I had a rotated coordinate system. (In space) I'd look out at the Earth, and I'd recognize the Earth had its own set of Earth-centered coordinates. The spacecraft had its space-centered coordinates. Whenever I saw the two in the same field of view I just automatically thought of the spacecraft as being oriented to the Earth, but more importantly, I had my own body-centered coordinates, and the input, if somebody allows them to, can be of those things. ...If you operate in egocentric coordinates "down" will be towards your feet. It makes no difference whether you're going over the Earth upside down or diving under it, or any of those things, if you really look at it as your world is where you are, and everything else is oriented around you."

(2) One contact said he thought it fun to look at the world upside down. "Trying to force a one-gravity mode of operation into zero-gravity is a mistake. It defeats all of the freedom which you are given."

(3) When he would go from one compartment to another, one person said, "There would be moments of disorientation and you would kind of flip your body around and you'd pick the work station you were going to work at, and then as soon as you got your body flipped around to where you were within about 45 degrees of that work station's local vertical then everything clicked in and you were comfortable."

(4) "I think that maybe if you start identifying up and down you may be reminding people of things they should be forgetting."

"I think we adapt easily to most any environment, but I just don't think there is a great deal to be gained by trying to force people to think as they do here on Earth when they are, in fact, in space."

Comments: If the opinions of this small sample of people are felt to be significant one must conclude that special efforts to identify "up" and "down" in Space Station will not pay large dividends. The comment to maintain a constant local vertical in each module seems worthwhile following, if it is architecturally feasible and charges no penalty from a design standpoint.

On the other hand, none of the ten subjects interviewed admitted to having experienced any degree of nausea. If none of the ten contacts became ill, and if approximately 40% of Shuttle crew members become ill, we are drawn to four possibilities:

(1) The sample is so small that chance alone resulted in my interviewing only those individuals who did not become ill.

(2) There really is some difference between those interviewed and Shuttle crew members.

(3) The persons interviewed did not admit that they become ill in flight. From the obvious sincerity and directness of these ten contacts, I am convinced that none of them became ill. This, I must admit, is a very subjective assessment, but it is my conviction that they were all truthful and forthright in their answers to my questions. This opinion is substantiated by the fact that one individual did admit that he would have become ill had he not paced his on-orbit activity for the first three or four days. This person's comments are found in the SPONTANEOUS COMMENTS section, which follows.

(4) The flight environment of these ten contacts was different from the Shuttle environment.

I suspect that the reason for the observed difference in distribution of nausea in this group is a combination of (1) and (4).

11. Use of vented gases for attitude control.

This was only asked of four contacts. One remarked that vented gases had been used as an expediency to control tumbling in Gemini V. Another had no comment regarding the use of gases for attitude control, but he did suggest that they be used to run turbines for power.

One said he did not think it such a good idea - use control moment gyros instead.

Comments: None.

12. Importance of private communications.

This question was asked of all ten individuals. Responses varied from, "Not all that important" to "Absolutely!"

Most of the respondents thought a private line was important for personal communication with families, but of equal importance was its use in operational control of the flight. One subject gave an example of a situation in which instructions had to be paraphrased to keep them from being heard by the press. The paraphrased instruction was misinterpreted to be a joke and was not followed. The example cannot be further identified or described here as it would reveal the source, but suffice it to say that the well-being of a crew member was jeopardized by this misunderstanding.

One contact said, "The Administrator [NASA] doesn't have a microphone in his office with the world listening into everything he says. Why can't astronauts have the same privilege?"

Another said, "They (the press) have no more right in your bedroom on orbit than they have in your bedroom on Earth. They are not allowed to go to your doctor and find out how you are and what you are doing (on Earth so they don't have that right in space). I don't care who's paying the bill."

Comments: The respondents' replies to this question were based more on their feelings of privilege rather than on the actual need for and utility of a private communications link. They admitted the importance of the right to speak privately to their families, but they did not seem too concerned with the beneficial effect such communications would have on mission accomplishment. The comment regarding the utility of a private link to discuss purely operational matters was significant.

I would like to point out that during stressful training exercises during the Mercury program I had many opportunities to use the private line and found it to be of great benefit in assessing the status of the trainee. The trainees more than once made statements as to their physical status to me on the private line that they would not make on the open loop. As an individual, and not as the investigator in this study, I would strongly recommend that an absolutely private communications link be provided. The "Earth end" of the link would be under the control of the crew member. That is, the crew member would decide who he would talk privately to, his family, the flight controller, the physician, or anyone else. One of the contacts in this investigation even mentioned that a person spending many weeks or months in a Space Station might wish to speak privately to his broker!

13. Use of portable fans.

Five contacts were asked this question, and none of the five ventured an opinion. The question was not presented to the other five.

Comments: None.

14. Opinions regarding translational aids, control/switch protective devices, orientation cues, and protective gear for personal wear.

Five of the ten contacts were not asked any part of this question. Of the five remaining, only parts were asked, or only parts were answered.

Four subjects expressed satisfaction with the common "wicket-type" switch guards.

One person said he could not visualize roll rates of such a magnitude as to require personal protective equipment such as headgear. He also said rounded corners and other methods should be used to protect a person moving about in the cabin. One other person said he did not believe headgear would be required.

Comments: None.

15. Opinions regarding the airlock on Skylab.

This question was presented to only three people, and only one of them had an opinion. He stated, "There should always be a safe haven one can get to. The racetrack design is good. To have a safe haven in each module is too costly, it takes up too much room."

Comments: None.

16. Ideas regarding crew quarters.

This was addressed by nine out of the ten interviewed. Only two did not feel that private crew quarters were necessary. One of these two advocated very Spartan conditions. He commented that we can't afford to build a Space Station to accommodate anybody and everybody. We must select crews that can tolerate Spartan living conditions for ninety days. "Give them a sleeping bag they can hang up anywhere." The other one of these two said he compared a ninety-day Space Station tour with an overseas military tour or a camping trip. He said, "I don't think you need to have a private room and all that as long as you have a place to sleep."

One of the remaining seven who commented said he saw two conflicting requirements, one was the need for quiet and privacy, and the other was the need to be near the work station to respond to emergencies. He suggested that NASA explore the possibility of providing a "sea cabin" for one or more crew members. He also felt that any alarms sounded in the crew quarters should be prioritized - perhaps only a "Battle Stations!" type of alarm.

One contact with Skylab experience said he thought the crew quarters should be at least twice the size of the Skylab quarters. He also advised that they not be located near the exercise area to diminish the noise levels.

One person commented that the Apollo sleep restraints were adequate, and one commented that the Skylab sleep restraints were good.

With the exception of the two "Spartans", everyone believed private, individual, comfortable quarters should be provided.

Comments: There seems to be no question but that private crew quarters should be provided. These should be as large as is practicably possible. It is evident that the early Space Station will not be large enough to provide commodious quarters, but it seems that, given the alternatives, privacy is more to be desired than volume.

17. Medical training for crew members.

This question was presented to eight of the ten contacts. The most common response was that either a flight surgeon be on each crew, or that two of the crew members should be trained to the level of paramedics. One respondent said he believed all crew members should have extensive training in physiology so that they would better understand medical or physiological problems that arose in themselves or in others. He also felt there should be a flight surgeon on board for long-term exposures. Another felt that every crew member should have the equivalent of paramedic training, and that a physician was not necessary unless he was dual trained - as a payload specialist for example. One other contact suggested that if a physician were assigned he should be

dual trained. Another contact recommended that NASA, in their selection program for mission specialists, include sufficient physicians as to provide one for each Space Station crew.

Comments: Clearly, a minimum of two people on each crew must have some competency in providing medical care. If one of these two becomes ill, the other can take care of him. A good compromise would be for one of the crew members to be a dual-trained (as a payload specialist) physician and the other as a dual-trained person with medical training equivalent to that of a paramedic.

18. Need for group dynamics training.

Group dynamics training was briefly described as a psychological technique which helps people to work together and to give each other mutual support and tolerance.

This question was presented to nine contacts. Only two felt no training was required, and one felt it should be given only if a problem arose. One stated he had heard the Russians had had a problem. One commented as follows:

"I think that it's going to be increasingly important that they have at least some amount of this [group dynamics training] because you would like to have a preconditioned attitude of how they're supposed to work together. You don't want to have some highly motivated mission scientist back there [in the space lab or an analogous part of a Space Station] who doesn't understand where that priority interfaces with these other priorities."

Another commented that he felt future crews, who would not have as much interactive training as those of today, should be required to function in some sort of environment together before they launch. He suggested that Survival School might be useful for that purpose.

One contact was especially concerned in regard to this matter. His comments took up more than a page of single-spaced typescript, and included the following statements:

"I think that [the lack of psychiatric or psychological support] is one of the shortcomings of NASA over the years, and I don't know if they've solved that problem yet today, and that is that there is no active program having to do with the behavioral sciences that helps either the astronauts in dealing with one another or the astronauts and their families dealing with the situation."

"I think it is unfortunate that astronauts have never been given any kind of opportunity for behavioral science understanding. There has been such a stigma associated with psychologic or psychiatric therapy that everyone stays away from it like it is some kind of poison."

"I though it was just really too bad that there was not some sort of a program in NASA to help in some sort of an upbeat way - to give them access to these people - give them some training on techniques of dealing with these problems. The problems are there!"

Another contact's comments filled three single-spaced typescript pages, but were mostly personal experiences with his friends, and cannot be reported here because of the possibility of revealing the source. He left no doubt in this interviewer's mind that he was strongly in favor of professional psychological support for the crews and for their families.

Comments: See comments to Question 19.

19. Should families have similar psychological support?

This question was posed to eight of the ten contacts. One had no comment, two said it need not be provided, and one said it should be provided only on a voluntary basis if the family member felt the need and asked for it. The rest felt it should be provided in some degree or another.

A commonly expressed suggestion was to keep the families very well informed about all aspects of the program, and to get them involved with whatever is going on. One man said, "The more you involve the wives into the

operation, the more support you get from them. Keep them informed and give them lines of communication to, for example, Mission Control Center." He also said, "I know when I was there [assigned to NASA], the wives and the families were really isolated. They were really pushed back in a corner. The problem is, that kind of treatment was infectious. The program treated the wife that way, and pretty soon we started treating our wives the same way. It was really tragic." "I know it cost a lot of guys their marriage." He continued by saying, 'You can't treat people like numbers, and that's what NASA did. If the wives were unhappy, well, that's too bad! 'Think of all this important work that your husband is doing and go home and shut up!' It didn't work."

On the other hand, another contact stated, "The things that don't kill you make you stronger. I, frankly, think the experience was a positive experience for my wife."

He was not one of those in favor of a formal program for the families.

Comments: Because Question 18 and Question 19 are so closely related, comments to both of them will be presented here. For some reason there seemed to be more enthusiasm expressed for providing some sort of psychological support for the crew members than for providing similar support for the families. I had expected the reverse would prove the case. It would seem important to ensure that future Space Station crews have the opportunity to work very closely together in situations that will require mutual support. Although it might be difficult to justify giving survival training to Space Station crews, that sort of social interaction would probably pay large dividends when the crew occupy the Space Station. It might also be of benefit for NASA to introduce a certain amount of psychological training into the program.

The contacts, for the most part, were not concerned about providing psychological support for the families. However, those who were in favor of such support were very positive in their statements. My personal feelings in this regard, and many of these feelings have been generated by the very strong

and sincere statements expressed by two of the contacts, are that NASA has been remiss in not including the families as part of the program. It seems that more detailed briefings might be given the wives so that they would have a better idea of of what their husbands are doing. This action might not improve the effectiveness of the husbands, but nevertheless should be provided if only for humanitarian reasons.

The question of religious beliefs was never presented as a formal question, but it did come up spontaneously in the discussions with most of the contacts. From their expressions of belief and faith it is my conclusion that a resident chaplain at JSC would be of great value to the program.

20. Crew interactive training in a one-g simulator.

Because of the many very strong polarized feelings brought out by the questions on group dynamics training (Questions 19 and 20), it was felt that this question should be eliminated. It was asked of only one contact and he misinterpreted it. His answer related to command structure of a Space Station crew, and will be included with the answers to Question 45.

Comments: None.

21. Problem of ambient noise.

Here is another question that was, for all intents and purposes, eliminated. The contacts actually answered it when speaking of the need for quiet in private quarters.

The question was posed to three individuals. One implied in his answer that noise was not a big problem - one gets used to it. On the other hand, unanticipated noises or motions of the spacecraft are very distracting. The third said that on his flight, crew member noise prevented sound sleeping in shifts.

Comments: None.

22. Wardroom, entertainment, external viewing, and Earth position.

All ten contacts agreed that a wardroom was important.

There was near-unanimous opinion that personally selected books and music tapes were important things to take along. Other suggestions included the provision of movies on VCR tapes, and one individual suggested that books, movies, and other forms of audio-visual entertainment could be put on laser video discs. Many individuals commented on the fact that real-time commercial news programming and entertainment shows could be up-linked with little difficulty.

Only one person had no strong opinion on the need for windows, but even he said they were highly desirable, but not of prime importance. One person said, "Nobody ever gets enough time looking out of windows." Another said, "They should make sure that there are as many windows as possible." He suggested one be put near the exercise device so one could look out while exercising. One man said the windows are extremely important from a recreational as well an inspirational standpoint. He said, "You need viewing ports and time to use them." One of the contacts said, "The more windows in a spacecraft the better. One of the most enjoyable things you have to do up there is to look out the window. In fact, even a bubble window might be nice."

One of the more articulate contacts said:

"I, for one, am totally convinced that the magic of space and the value of being there involves being able to see what's out there...It is from the human standpoint that I think you need lots of viewing ports. I think that's very important. I don't care if it does cost more money. The return in keeping people's interest, and the motivation and all that sort of thing, to do more and more, and to go further, is very dramatically enhanced by being able to see."

Comments: The most consistent answer to any of the fifty-one questions was the strong positive expression of a need for a wardroom with some sort of entertainment equipment. The suggestions for this equipment clearly followed individual preferences. Of equal unanimity was the expressed need for many

and large windows. This has such great importance that it would appear important to consider the possibility of providing bubble windows, as was suggested by one of the contacts.

23. Body waste collection and disposal.

Six contacts were asked this question. Two had no comments, and two said they felt that the Skylab system was adequate, although they did not like the idea of bagging the feces. One man said even the Apollo system was all right in spite of the need to bag the feces. The third comment related only to urine collection and that person said he felt the ordinary aircraft relief tube was adequate. Although he did not say so, it was clear that he meant such a device would have to be adapted to the zero-g environment.

Comments: None.

24. Personal cleanliness.

Since this question had also been addressed in Question 8, Personal Hygiene Equipment, it was presented to only four of the contacts. Two of them had no comment; one recommended the use of a spring-driven razor; and another, who uses a blade razor, said he felt frequent or daily shaving was good for crew discipline. This was the second contact to make that comment.

Comments: This was considered in the comments to Question 8.

25. Exercise.

This question was asked of nine contacts. All agreed that exercise was important. One said he felt exercise and good food were the two most important things to provide for long-duration space flight. Two others said they felt exercise was important from a psychological and morale standpoint as well as from a physical well-being point of view.

Five people recommended that both a bicycle ergometer and a treadmill be provided. One mentioned only a treadmill and one mentioned only a bicycle.

Two people mentioned that it is also necessary to exercise the upper torso and arms. One of these recommended spring or bungee devices for this purpose. Another thought a Nautilus-type of exercise device should be provided.

One person said he thought the Exergenie was a very useful device, but another stated that he tried to use it on his flight and found that the nylon ropes heated from the friction of use and stretched, making the device useless.

Another person said he believed there is a need for something that will provide structural stress to the skeletal system, but he had no ideas on how to do that.

Only two people suggested a duration for the exercise period. One suggested ninety minutes and the other sixty minutes.

Comments: The need for exercise was strongly supported by all. It is my understanding that investigations into the types of exercise equipment needed are being conducted. I can only urge that these investigations be continued both on the ground and in flight.

26. How to manage books and manuals.

This question was presented to only four of the ten contacts. One stated he preferred books, but could learn to live with information presented on CRTs. One contact had no comments, and the other two said that they did not think that everything had to be in data banks. Some material can best be presented in book form, and other material can be stored in data banks for retrieval when needed.

The feeling seemed to be that recreational material was best presented in book form, but technical material (with the exception of emergency checklists) could be stored in data banks.

Comments: None.

27. Man/machine interface.

This question was put to five of the ten contacts.

One suggested that color be used more in the design of the Space Station, and one said color was not all that important. One had no comment.

One man suggested that NASA employ what he called "functional artists" to help in designing the interior of the Space Station. He stated that the wardroom should be of a "relaxing" color and the flight deck should be of an "alerting" color.

One individual urged caution in accepting the use of digital displays. He said:

"Digital offers various advantages in terms of accuracy, precision when you need precision, but the human being is an integrator, he doesn't take snapshots, and there is a lot of information and intelligence lost when you're looking at a digital display."

Comments: The science of architecture is advancing at a great pace. NASA would be well advised to use the services of this discipline in establishing interior design criteria for the Space Station.

I was impressed by the warning about digital displays. From a purely personal standpoint I find it easier to integrate analog informational displays than I do digital displays, but this may be purely cultural. An interesting area for investigation would be to assess whether people get more or less information from one display than the other. Unquestionably, it is easier and quicker to read, for example, the exact time from a digital display, but does one find it also easier to tell how many minutes have elapsed since a given event or how much time remains before a given action must be taken. I am sure similar analyses could be made of altimeters, and other displays of changing quantifiable information.

28. Three shifts or one?

This question was asked of six people. One had no comment. Only one of the remaining five felt that all crew members should be allowed to sleep at the same time. They felt that someone should be awake and on watch at all times. One man said that the crews should be able to work longer than eight-hour shifts. He said, "You're not there on a vacation, even for three months."

One contact stated that timelines should be flexible enough to accommodate the mission, and the crew members should be indoctrinated in the occasional need for working on their off-duty time. For example, an Earth resources task might require that the Earth resources specialist take photos at a particular time on a particular orbit, and that might occur during his off-duty time.

This question also asked the contact to comment on whether exercise should be an off-duty endeavor or a duty-time activity. Only three answers were obtained. One man said exercise should be done during off-duty hours. The second said the question was irrelevant because one is never "off duty" in space. The third said he thought half of the exercise should be done during on-duty time and half of it when off duty.

Comments: As was the case in most of these questions, there was no real unanimity of opinion unless it was that someone should be awake at all times. This seems to be a most reasonable and logical position.

29. Importance of real-time TV.

Here is another example of a question that was covered fairly well in an earlier question. See Question 22, which addresses wardroom accommodations.

This question (29) was asked of only three persons. One had no comment; one thought it was very important; and the other did not believe it to be of great importance.

Comments: None.

30. Who should select the crews?

All but three of the contacts were asked this question and, as one might expect, there was a wide range of opinion in this regard. The replies of each person are summarized in the following paragraphs. No real pattern emerged.

(1) A crew selection committee has virtue. The selection should not be made by one person. Perhaps the Captain should be selected first. He would then select a second person; the two of them would select the third; and so on until all crew members had been chosen.

(2) Overall Management should make the selection. The Commander should not have sole selection authority, but he should have veto powers. The peer review concept has virtue in that it identifies the unpopular individuals.

(3) The crew should be selected by Management - they have more information available to them than does anyone else. The peer review process is a useful tool. Management needs an input from the crew Commander. This contact believed that a small group of crews should be selected and flown frequently. This saves expensive training time over the other alternative, which is to have a large pool of candidates from which crews are selected to fly less frequently.

(4) Believes a nucleus of crew members should be selected. These people fly frequently and train their own replacements (the right-seat man eventually moves into a left-seat assignment). Whatever system is used, it should be well understood by all the candidates. Each should know what the selection criteria are, and how the process operates.

(5) Mentioned that he liked the way Slayton handled the selection process, but believes the selection pool is much too large.

(6) Also mentioned that he liked the way Slayton did his job in the past.

(7) NASA management should select the operational crew. Some other authority should select the technical crew. The combined group should work together for a period of time, and the Commander should be able to exercise veto power over members of both groups if he felt an individual would not fit in.

Comments: I am inclined to go along with respondent Number 3. Respondent Number 7 made essentially the same comments. My disagreement with Number 3 is

only in regard to the concept of peer review. I am sure it does point out the unpopular individuals, as stated by contact Number 2, but at what expense? I am sure the unpopular individual is already known by Management by the time they get around to selecting the crews. One is inclined to ask how important is popularity anyway?

31. Does EVA require the "buddy system"?

Only four people were asked this question. One had no comment, and the other three said they believed it was necessary. One of them said he thought the buddy might be a fully suited astronaut who remained inside the station, but was ready to go outside at a moment's notice.

None said they though the buddy system was unnecessary.

Comments: None.

32. How can the EVA suit be improved?

This question was asked of seven people. Again, the comments were not consistent, and reflect the individual's personal views. There is also some overlap in the answers with the answers to some of the other questions.

(1) For prolonged EVA the astronaut should be provided with a "motorman's friend", a diaper, water, but no food.

(2) For missions that will require EVA soon after attaining orbit, the EVA crewman should be selected from a pool of individuals who, by their past experience in orbit, have shown to be resistant to space motion sickness. Nevertheless, vomitus containment apparatus should be provided "just in case."

(3) Consider using honey water as a source of energy and fluid. The glove needs improvement so as to provide better tactile sensation. A wire saw (Gigli saw) should be taken along on every EVA for emergency use.

(4) Mentions better gloves with improved tactile sensation.

(5) Suggests that the problem of finger tip injury could be solved by closer trimming of the finger nails.

(6) Recommends the hard, rigid, high-pressure (8 psi) suit.

(7) One man had no comments.

Comments: The suggestion to use honey water as a source of nourishment and of fluids certainly deserves investigation. Methods for collecting urine and feces (a diaper should be adequate for emergencies) are essential, and I believe that some sort of vomitus containment device is also essential. People still become ill, even on the surface of the Earth in a one-g field, and there is no reason to suspect things will differ in space. In fact, if a problem comes up with the food storage equipment, there might well be some gastroenteric illnesses developing. Finally, it seems logical to develop a suit that provides at least 8-psi pressure, more if feasible. The advantages to such a garment are too well known to warrant elaboration in this report.

33. EVA restraints, tethers, hand holds, lights, etc.

After receiving three "no comments" in a row, this question was eliminated. It was asked of four contacts and only one had any comments. His are as follows:

"There is a need for a small, multipurpose tool kit with interchangeable end-effectors. Small lights on the fingertips as were used in the Mercury program are extremely useful. These can be directed better than a helmet-mounted light."

Comments: The use of fingertip lights on the Mercury suit was most effective. This might be investigated again for the Space Station suit.

34. Suggestions regarding mortuary affairs.

This question was posed to four of the persons interviewed. Two stated that the sensible thing to do would be some form of on-orbit disposal. (One said, in some seriousness, "Shoot me into the Sun!" He was aware of the high-energy cost of doing this, so there was some levity in the remark too.) But they also recognize that this would not be acceptable in today's society.

One of the contacts said the problem should be addressed and solved before we go to Space Station, but he had no ideas. The fourth person agreed with the necessity to bring the body back in a condition suitable for an open-casket funeral, but he had no ideas on how this could be accomplished.

Comments: One approach to mortuary services might be to consult with various museums of natural history. One of the modern methods of taxidermy is to place the animal in a life-like pose and freeze it in that position. A vacuum is then drawn on the container, and the animal is completely desiccated. The desiccated specimen is then placed in a sealed case. This technique could be adapted to the Space Station as a method of preserving the body of a deceased crew member until a relief vessel makes contact.

35. Foot restraints at the work station.

This question was given to four subjects. Three had no comments, and one stated the triangular shoes used in Skylab worked fine.

Topics explored in this question were also addressed in Questions 33 and 36.

Comments: None.

36. Locomotion aids.

Only two subjects were asked this question. One had no comments, and the other said, "Only what is needed for facility and safety. The best locomotion is just to head out and across!"

Comments: None.

37. Body restraints for tasks requiring extreme steadiness.

This question was presented to only three subjects. Two felt it to be no problem, and one stated that perhaps a rigid arm could be installed at the work station. This could be swung out from a stowed position and used to clamp the astronaut into position.

Comments: None.

38. Thoughts on artificial gravity.

This topic was discussed with nine contacts. Two had no comments to make. One stated categorically that he thought there is a distinct medical need for artificial gravity. Three were of the opinion that artificial gravity should not be considered unless an overwhelming physiological need developed. One expressed the opinion that when the time comes when we can build very-long-term-exposure facilities, artificial gravity should be provided because the time expended in exercise (he estimated one to one and a half hours a day.) are nonproductive hours which could be put to better use if artificial gravity were provided.

No respondent felt artificial gravity is required for psychological reasons.

One was very strongly opposed to it. Our conversation went as follows:

"Another thing - I wouldn't worry about artificial gravity. I hope nobody is considering artificial gravity any more. I think that's a waste of time. And you destroy many of the advantages you gain by being weightless. Particularly for those people who may have a gravitational handicap. They don't have a gravitational handicap in space. They ought to be permitted to participate as full-fledged workers and crew members in space.

Q. There is some consideration being given to the so-called tether system, which will provide artificial gravity.

A. Well, I'll tell you - I think that's a waste of money, a waste of manpower and intellects to even worry about it. Fifty years from now you may have a good reason to do it. I don't think you have a good reason now. Certainly calcium loss is not a justification, in my opinion."

One person felt that there was a need for an artificial gravity area in the Space Station, but he had no ideas as to how this could be accomplished. He said:

"There are some good benefits from zero-g, but I would hope that in the Space Station there would be some area or some volume of the Space Station that would have artificial gravity. I don't know whether it should be the gravity of Earth or the gravity of the moon, but some light gravity field would prevent the deterioration, the deconditioning, of the cardiovascular system, and also the sickness that comes initially with exposure to the weightless environment."

Comments: I am in agreement with the contact who stated that the provision of artificial gravity negates one of the more important reasons for being there. Of course, it is self-evident that if an overwhelming medical or physiological need arises for artificial gravity, it must be provided, but lacking that, I can see no justification for it. The concept that the provision of artificial gravity would eliminate the need for exercise and thus be an economically justifiable approach warrants study. The economics of this question is beyond my area of knowledge, so I do not feel competent to comment one way or another on the suggestion.

39. What about autonomy?

This question was presented to eight contacts, and all but one had very definite opinions on the subject. Four contacts stated that they believed the Space Station Commander should be the final authority. Four felt that the ground should perform strategic planning only. Other comments included one that the Control Center should be used only for their more extensive resources. Two others stated that Mission Control Center should be used for routine data analysis only, and this because it was more economical to do this kind of information processing on the ground than in the Space Station. Another comment was that the Control Center should be informative, not protective, and finally, one person commented that the Control Center should be absolutely honest with the flight crew; no information should be withheld from the crew using the justification that they were being protected by this action. This respondent also said that the crew must be open and honest with the ground as well.

Comments: All of the contacts were inclined towards more autonomy for the Space Station, and less reliance on the ground. This trend seems to be most logical and appropriate. I concur with the comment that the greater analytical resources on the ground should be used in preference to in-flight analysis.

40. Utility of a miniature helmet-mounted TV camera.

This question was presented to only two contacts. One said it might be useful, but only for certain (unspecified) tasks. The other contact had no comments to make on the subject.

Comments: None.

41. What about an expendable launch vehicle rescue capability.

The question was put to five people, of which one had no comment. Only one person was enthusiastic about the concept and he said:

"I don't see why not. It would be expensive, but it would be only a one-time expense. Once you got the thing ready to go, the expense of recycling it would not be that great. You could even go with a solid. It would not have to be reserviced as often. Over a period of years there's going to be some times when it just might be needed, and it would certainly pay for itself."

One said he would rather put the emphasis on more on-board reliability. Another said he would rather use those resources to expand the orbiter fleet so as to provide a quick-rescue capability. One individual said he would rather have the escape capability built into the Space Station itself.

Comments: None.

42. How can man-on-board reduce redundancy?

This question was presented to only four contacts. Three of them said that they had no comments.

One stated he did not want to get involved in a lengthy discussion of the question, but did want to venture his opinion that we are still designing too much redundancy into experiments because the scientists refuse to accept that man can make up for it.

Comments: The comments following Question 2 point out the utilitarian value of man on the scene. Again, we should design equipment for repair and maintenance on orbit rather than provide layers of redundancy.

43. Ideas for design of a safe haven.

This question was put to seven people. Two of them had no comments. One stated that he did not think we needed more than two safe havens on the Space Station; another man said he thought every module should be isolatable; and a third suggested designing the safe haven so that the occupants could continue to be productive. He felt this was essential to their morale.

One contact stated, "I would put my efforts into introducing realism to the public." When asked to explain the statement he said that we must prepare the public to accept the fact that we're going to lose a spacecraft sometime.

Comments: The suggestion to provide means for crews to remain productive as a morale booster in the safe haven is one that deserves some thought.

44. Philosophy for EVA use.

Of the five people who were presented with this question, one had no comment; two felt that it should be used routinely; one said it should be used when cost effective; and one stated only, "I am sure it would be useful."

Comments: None.

45. On-board command structure.

This question probably stimulated as much discussion as any of the 51. It was presented to all ten contacts. Six of them unequivocally recommended a strong Commander with a clear and distinct chain of command. The most positive voice in this group was one who said:

"The Commander is the boss--just like in a military vehicle [or] in polar exploration trips. He's the boss. He can appoint deputies. He can ask for varied opinions on things. He's a real strong individual. He's going to say, 'This is the way it's done! [Strikes table for emphasis.]. We're not even going to question it.'"

A considerably milder comment was made by another contact who said that a clear chain of command was needed but, "...you don't need a man beating his chest."

The nearly opposite view was expressed by a contact who said:

"You know the stereotype of Marine Drill Instructor - you don't need those kinds of abilities up there - you need people with a broad perspective; people who are interested in enough different things outside their own area of expertise. I think that would be especially apropos of the Commander of the mission." He went on to say, "When you go to autonomy in space and you have your scientists up there [there are going to be conflicts which the Commander will have to solve]. You have to be able to compromise, and accommodate all those kinds of things. The Commander will have to be real diplomat."

Another contact recommended a strong authoritative Commander, but he has to be the kind of person who knows how to lead, and "...just to give an order is not the best way to lead." But, he said, there also has to be a strong command structure.

One man who stated there must be a chain of command suggested that there might possibly be a Commander for each shift with interaction between them. He said that the Commander should be not be resistant or blind to suggestion and inputs from the rest of the crew. When asked if he would recommend a military hierarchial system, he replied that he would prefer a NASA hierarchial system, which he said is not as rigid as the military system.

Another contact also recommended a dual command system, but constructed around different lines. He suggested a military Commander and a scientific

commander. The military Commander would be in ultimate charge, but as long as things are going well, he would delegate command to the chief scientist. He agreed that this might be somewhat analogous to the relationship that exists between the Captain of a carrier and his Air Group Commander. The contact stated that the ultimate responsibility must be assigned to one person. He said, "You cannot have a voting situation up there."

NOTE: The term "Military Commander" as used above was not meant by the speaker to imply that he advocated the Space Station be commanded by a DOD representative. He used it as a figure of speech.

Comments: Most of the respondents focused on the role that the Commander must play, and how he must act in exercising that role. One contact really caught the significant part of the question and stated that even more important than the Commander's actions was the need for a strong command structure. It has been my observation that some Military Commanders get the job done by virtue of the fact that their subordinates are afraid of them; others because they are respected;and others because they are idolized. Regardless of the Commander's attitude, the job always gets done unless the command structure breaks down. Even the autocratic Commander gets the job done unless he attempts to dissolve the command structure. When he does that, the organization falls apart and the mission is a failure.

46. How Hi-Fi should the Space Station simulator be?

This question was given to five people. Only one recommended that the simulator have as much fidelity as possible recognizing the limits imposed by gravity.

Two men felt that a complete simulator, a duplicate Space Station, was not needed. Part-task and modular simulation should be adequate. These were thought to be especially valuable devices for problem solving.

One man suggested that the Space Station control room should be fairly well simulated, but the other functions of a Space Station need not be

duplicated on the ground. He suggested a minimum ground training period and completion of training in the Space Station itself under the supervision of the crew. He presupposed that only part of the crew, perhaps two out of ten, would be replaced at any one time.

One man had no comments.

Comments: The suggestion that part-task and modular simulations should be adequate seems to be a reasonable approach. The concept of training after arriving on station is an interesting one and might be an area for investigation.

49. Accommodating diverse groups of people.

Seven people were asked this question. Two people expressed disapproval of the concept of taking the "man on the street". Both of these contacts felt that, in the foreseeable future, we would be taking selected people. One mentioned that we would select them first for their skills, second for their motivation, and third for their physical and mental health. One contact mentioned construction workers. He thought we would ask for volunteers from the population of construction workers, then we would select the most skilled and the most fit.

Three contacts mentioned their opposition to the practice of applying arbitary age limits. They felt that the results of a physical examination should determine a person's fitness to fly, not his age. One mentioned a Dr. Vincent in Houston who has a program that is an excellent predictor of mental acuity. The respondent thought some of the airlines were using Dr. Vincent's technique.

One stated that we could markedly relax our physical requirements because there are no stresses in space.

Another felt that most of the problems will be societal, and the Commander will have to deal with them.

Another suggestion was that planning for medical care facilities must take into consideration that crew members of the future may not be in the best of health or of optimum age.

Comments: I was pleased to hear one of the contacts state that we could markedly relax our physical requirements because there are no stresses in space. I do not know, in any great detail, what physical limitations NASA places on selectees for space flight, but senators and school teachers are now being considered. From a purely scientific standpoint it seems reasonable to fly a group of "average" people to see whether they perform any differently than the highly selected and superbly fit persons we have flown in the past. There was really no reason for selecting the cream of the crop after Mercury and Gemini. Both of those early missions had the unknown possibility of requiring the ability to sustain high-Q reentry followed by a survival experience lasting several days at sea or on the desert. Obviously an extraordinarily fit human specimen was required. We might be surprised to find out that the average person who is accustomed to a more sedentary life might even perform intellectual tasks in space at least as well as the more fit person does.

I have not followed up on the suggestion that Dr. Vincent in Houston be contacted because of his ability to predict mental acuity separate from age.

50. Thoughts regarding safety hazards.

This question was presented to nine contacts. Three stated that they had nothing to contribute. One said the only thing he could think of was a kit to seal meteoroid punctures. Another suggested only that we build in as much redundancy as possible. One person said that aside from the pure vacuum of space, living in the Space Station is no different, from a safety point of view, than living on Earth. The hazards are the same and you protect against them with structural design. You can't protect against all eventualities. He felt compartmentalization will solve many problems.

Another person made these five points:

1. Follow established procedures.

2. Have two cues to a problem, i.e., audio and visual warnings in case one or the other is missed.

3. Eliminate single-point failures. He said NASA has done a very good job of doing that.

4. When a failure does occur, fall back to a safe position immediately, and examine the failure.

5. Use extraordinarily well-trained people in positions of principal responsibility.

One respondent urged that NASA do careful failure mode analyses, and where they discover hazards that the crew will have to live with, then make sure the crew is well trained, or even overtrained to deal with them.

One of the most lengthy and thoughtful comments was:

"The hazardous situation is a complicated one in which you are not quite sure what to do. The simpler the situation, the less danger there is of screwing it up. I think the most important thing from that standpoint in Space Station is to clearly identify and color-code all the various pieces of equipment at different levels of hazard. The most serious being red, the next yellow, then maybe yellow-and-black stripes. Basically like the military does now. Mark 'NO STEP' and 'HAND HOLD', and so forth. A concerted effort should be made to see that we don't get sharp corners and that sort of thing.

"The dangers are going to be in the pressure suit people wear. With a lot of people up there working around there is going to be a suit puncture, or someone is not going to put the wrist seal on properly and a glove will pop off. Those are the kinds of problems we are going to have. We are not going to have any problems inside."

Comments: Of all the respondents, I concur most closely with the individual who made the five points. They should be remembered and practiced by all who have any role in safety design or practices - and that includes nearly everyone.

51. Suggestions which would help maintain crew health.

This question was asked of nine contacts. Two stated they had no comments to make. Proper nutrition or diet was mentioned by three people, as was proper exercise. Recognition that people have the same psychological needs in space as on Earth was mentioned frequently. One contact urged that the time line be structured to provide time for quiet reflection and contemplation. The benefit in crew member contributions to the mission will outweigh any cost in time. Another said that we must choose sensitive, intelligent people to serve on Space Station. You don't need the "macho-man", and brute-force kind of people - they should be kept out.

One man stated, "Try to make it as much like a normal civilian life as possible, recognizing that we're going to have a command structure, and by that I mean if a guy wants to have a glass of wine with dinner or a shot of brandy after, he ought to be entitled to do so. He's not flying an airliner - it's home!"

One other man had mentioned that he thought moderate consumption of alcohol was probably beneficial. Another man, who I am sure would have agreed with the comments above regarding wine with the meals and brandy after, nevertheless warned against what he perceived as the current social acceptance of overindulgence by military pilots. He felt that behavior was hazardous to safe flying the next day.

The mental health aspects of the Space Station were considered by another contact. He said, "We should allow a routine-enough work cycle and approach to Space Station operations so that if someone does get sick they can go take a day off and rest. Let's ease off on the work load. Let's let the astronomers have some time to just sit there and look through the telescopes. What's wrong with that? That's where all the great astronomers got all their great ideas anyway."

Comments: Here again, I was pleased to see the emphasis on factors influencing mental health. If one lesson should have been learned from all of

our space flight projects, it is that we must guard against overloading the crew member. I was most impressed by the last comment recorded, "Let's ease off on the work load. Let's let the the astronomers have some time to just sit there and look through the telescopes. What's wrong with that? That's where all the great astronomers got all their great ideas anyway."

I can only applaud that advice.

SPONTANEOUS COMMENTS

As stated in the section entitled METHOD, the 51 questions were actually used only to stimulate discussion. Although a great many comments were received in response to those questions, there were some additional statements made either spontaneously or as a result of thoughts stimulated by the questions. Some of these spontaneous statements are presented in this section.

1. It had been several years, and even decades, since some of the contacts had flown. One of them opened the interview with this statement:

"It is interesting your coming around doing this. I commented to [his wife] this morning that this is the first time anybody has asked my opinion about anything since the day I left NASA. And, consequently, it is of a lot less value than it might have been a year after I left NASA."

Comments: In light of the remark made by one contact that his remarks might have had more value had he been contacted a year after leaving the program rather than several years later might suggest that NASA give consideration to establishing a procedure whereby all former astronauts would be interviewed a year or two after they leave the program. I feel confident that individuals who are no longer competing for a flight position, or who are no longer hoping for advancement in, or rewards from, the system might well be a very valuable source of information. Among the ten people I interviewed, I felt that some of them were so long out of the program as to be of little value to this project. On the other hand, some who were more recent members of NASA had many good comments which they probably would not have made had they been competing for flight assignment.

2. One stated that he felt gymnastics might be a good training procedure, particularly use of the trampoline, in combatting space motion sickness.

Comments: None.

3. In view of the fact that EVA astronauts do not appear to use their legs very much, one contact was asked his opinion regarding a suit without separate legs. He replied:

"Some of the EVA tasks would require that you anchor your feet somehow, because that's the way you apply the torque. If, of course, you have some umbilical 'belly-button' kind of thing with which you attach yourself rigidly through your center of gravity, then you could obviously use your arms pretty well without a foot restraint. I would kind of think that having your legs separate would give you much better torque and muscle control."

In response to the same question another contact said:

"But if you're thinking in terms of a Space Station where you're going to have to do some manual work with your arms, and you look at the situation where you put in a torque motion, I don't know how you would counteract that without having your feet somehow [stabilized]. Speaking of construction work in space he said, "It is in that kind of a mode where I would envision that you might want [to use your legs]."

Comments: None.

4. When speaking of training, one contact mentioned what he called an "advocacy" position in training. It is sitting down ahead of time and asking what one will do if a certain event takes place. He said:

"Within certain limitations you could take the advocacy role ahead of time. It's a 'brain-washing', and I know that's a bad word, but you train to the point where, when you get there, the actual case is a piece of cake. And many times it doesn't have to be a hands-on kind of training. You can sit in a room and discuss what we're going to do if this happens and why do that one. But you gotta go through that exercise. It's a very important part of

getting ready to go." The contact then gave two examples from his flight where familiarity with the system and procedures saved the mission.

Comments: The remarks regarding "advocacy" training were interesting to me. The mental exercise of sitting quietly alone or with one's colleagues and contemplating possible events and how to cope with them is probably an excellent way to train for foreseeable eventualities. Perhaps such training methods could be encouraged.

5. At the close of his interview, one contact offered the following independent thought:

"One of the things I don't think we're doing too well...is designing things like the Space Station, taking advantage of the real and unique environment. Using the delta temperature and the delta pressure as driving forces to some degree in equipment design. We're still designing things for here that we then make all sorts of special precautions to operate up there instead of designing them to really optimize the environment they have to be in. I think when that happens we will have problems testing it down here, but it will [work better up there.]" When asked for examples he said that he had none at the moment.

Comments: None.

6. Another contact in explaining why he thought he did not get motion sickness in flight said:

"We would go up and do parabolas in the T-38 where we could do between 15 and 23 rolls on a given parabola. We put our head in different orientations with each roll. I'd do that maybe twice, and all of a sudden the sweat would break out--you'd sit there with the world going around and you'd try to fly straight and level for five minutes until you could get the world back together again, then you'd go at it again. I did that down at the Cape [before the flight]. I got to where it really took something to get me sick. I don't know whether it was that conditioning that helped or whether it was that I was just more naturally resistant than some. You can do the same thing

in a swimming pool. You can get some pretty high rates--until you get severe nystagmus."

He continued to comment that performing rolls in a zero-g parabola and holding the head in different positions at the same time was the most efficient way of producing nystagmus that he knows. He got to the point where he could make the world "twitch" in any direction depending upon how he held his head during the roll.

Comments: NASA might give some thought to investigating the training routine described by the contact who stated he and his partner executed 15 to 23 rolls while in a zero-g parabola, with their heads in a different orientation for each parabola. I am astounded at the piloting skill which this maneuver requires, but if it can be done it might be of value in anti-motion sickness training. I know that aerobatics have been attempted to train against motion sickness, largely without benefit, but this is the first I have heard of stimulating the semicircular canals while in zero-g.

7. One contact was asked for his ideas regarding the changing crews. He said that it might be necessary to bring up one or two specialists for short periods to perform specific tasks, but he felt it was important to change the entire basic crew at the same time to maintain a cohesive unit.

Comments: None.

8. Another interesting concluding remark was:

"There is one other thing I always make a pitch on, and that is that they do not realize that people in space flight or in zero-gravity condition are no different than down here. You have zero gravity and a better view, but other than that you are dealing with the same person and the same working environment and they can do exactly the same thing they can do down here. If a person is exceptionally good as an observer or working out something analytically, or if he is good at doing any kind of a detailed task (for example, a photo interpreter), you can put him up there where he is looking at

the real thing. He can do just as good a job up there as down here. There is no reason for not using a person's intellect fully. So far, the way space flights have been constructed, they want to dictate everything by checklist and take away your ability to think.

Comments: See comments following Statement 9.

9. Another man expressed the same thoughts in this way:

"My big 'soap box' effort is the thing about let's not forget who we are and what our needs are as people, and carry those things with us. Let's not lull ourselves into thinking that this is such a special environment that all the rules change and everything is different, and that people will give up this and give up that in order to be up there. They will do it for a ten-day mission, but they won't do it for ninety days."

He went on to say, "One of the problems we ran into on our mission was that we forgot to think about those things, and we got ourselves caught up in a workaday thing where we were working fourteen to sixteen hours a day, and working strictly following a carrot - following a very precise agenda every day. Halfway through the mission we began to get inefficient and made mistakes. We finally recognized our problem and did something about it, and came out at the end of the mission in good shape. We finished everything we were supposed to do and got it all right."

Comments: I commend the two remarks regarding utilization of people for their capabilities and their human abilities to NASA for serious consideration. I agree with both comments. If we are to put people in space we must take advantage of their capabilities and their "humanness", whatever that is. We should recognize the tendency to overschedule and actively correct for that tendency.

10. One contact believes that the absence of low-frequency electromagnetic radiation in space might have some physiological consequences. He said that this radiation is commonly referred to as Schumann resonance. Speaking to this subject he said:

"Within the ionosphere-Earth surface cavity there is, I think, about an 8-Hz to 32-Hz oscillating field with a series of peaks in that field that is generated by lightning storms on Earth, but the net result of all that electromagnetic activity is that we're exposed from conception to death to this oscillating field, and there is some evidence that if you play with that field here on Earth, particularly by superimposing a 5-Hz, 4-Hz, or 3-Hz field on what is already there (and it is very difficult to isolate the individual from it unless you go underground) and you get some neurological problems. It does affect people, and it is probably related to what happens to you when you get a relatively low-frequency strobe light flashing at you. A lot of people feel very very uncomfortable neurologically when that happens. In space, of course, it's absent. Once you get above the ionosphere that field is absent, and there is some concern among physicists who have a background in neurophysiology that there might be an instantaneous effect contributing to the Space Adaptation Syndrome, but they are more concerned about what the long-term effect may be if the brain actually uses that frquency on occasion or continuously to reset it's own timing signals in it's central processor. So, I would FLAG that as an unknown."

This contact was also concerned about "intermittent sleep." He felt it could cause difficulty from the standpoint of loss of REM sleep. Intermittent sleep is different from simple insomnia. Intermittent sleep is that situation where a person wakes up and goes back to sleep several times during a sleep period. It should cause no problem over short periods, but if continued for two months or so it might. It has been noticed in sleep labs on the Earth, but the contact was of the opinion that it occurs more frequently in space flight than it does on the Earth.

Comments: I cannot comment on the role of low-frequency electromagnetic radiation in space and its physiological consequences and I am unaware of "Schumann Resonance", but I do want to underline this individual's comment as a possible route of inquiry, which NASA might investigate. I also am unable to comment on this same contacts remarks regarding "Intermittent Sleep".

11. One man mentioned that he felt his mind worked better in space. When asked to elaborate on that subject he said:

"...it might be just that you are doing it for real rather than in practice. The fact that you're in 100% oxygen environment - that should allow you to perform a little better. I think in a place of reduced gravity, that could have a contributing factor too. [There was a] changed response pattern, including mental. That is particularly true in the weightless situation."

Comment: None.

12. One contact mentioned that it took him four to five days to get adjusted to the zero-g environment. He said that he knew that if he moved about quickly he would become sick, so he moved very slowly and very deliberately until he became accustomed to the environment.

He also mentioned that upon his return to Earth he had "vertigo". He felt as if the bed was inclined about 30 degrees head down. This sensation lasted for about a week. He mentions that he was unable to clear his ears during parachute descent at the end of his mission and wonders if that did not contribute to his feelings of "vertigo". He believes it would have been interesting to go through vestibular testing during that period, but other matters seemed to occupy the time of the physicians.

Comments: The contact who said it took him four to five days to get adjusted to the zero-g environment was the only one of the group that admitted to even the least trouble. I found it interesting that he experienced a head-down sensation after return to Earth. I would have expected him to experience a head-down sensation in flight due to migration of fluid to the head and a head-up sensation upon return to Earth.

13. Several subjects mentioned difficulty sleeping in flight. The consensus seemed to be that free-floating sleep was not comfortable or restful. One man mentioned that in order to get a comfortable night's sleep, the head and hands have to be restrained to prevent them from moving about in random fashion.

Comments: I believe this last remark regarding the unsatisfactory nature of unrestrained or free-floating sleep has been made before, so it requires no further investigation, but should be kept in mind when sleep restraints in the Space Station crew quarters are being designed.

APPENDIX A

1. Flight Crew Health Stabilization Program;
   Discuss in context of SS vs Skylab, Apollo, and STS.
   Worthwhile?
   - Retain?
   - Eliminate?
   - Modify?

2. Do you have any thoughts on facilitating SS maintenance activities of the crew?

3. Discuss alarm systems:
   - False alarms.
   - Lights.
   - Horns.
   - Voice.
   - Tactile.

4. Any thoughts as to tools for on-orbit repair and maintenance?
   Including "work bench", location, equipment, etc.

5. What about food and meals?
   - All eat same foods on same days?
   - Individually selected menu?
   - Suggested changes/improvements.

6. Any suggestions regarding trash disposal?

7. Any thoughts on clothing design?

   One piece coveralls vs. pants and shirt?

   Pocket location, design, closure?

   Off-duty and on-duty. Any difference?

   Special clothing for exercise?

   What kind of sleepwear would you choose?

   Any personal items of clothing for you?

8. Suggestions as to personal hygiene equipment.

9. Aids to transfer of massive objects.

10. Skylab crews found that they oriented to the floor in small compartments, but translated head-first in large compartments. Does this influence your thinking in regard to identification of "up" and "down"? Would visual orientation cues as to "up" or "down" be helpful or harmful?

    [At least one Skylab crew member reported that he always oriented down towards his feet.]

11. What about using vented gases for attitude control, or what about using opposing vents to cancel any effect from venting?

12. What is the importance of private communications with operations staff, medical staff, friends, and relatives?

13. Some Skylab crew members reported that portable fans were of little use for crew comfort, but were useful for equipment cooling. Others reported that they are useful, especially to cool a person during and after exercise. What is your opinion?

14. Do you have any ideas concerning:

   Translation aids?

   Control/switch protective devices?

   Orientation cues?

   Protective devices for personal wear (helmets, gloves, etc.)

15. Skylab crew's comments about the airlock included such remarks as:

It was too small for two crewmen.

Insufficient stowage volume. "Like a rat's nest during EVA."

Lack of foot restraints.

Poor location:

-Between Multiple Docking Adapter and Orbital Workshop.

-In mainstream of traffic.

-Failure of any one of three hatches would be cause for mission abort or even catastrophic situation (EVA crewman being trapped outside).

QUESTIONS: Were any of these problems present on STS?

What suggestions have you for Space Station?

16. Any ideas about the individual crew quarters?

Location.

General arrangement:

(1) Size (Skylab nominal was 28 in. x 38 in. x 78 in.).

(2) Restraints.

(3) Stowage.

Noise.

Lighting.

Temperature.

Ventilation.

What kind of sleep restraint?

Should washing and toilet facilities be included?

-Comode?

-Urinal?

-Both?

What about shift occupancy?

Communications?

Warning signals?

17. How much medical training should crew members have?

Equivalent to EMT?

More? Less?

18. Do you believe crew members should engage in "group dynamics" training before being assigned to SS? Should one CM be trained in this discipline?

19. Should families be given similar psychological training and support?

20. What about crew interaction training in a one-g simulator?

21. How much of a problem is ambient noise?

22. Wardroom:

What suggestions for entertainment?

Will external viewing be of great importance from a recreational standpoint?

Is it important that the Earth appear "down"?

23. Discuss body waste collection and disposal.

24. Personal cleanliness.

Shaving.

Haircuts.

Showers.

25. Exercise.

What kind?

26. How best to manage books and manuals.

Should everything be in data banks with CRT display?

27. Man/machine interfaces.

Brightness.

Shape, color, texture.

28. Three shifts or one (or two)?

All sleep at the same time?

How long a work day? Eight hours? More? Less?

Should work time include one to two hours of exercise, or should all exercise be performed in off-duty time?

29. How important would be real-time TV, including network news?

30. Who should select the crew?

What input should crew members have in regard to crew composition?

31. Does EVA require "buddy system" or can one person do it alone with monitoring from the inside?

32. How can the EVA suit be improved?

Urine collection.

Fecal collection.

Provision for food and water.

Vomiting.

33. EVA

Restraints and tethers.

Hand and foot holds.

Lighting. Helmet mounted?

Tools.

34. With a twenty-one-day rescue time at worst, do you have any suggestions regarding mortuary services?

35. What about foot restraints at the work station?

Locking grid and shoe.

Stirrups.

Clamps.

Velcro.

Other.

36. Locomotion aids.
    - Lines, slidewires.
    - Distributed handles.
    - Other.

37. What about body restraints for tasks requiring extreme steadiness?

38. Any thoughts on artificial gravity?
    - Need.
    - Methods.
        - Rotating SS.
        - Tether.
    - Continuous or intermittent?

39. What about autonomy?
    - Is "control" by MCC a pain, or is it reassuring?

40. Would a miniature helmet-mounted TV to record EVA activities be useful?

41. What about an ELV rescue capability? For example, a Titan with reentry capsules.

42. How can man-on-board reduce redundancy?

43. Any ideas for design of a safe haven for two to three weeks' occupancy?

44. What about EVA?
    - Use only for contingency?
    - Use for contingency and major tasks only?
    - Design for and use routinely?

45. On-board command structure:
    - Strong, authoritative Commander with clear chain of command?
    - Participative management?
    - Committee decision making?

46. How Hi-Fi should the SS simulator be?

47. Is the orbiter overdesigned for safety?

Can safety requirements be relaxed for SS? Any examples?

48. Any suggestions as to docking techniques or aids?

Proximity operations.

Approach corridors.

Plume impingement considerations.

Others.

49. In the future many diverse groups of people will have to participate in Space Station activities. For many of these people--scientists, construction workers, and so forth--there will be no arbitrary age limit.

Can you think of any investigations that should be performed now, either to select those persons or to accommodate them in flight?

50. Do you have any thoughts as regards safety hazards?

51. Do you have any suggestions as to measures that would help maintain crew health?

National Aeronautics and
Space Administration

Ames Research Center
Moffett Field, California 94035

APPENDIX B

NASA

Reply to Attn of: LMA:239-2

Dear Space Mission Participant:

The purpose of this letter is to introduce Dr. William K. Douglas and a project that he is conducting under the sponsorship of NASA's Ames Research Center.

The Ames Man-Vehicle Systems Research Division under its Space Human Factors Office is in the process of planning research that will help to assure high levels of crew effectiveness on future space missions, including NASA's proposed space station. Several expected differences between the space station and previous missions suggest that such research is warranted. Such differences include more heterogeneity of crew members in background and experience, broader variety of work requirements (including more EVA), larger crews, and longer durations.

To accommodate some of these changes, plans and designs are being developed for configurations of the total station, individual modules, and work stations, as well as for habitability issues and operational procedures. In many cases the appropriate design or plan for promoting and maintaining effective crew performance under the changing conditions is unknown. Numerous cases involving new designs for work stations and habitats have been documented, in which serious performance problems have arisen because of either the lack of human factors information or the failure to incorporate available information.

The Division has been active for several years in research to support the aviation community in developing methods for avoiding such errors in design, and operations. One of the more valuable sources of information that has directed our research activities has been the Aviation Safety Reporting System (ASRS), which we direct (through a contract, under the sponsorship of the FAA). The system solicits voluntary comments and recommendations from pilots and air traffic controllers that concern any procedural problems encountered in the aviation system, and how these might be corrected. The reports are completely deidentified to insure anonymity of the reporter. Publication of the obtained information is generally in the form of a report that synthesizes individual comments and recommendations related to some particular issue.

Information such as that generated by the ASRS has proven of value, not only by indicating problems that require research for their solution, but by indicating when research is unnecessary, either because information is available to effect a solution, research is already in progress, or the

problem is not amenable to research. When research has been prescribed, the value of its product has been enhanced significantly by the direction received from such information.

The project being conducted by Dr. Douglas is consistent with the intent and spirit of the ASRS. We are convinced that the experience of participants in previous space missions can form the basis for cogent recommendations for design, operations, and appropriate research relevant to future space missions, similarly to our experience in aviation. Therefore, we have asked Dr. Douglas to solicit thoughts regarding space station design and operational requirements. The information obtained will be used to help us (and others) supply guidelines to designers, and to discover inadequacies in available knowledge that indicate a need for further research.

Dr. Douglas has contacted you as part of that process. Dr. Douglas was the first flight surgeon for the Mercury astronauts. We sought his assistance in this project because of his reputation for sensitivity, objectivity, general knowledge of and appreciation for the human in space missions, and his acquaintance with many members of the astronaut corps.

We are requesting your participation because of our sincere interest in helping to assure a high level of effectiveness for future manned space missions. Dr. Douglas' approach will be informal. He will ask you a series of questions designed to focus your consideration of design and operational issues, which we judge are important to the success of future missions. In your answers to the questions we are asking you to project from your experience to the expected conditions on a space station.

We are not interested in documenting or reporting problems, either personal or general, from past missions. Rather, we are asking for your judgment of where impediments to task performance, motivation, morale, etc. could arise; what changes in design and operations would you recommend, based on your experience and expected mission differences.

Dr. Douglas will be assisted on the project by Mr. Donald K. (Deke) Slayton, whom you may know personally. Mr. Slayton's experience and knowledge should be of great assistance to Dr. Douglas in interpreting and synthesizing the information, and producing a useful report.

Please be assured, should you elect to participate, that the information obtained by Dr. Douglas will be completely deidentified from you as the source. Not only will your individual anonymity be assured with respect to specific information that you volunteer, but the identity of those persons interviewed will not be revealed by Dr. Douglas or Mr. Slayton.

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15. Supplementary Notes

The author was the flight surgeon for the original Mercury Seven Astronauts.
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16. Abstract

Ten former NASA astonauts were interviewed using a set of 51 questions developed to encourage the contacts to discuss any thoughts, opinions, conclusions, or suggestions which might have evolved since they left the astronaut program.

Strict confidentiality was maintained. The reader will not be able to attribute any recorded remark to an individual person or to a particular mission.

At least one astronaut from each of the NASA manned space flight programs, excluding the Space Transportation System (Shuttle), was interviewed. The report records the answers to the questions asked, spontaneous comments, and the investigator's own personal evaluations of the material obtained. No statistical analysis of the material was attempted.

The professional opinions of these ten experienced astronauts will be of value to persons concerned with the design and operation of manned space craft and manned space stations.

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