NEW DIRECTIONS IN BEHAVIORAL HEALTH:
A WORKSHOP INTEGRATING RESEARCH AND APPLICATION

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EXECUTIVE SUMMARY

Space missions are complex systems that depend upon the integration of technical and human subsystems. Over the years there have been repeated calls to attend more closely to the human subsystem, including psychosocial adaptation to life in space. In 2001, the National Academy of Sciences published *Safe Passage: Astronaut Care for Exploration Missions*, a comprehensive review of biomedical and behavioral issues that we must address now so that we can mount the next generation of manned space missions. *Safe Passage* draws attention to *behavioral health*, an overarching topic that subsumes psychological, interpersonal, and cultural adaptation to space. In the Bioastronautics Critical Path Roadmap, psychosocial adaptation and behavioral health fall under Risk 18 (Human performance failure because of poor psychosocial adaptation) and Risk 21 (Human performance failure because of neurobehavioral dysfunction). These topics are timely in light of President Bush's mandate to return to the Moon by 2020 and prepare for the first human mission to Mars.

The New Directions in Behavioral Health Workshop was held at the University of California, Davis on December 2-3, 2003. The purpose of this workshop was to promote fruitful dialogue between researchers and operational personnel in the interests of expanding our understanding of psychological, interpersonal and cultural adaptation to space. The specific goals of the workshop were to: (1) assess the current stage of behavioral health with special emphasis on recent developments in research and practice; (2) identify research topics, strategies and applications that will inform future NASA manned spaceflight operations; and (3) present findings and recommendations in a forthcoming issue of *Aviation, Space & Environmental Medicine.* The workshop and publication are intended to serve as a valuable resource for administrators, scientists and operational personnel by stimulating a large and diversified pool of creative, high-quality research proposals in response to NASA RFPs, and by pointing research in directions that will generate practical solutions to the ever-shifting problems of supporting people in space.

A good understanding of psychosocial adjustment and behavioral health are important to assure astronauts' safety, performance, and quality of life. Experience in demanding environments such as Antarctica suggest that the likelihood of a major psychiatric episode is very low, but should it occur can be very dangerous. Even minor problems can prove catastrophic, by leading to a series of small but cascading errors from which recovery is impossible. The ability of past astronauts to withstand the psychological stresses of space does not mean that this will be true indefinitely, or for missions that differ from STS and ISS missions in many significant ways.

This workshop sought to forge stronger links between researchers and operational personnel. Flight psychiatrists and other operational personnel can identify operational issues and provide guidance on conducting research in spaceflight settings, and research results can inform operations in space. Researchers and operational experts fail to connect in meaningful and effective ways because of high levels of workload, patterns of rewards that encourage preoccupation with immediate tasks, and own-group bias as reflected in beliefs that practitioners do not understand good science or that researchers are not interested in practical issues. Not only do operational responsibilities leave scant time for involvement in research, the confidentiality and trust that are so crucial for effective medical treatment may preclude data collection in such areas as mental health.

Because behavioral health issues are multidimensional and complex, a successful overall research program will require a multiplicity of research methods (archival research, case histories, surveys, naturalistic field studies and experiments) and settings (space simulators, spaceflight-analogous environments, and space itself). Simulators, such as shuttle simulators and neutral buoyancy chambers, are constructed to recreate selected aspects of spaceflight. Analogues, such as polar outposts and underwater research vessels, exist for other purposes but are selected as research sites because some of their attributes resemble those that we associate with space. Both simulators and analogues have played roles in past behavioral research and will remain important in the future. Although both offer many advantages such as safety, accessibility, economy, and (in the case of analogues) the opportunity to study people under naturally occurring stress, simulators and analogue environments are not to be confused with space environments and we must be cautious extrapolating from the former to the latter. Generally it has not been the practice to conduct behavioral research on astronauts who are participating in training or engaged in flight, but such research would be useful for informing future operations.

In discussions of Risks 18 and 21 of the Critical Path Roadmap, conference participants identified many stressors. In addition to the major stressors associated with life in space (danger, isolation, confinement, and hardship), these include intermittent or situational stressors such as the breakdown or malfunction of equipment, extravehicular activity and other periods of intense workload, loss of communication, invidious status distinctions, cultural conflicts, and the inability to respond effectively when family emergencies occur. Future missions as envisioned by President Bush will impose new stresses, including extended surface operations, and, in the case of Mars, unprecedented transit times, lengthening communications delays and, eventually, the loss of visual contact with Earth.

Individual factors (physical and mental fatigue, mental health problems, motivational decline, social withdrawal, inability to cope with overload or to respond flexibly under stress), small group factors (poor communication or leadership, lack of coordination, intra-group conflict), organizational factors (lack of sufficient regard for behavioral issues, failure to accept implications of behavioral health research) and cultural factors can all contribute to the deterioration of individual and group performance.

Tendencies of popular writers to sensationalize reports coupled with a code of silence and medical confidentiality make it very difficult to assess the number of critical psychological incidents and their impact on space missions. Problems encountered in isolation and confinement on Earth include: insomnia, exhaustion, boredom, withdrawal, impulsive behavior, frustration over situations at home, depression, anger, friction among subgroups or factions, dysfunctional leadership, perceived favoritism in the allocation of resources, and changing sexual partnerships. They also include lowered energy and decreased capacity for intellectual pursuits, memory impairment, lowered productivity, impaired problem solving, lowered individual and team efficiency, increased hostility toward other crewmembers and toward “outsiders,” declining attentiveness, excessive concern with health, and impulsive behaviors. Some of these problems have also occurred in space. While we must remain vigilant, we should not overlook the many positive consequences of life in challenging environments, such as the vastness and beauty of nature, membership in an elite group, increased self-confidence, camaraderie, and “bragging rights.”

Promising techniques for monitoring psychosocial adaptation, behavioral health, and performance include tests of cognitive function, real time brain imaging, and the computer analysis of facial expressions and paralinguistic cues. Regular monitoring of psychosocial adaptation and behavioral health would enable early identification and intervention, but from a crew’s perspective, surveillance is unwelcome. One solution is to promote techniques for the crew to monitor its own behavior, coupled with the availability of external consultants.

Selection, training, and on-site support are among the countermeasures for assuring behavioral health. Peers, especially when trained, provide useful support. Psychoactive medications can be carried on board, but it is unlikely that crews will be able to perform titration to adjust dosages, and such medicines may have unwanted side effects. Other strategies include teletherapy and computer assisted therapy. These approaches are in their infancy, especially in terms of applications to space.

Close collaboration among behavioral researchers, operational personnel, and the end users – astronauts – is crucial for a vital and enduring behavioral health program. Powerful factors work against such close collaboration, including public relations considerations, engineering and astronaut cultures, and limitations in the field of behavioral health. Nobody wants a mission to be disrupted due to behavioral health problems, but the different interests and priorities of various constituencies (managers, engineers, researchers, support personnel and astronauts) mean that a strong behavioral health research program will not easily take hold. Substantial and sustained progress will require bringing different constituencies together and building consensus on a fruitful plan of action. An effective overall strategy will require open-mindedness, organizational change, and high levels of interpersonal trust.

RECOMMENDATIONS

1. ***Now is the time to establish a strong and viable program of operationally relevant behavioral research. This research should be securely and adequately funded, pervasive, and considered an integral component of space mission planning.***

2. ***The peer review process should be adjusted to assure that scientifically competent projects that have high potential for application are not prematurely eliminated.***

3. ***Behavioral researchers should give higher priority to translating behavioral findings into useful operational requirements.***

4. ***A successful overall behavioral health program will require a broad perspective, multiple convergent research strategies, ingenious measures, and a variety of settings, including space itself.***

5. ***Research in space itself should employ measures that make minimal demands on astronauts' time, engage their interest, and work within the constraints of the highly engineered space environment.***

6. ***Researchers who study analogue environments should systematically relate specific environments, populations and tasks to specific spaceflight situations.***

7. ***Research on psychosocial adaptation and behavioral health should proceed at multiple levels: individual, group, and organizational. It is particularly important to improve our understanding of the interactive effects of variables at different levels on individual and team performance.***

8. ***It is time to study an expanded role for standardized psychological tests in astronaut selection.***

9. *It would be useful to further strengthen the behavioral sciences department at Johnson Space Center and use it as a major conduit for communication between research and operations.*

10. *It is time to establish a cumulative database to track variables that affect psychosocial adaptation, behavioral health, and performance.*

11. *NASA should expand research on stressors and their effects. We need a better understanding of the link between specific stressors (alone and in combination) and specific outcomes, taking into account moderating variables such as personality traits (hardiness, resilience) and coping skills.*

12. *Although the concern of the Critical Path Roadmap is dysfunction leading to failure of a mission we need to know more about the positive aspects of spaceflight that are inherently rewarding, act as incentives, and strengthen commitment to the space program.*

13. *Many governmental agencies are interested in supporting high performance teams in demanding environments. NASA would do well to monitor and collaborate with relevant projects sponsored by other governmental agencies.*

14. *To minimize the problems associated with remote surveillance, we should develop devices that help astronauts monitor their own psychosocial adaptation, behavioral health, and performance.*

15. *We need more research on therapy at a distance, such as by teleconferencing or by computer. This research should factor-in communications delays and other requirements of future space missions.*

16. *As efforts continue to revise the Bioastronautics Critical Path Roadmap, it is important to include topics that might be overlooked because they fall between the foci of different study groups (such as human factors engineering and behavioral health).*

17. *The Workshop represents one step towards a strong behavioral health research program. We must expand the number of researchers and operational personnel involved in the discussion, and provide opportunities for selected groups of experts to hold in-depth discussions of specific topics.*

18. *A sustained and pervasive behavioral research program will require regular, dedicated, and ample funding. Management support for behavioral health should be continuous as a matter of course, not a reflection of an occasional need.*

NEW DIRECTIONS IN BEHAVIORAL HEALTH:
A WORKSHOP INTEGRATING RESEARCH AND APPLICATION

In 2001, the National Academy of Sciences published *Safe Passage: Astronaut Care for Exploration Missions*, a comprehensive review of biomedical and behavioral issues that we must begin addressing right now so that we can mount the next generation of manned space missions (National Academy of Sciences, 2001). *Safe Passage* draws attention to *behavioral health*, an overarching topic that subsumes psychological, interpersonal, and cultural adaptation to space. Behavioral health in this context refers to identifying and countering the psychiatric, psychological, psychosocial and psychophysiological effects that could impact extended space missions. Compared to earlier formulations (such as mental health), behavioral health is less limited in that it recognizes that effective, positive behavior depends upon interaction with the physical environment and with other people, as well as upon the absence of neuropsychiatric dysfunction. Furthermore, behavioral health is evident not only at the level of the individual, but also at the level of the group (including crews and families) and intergroup relations (such as between a crew in flight and mission control). Behavioral health is an interdisciplinary field, and maximizing behavioral health in space requires contributions from psychiatry, anthropology, education, sociology, and several fields of psychology including personality, abnormal, social, industrial, organizational, and clinical. Among the recommendations made in *Safe Passage* is the following:

"NASA should give priority to increasing the knowledge base of the effects of living conditions and behavioral interactions on the health and performance of astronauts on long-duration space missions beyond Earth orbit." (p. 170)

Safe Passage calls for a new generation of behaviorally oriented research that will increase the scientific dividends of our space efforts, and, more importantly, inform spaceflight operations. This research should help trainers, flight surgeons, and other support personnel as well as the astronauts themselves to prevent or mitigate the accumulation of stresses that could lead to performance lapses or decrements, interpersonal strife, or psychiatric difficulties both in flight or afterwards. This call is timely and germane in light of President Bush's January 2004 mandate to return the Moon within the next ten to fifteen years and to establish a human presence on Mars sometime after that. A new generation of missions that includes extended surface operations and, in the case of Mars, unprecedented transit times, will impose new demands on technology, astronauts, their families, and support personnel. The time to address these issues is *now* so that the results can materially benefit tomorrow's manned space missions. Timeliness is confirmed by the widely distributed NASA communiqué from Associate Administrator Mary E. Kicza that is reproduced in full on the next page (emphasis added).

THE CRUCIAL ROLE OF BEHAVIORAL HEALTH

Space missions are complex multidimensional systems whose functioning depends on the coordination of technology and people. Systems have both structural and functional properties and, while they function as a whole, they can be analyzed in terms of their component subsystems (Connors, Harrison & Summit, 1994; Fogleman, 2004; Miller, 1978, 1991). Systems consist of interdependent parts such that the failure of any part can result in the failure of the system as a whole. For a space mission to succeed, the technical and human subsystems must perform if not flawlessly then within the latitudes of where recovery is possible, and the subsystems themselves must be integrated into a seamless whole. Given the harsh and demanding conditions of outer space, the spectacular nature of the technology required for getting us there, and the early history of NASA, it is not surprising that most attention has focused on the technical subsystem. This, along with the widespread but risky (and, as we now know, unrealistic) assumption that the exceptional people who become astronauts have the "right stuff" to handle all contingencies, may obscure the potential liabilities of the human subsystem, and divert attention from the research and operational efforts required to support the people who represent us in space.

Space biology and medicine, human support technology, space human factors engineering and behavioral health are among the disciplines that focus on the human subsystem. In the US space program, a brief period of interest in behavior was followed by a lengthy hiatus of behavioral research (Brady, 2003). During this interval, psychological adaptation, mental health, interpersonal dynamics, and intergroup relationships were either cavalierly dismissed (Santy, 1994) or expected to gain ascendance sometime in the future when crews grew larger and more diverse, and as missions increased in duration (Connors, Harrison and Akins, 1985, 1986). The premise of the New Directions in Behavioral Health Workshop is that for planning and research purposes, the long anticipated next generation of space missions is upon us.

Dear Colleague,

On January 14, 2004, President George W. Bush announced a new vision for the Nation's space exploration efforts. The vision provides clear direction for our human and robotic exploration endeavors. It specifically calls for, among other things:

- *Implementing a sustained and affordable human and robotic program to explore the solar system and beyond*
- ***Extending human presence across the solar system, starting with a human return to the Moon by the year 2020 in preparation for human exploration of Mars and other destinations***
- ***Developing the innovative technologies, knowledge, and infrastructures both to explore and support decisions about the destinations for human exploration***
- *Promoting international and commercial participation in exploration to further U.S. scientific, security, and economic interests*

The Biological and Physical Research Enterprise is proud to be part of this endeavor. Our work in developing our Enterprise Strategy -- which is founded on the premise that humans will extend their exploration endeavor beyond low Earth orbit -- serves as an excellent foundation from which to move forward*. The President's vision now provides clarity in terms of specific objectives and time frames. While we recognize these objectives will be challenging to achieve, we are convinced that they are achievable.*

The International Space Station (ISS) is a required and integral component of the stepping stone approach to the exploration goals articulated by the President. Our research on the ISS will focus on supporting space exploration, with an emphasis on understanding how the space environment affects astronaut health and on identifying and implementing required countermeasures and human support technologies.

We have begun the process of systematically reviewing our research portfolio to determine how our programs can best contribute to providing the products in the necessary time frames to realize the exploration vision. Initially our review will be done internally, but as we progress we will seek the advice of representatives from our research community.

As a result of the agency's direction and our own review, we expect to change the emphasis of our solicitations for research and technology. In some cases, you may see changes in our solicitation approach. The quality of our peer review processes will not change.

Through exploration, we seek the answers to questions of scientific and societal importance. We develop technology innovations to serve our exploration objectives. And, as we've seen through past experience, these discoveries and innovations will benefit us here on Earth, as well.

The journey we embark on is not about a destination. It's about our destiny as explorers, and about preparing the way for the generations of explorers to come.

Please join us, as we take the next steps on this bold journey!

Sincerely,

Mary E. Kicza
Associate Administrator,
Office of Biological and Physical Research
NASA Headquarters

One of the first reports to thoroughly address psychosocial adaptation was an insightful and forward-looking monograph prepared by Nick Kanas and William E. Fedderson over three decades ago (Kanas & Fedderson, 1971). Almost immediately thereafter, the National Academy of Sciences released the findings of a study panel chaired by Donald B. Lindsley of UCLA. The intent of this panel was:

"to indicate the blocks of research, roughly in order of priority, that will be most fruitful in the years ahead in coming to grips with the problems of long-duration missions... In this, there is little doubt in the minds of the study participants that the difficulties are formidable, the unknowns significant, and the prerequisite research extensive ..." (Space Sciences Board, 1972, p.15).

Many of the scientists on this panel were interested in space physiology and medicine, but it also included psychologists with expertise in stress, social interaction, and behavior in isolation and confinement. In addition to recommending basic biomedical and life support research, the panel urged research on subjective states (emotions, dreams, imagery, fantasy, hallucinations), skilled performance, environmental habitability, group processes, interpersonal interaction, and the relationship of the space crew "microsociety" to the larger flight team.

In the mid-1980s, the Committee on Space Biology and Medicine of the National Research Council sought to give further impetus to strengthening our understanding of human adaptation to space. This panel saw benefits for both research and operations:

"The overall goal for the study of human behavior in space is the development of empirically based scientific principles that identify the environmental, individual, group, and organizational requirements for the long-term occupancy of space. Although the evidence is fragmentary, it seems likely that behavioral and social problems have already occurred during long-term missions and that such problems will be exacerbated as missions become more complex, as mission duration increases, and as the composition of crews becomes more heterogeneous. An understanding of the problems and their amelioration is essential if man desires to occupy space for extended periods of time. Even more important from a scientific perspective, it seems likely that significant advances in our basic knowledge of human interaction and processes will emerge from the research needed to ensure effective performance and adjustment in space." (Committee on Space Biology and Medicine, 1987).

Revisiting the issue ten years later, the subsequent Committee on Space Biology and Medicine reaffirmed the value of their predecessors' recommendations:

"Despite [the 1987 Panel's] assessment of the importance of behavioral issues, little progress has been made transforming the recommendations for research on human behavior and performance in space into action. In contrast to the routine collection of data on cardiovascular, neurological, and musculoskeletal changes in flight since the earliest days of the US space program, there has been relatively little effort to collect data on behavior and performance in a systematic fashion. Nevertheless, as missions have become longer in duration, issues relating to human behavior and performance have gained increasing prominence... As could be predicted from controlled simulation studies, the history of space exploration has seen many instances of reduced energy levels, mood changes, poor interpersonal relations, faulty decision-making, and lapses in memory and attention. Although these negative psychological reactions have yet to result in disaster, this is no justification for ignoring problems that may have disastrous consequences. Furthermore, there are degrees of failure short of disaster and degrees of success short of perfection; if favorable organizational and environmental conditions can increase the level and probability of success they are worthy of consideration." (Committee on Space Biology and Medicine, 1998, p.195).

The 1998 Committee recommended studying the effects of the physical and psychosocial environments of spacecraft on cognitive, psycho-physiological, and affective measures of behavior and performance; developing and evaluating countermeasures for mitigating adverse effects of the physical and social environments on individual and group performance; conducting in-flight studies of the characteristics of sleep during long-duration missions; conducting ground-based studies of change and stability in individual psychophysiological patterns in response to psychosocial and environmental stressors; considering the effects of individual differences on cognitive, psychophysiological, and affective measures of behavior and performance; developing improved methods for assessing interpersonal relations and crew compatibility; and establishing improved training [didactic and experiential] in psychological and social adaptation to space. It also recommended exploring the effects of crew composition on topics such as crew tension, cohesion and performance; factors affecting ground-crew communication and inter-actions; conditions that affect the distribution of authority, decision-making, and task assignments between space crews and ground control; shared mental models; and managerial issues such as task scheduling, the distribution of authority, and the locus of decision-making.

The most obvious risk is that psychiatric problems such as anxiety and panic attacks, severe depression, or obsessive-compulsive behaviors could lead directly to a catastrophic failure, perhaps through making it impossible for a crewmember to perform essential tasks at critical times. Experience in other demanding environments such as in Antarctica and nuclear submarines, suggests that the likelihood of a major psychiatric episode is very low, but should it occur, its consequences could be very dangerous (Lugg, 2003). A second path to disaster is if cumulative fatigue, mild depression, psychosomatic disorders, loneliness, and social tensions continue to degrade performance gradually. Even minor problems could prove catastrophic, either through contributing to a seriously flawed decision or by leading to a series of small but cascading errors from which recovery is impossible.

The ability of past astronauts to withstand the psychological stresses of space does not mean that luck will hold indefinitely, especially during the next generation of missions that will differ from STS and ISS missions in many ways. Additionally, we may expect differences in the kinds of people who are drawn to space. From its inception until relatively recently, the Space Program has primarily attracted candidates who are interested in aviation. In the future, with actual spaceflight only a part of the overall task, other types of people, perhaps cast in the mold of early polar explorers, may be more interested in becoming astronauts.

Another justification for attending to behavioral health is that this would promote a high quality of life in space that would benefit both NASA as an organization and the astronauts (Suedfeld, 2003). Astronauts are more than “operators” or “patients.” They are people who deserve good treatment. Astronauts who believe that their individual needs have been ignored may be reluctant to sign up for additional missions despite NASA’s massive investment in their training, or they may express negative attitudes towards their former employer after they depart. Satisfied people are less likely to quit and are more likely to maintain high commitment to organizational missions and goals. Thus there are strong justifications for improving our understanding of behavioral health. Over the years there have been many calls to do so (a partial roster of such calls appears in Table 1) and these gain in urgency as we move into the future.

Recommendation 1. Now is the time to establish a strong and viable program of operationally relevant behavioral research. This research should be securely and adequately funded, pervasive, and considered an integral part of space mission planning.

TABLE 1
A SAMPLE OF CALLS FOR RESEARCH ON BEHAVIORAL HEALTH

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THE WORKSHOP

The New Directions in Behavioral Health Workshop sought to promote fruitful dialogue between researchers and operational personnel in the interests of expanding our understanding of psychological, interpersonal, and cultural adaptation to space. The specific goals of the Workshop were to: (1) assess the current stage of behavioral health, with special emphasis on recent developments in research and practice; (2) identify research topics, strategies, and applications that will inform future NASA manned spaceflight operations; and (3) present the findings and recommendations in a special issue of *Aviation, Space & Environmental Medicine.* The workshop and publication are intended to serve as a useful resource for administrators, scientists and operational personnel by stimulating a large and diversified pool of creative, high-quality research proposals in response to NASA RFPs, and by pointing research in directions that will generate practical solutions to the ever-shifting problems of supporting people in space. Organized by a Planning Committee consisting of Frank E. Carpenter, M.D. (Johnson Space Center), Albert A. Harrison, Ph.D. (Committee Chair and Principal Investigator, Professor of Psychology, the University of California, Davis), Desmond Lugg, M.D. (Chief of Medicine in Extreme Environments, NASA Headquarters), Marc Shepanek, Ph.D. (Deputy Chief of Medicine in Extreme Environments, NASA Headquarters) and Peter Suedfeld, Ph.D. (Professor Emeritus of Psychology, University of British Columbia), the Workshop was held in Davis, California on December 2-3, 2003.

Participants reviewed justifications for a comprehensive and sustained program of behavioral research, examined past research, and sought new paths to better inform spaceflight operations. Topics included an orientation to behavioral health, research settings and methods, a brief overview of selected substantive research areas pertinent to the Bioastronautics Critical Path Roadmap, and strategies for mounting and sustaining an effective and comprehensive behavioral health program (Appendix I, Program). The Workshop assembled a small but diverse group of approximately 40 professionals including NASA managers, NASA operational personnel, and university and industry-based researchers (Appendix II, Roster of Participants). The limited size of the Workshop meant that it included only a small sample of the eminently qualified managers, researchers, and operational professionals who could help set new directions in behavioral health.

RESEARCH AND OPERATIONS

Theory-based, methodologically rigorous research gains in value when it has an "action" or "applied" component so that, properly communicated and understood, the findings can be put to good use. Psychiatrists, psychologists, educators, and other professionals who have operational responsibilities can inform and guide such research. Practitioners can explain to researchers the issues that they consider important. Their in-depth work with individual astronauts and flight crews give them insights that, shared with researchers, can help guide research. Additionally, they can tell researchers where *not* to go, that is, steer researchers away from areas that look promising but that are unlikely to generate applicable results.

Ideally, there is synergy between research and practice, with both groups of specialists working in a complementary fashion for a common good. Since NASA is concerned with science *and* operations, the most useful research projects are those that are theoretically and methodologically sound and have implications for flight. When there is minimal dialogue, researchers may have only a partial and shallow understanding of the realities of life in space, having gleaned their knowledge from hearsay and rumor and from popular sources such as books, newspapers, and television shows that present an incomplete and sometimes erroneous picture (Douglas, 1991). Operational personnel, on the other hand, may be unaware of useful findings or the availability of theories and methods that could provide them with helpful ideas.

Researchers and operational experts fail to connect in meaningful and effective ways because of high levels of workload that make it difficult to broaden one's perspective, patterns of rewards that encourage preoccupation with immediate assigned tasks, and own-group bias as reflected in beliefs that practitioners do not understand good science or that researchers are preoccupied with "ivy tower" projects and do not really care about the practical utility of their results. A consistent theme is that operational personnel do not have the time to get involved in research, or that at they can attend only to "today's most pressing problem" rather than the vast panorama of topics that require serious attention. From the operational perspective, the most immediate and pressing problem absorbs all attention, even though there are many others that require research.

Flight surgeons report conflict between their role as medical practitioner and their potential role as data-collectors (Flynn, 2003). Not only do operational responsibilities leave scant time for research, the confidentiality and trust that are so crucial for effective medical treatment preclude involvement in behavioral health research. Specifically, any real or suspected breach of confidentiality from the therapeutic to the research setting would undermine patient trust and render therapy ineffective. Consequently, it is very difficult for flight psychiatrists or psychologists to become engaged in research pertaining to psychosocial adaptation and behavioral health.

We heard expressions of frustration with regard to current NASA peer review procedures that begin with a compartmentalized assessment of scientific merit. Peer evaluations are undertaken by leading academics who excel in their research specialties but who are not necessarily versed in the behavioral aspects of spaceflight. In consequence, academic reviewers may not notice the high operational relevance of some proposals, or accord them low ratings on the basis of experimental design or procedures even though the proposed methods are the best available given spaceflight constraints. This is *not* to say that application-oriented proposals that are scientifically incompetent should be passed because they seem useful; indeed, if the science is deeply flawed, translating the results into application is a waste of time, effort, money, and perhaps lives. But at the same time evaluations must reflect what can be done as well as what reviewers wish they could see done.

Another daunting and recurrent problem – one that should be high priority for researchers - is translating "messy" behavioral findings into useful guidelines and countermeasures. Behavioral issues tend to be multidimensional, complex, and difficult to translate into straightforward applications. Typically, there are too many qualifications and exceptions to formulate a general rule. Finding new ways to apply behavioral findings in space is essential for strengthening the relationship between research and operations.

Recommendation 2. The peer review process should be adjusted to assure that scientifically competent projects that have high potential for application are not prematurely eliminated.

Recommendation 3. Behavioral researchers should give high priority to translating behavioral findings into operational requirements.

RESEARCH STRATEGIES

Because behavioral health issues are multidimensional and complex, a successful overall research program will require a multiplicity of research methods and settings. This program will benefit from case studies, qualitative and quantitative analyses of historical documents, surveys (including the administration of psychological tests), naturalistic field studies, and experiments. There is no one path to knowledge. Instead, we will need to use many tools to obtain convergent evidence on how to best achieve objectives in the area of behavioral health. At the same time, weight and volume limitations of spacecraft, the high workloads assigned to astronauts, and the attitudes of our international partners mean that we must be inventive when planning such research.

MEASURES AND METHODS

There is a value to measures that are unobtrusive in the sense that they do not make significant demands on the subject's time or interfere with on-going activities. Efforts to develop measures of stress and performance based on monitoring facial expression and voice stress analysis are promising examples of this (Dinges, 2003). Measurement devices must be compact and lightweight, perhaps loaded into laptops or handheld computers that are already destined for the space habitat. WinSCAT, a Microsoft Windows-based device and MINICOG, which is based on the Palm handheld computer, rest on the translation of standardized tests of cognitive functioning into simplified formats that can be administered by computers in remote settings (Kane, 2003). Results can either be stored, or downloaded for immediate analysis and interpretation.

Experimental tasks that are face valid in the sense that they are easily recognized as mission relevant have an advantage over tasks that strike astronauts as pointless (Currie, 2004). Planning a rescue mission is more likely to motivate and engage research subjects than, say, crossing out all of the vowels on a sheet of newspaper. Realism and significance may be particularly important for astronauts, who are willing to work for the success of their group but have no motivation to waste time on meaningless activities.

RESEARCH SETTINGS

Thus far, NASA has gained considerable information from space on biomedical issues and basic life support, but not much in the area of psychosocial adaptation and behavioral health. Some astronauts have volunteered to fill out questionnaires or to keep diaries during missions, but the general rule is that little scientific behavioral data are collected either during an actual mission or even during training. Former flight psychiatrist Patricia Santy has documented the difficulties confronted by researchers who have tried to conduct studies of astronauts or collect flight data (Santy, 1994). Consequently, instead of drawing on 40 years of accumulated findings we have had to rely on studies of non-astronauts in terrestrial settings, newspaper accounts, expert opinion, and hunch, an amalgam that offers a shaky foundation for mission planning.

Since space itself is all but inaccessible, researchers have turned to simulators and analogue environments that, at least along some dimensions, are "spaceflight like." Simulators are laboratory mock-ups of spacecraft or habitats that are designed and built to capture aspects of spaceflight and have no other intrinsic purpose. Examples include shuttle simulators, neutral buoyancy chambers, aircraft that can produce brief periods of microgravity during parabolic flights, and the Advanced Integration Matrix at Johnson Space Center. Analogue environments are real-world settings where work goes on, as in polar stations, submarines, and missile silos. They are selected as research sites because of their resemblance to space. Analogue environments are typified by conditions such as the following: highly motivated self-reliant people, danger and risk, deprivation including the lack of customary amenities, isolation from the home community, confinement with a relatively small number of other people, lack of privacy, difficult and demanding tasks, limited opportunities for communication, and a degree of dependence on "outsiders." (Not all of analogues share all of these characteristics but some analogues have many of them). The presumption is that, when it comes to human behavior, fundamental similarities between analogue and spaceflight environments outweigh superficial differences and make it possible to extrapolate from the former to the latter. As Jack Stuster pointed out:

“Comparisons are often made between expeditions of the past and future space exploration. From an engineering perspective, the differences between past and future expeditions are considerable. Spacecraft are far more complex than the ships in which the explorers of the Earth sailed. The technological differences are enormous, but from a behavioral perspective, are the differences really that great between confinement in a small wooden ship locked in the polar ice cap and confinement in a small high-technology ship hurtling through space? The psychological differences probably are few.” (Stuster, 2003)

Among analogues, caves are interesting because they may house the first shelters that are constructed on the Moon or Mars (Boston, 2004ab). Maritime environments are informative, as illustrated in recent research on “endurance management,” conducted primarily on board US Coast Guard vessels (Comperatore, Rivera & Carvalhais, 2003). To ensure safe operations, mariners are taught to maintain their mental and physical states within limits that prevent performance degradation. Research submersibles such as the Ben Franklin, Sealab, and Tektite may be particularly good analogues for space stations, since in both cases workers make forays to the “outside” where they float and work in cumbersome protective gear under dangerous and difficult conditions. Prominent today is NASA-sponsored underwater research conducted on the NOAA habitat, Aquarius.

Polar environments, especially Antarctic environments, are perennial favorites for behavioral researchers in part because of the diversity of groups and communities that can be found there (Lugg, 2003; Palinkas 1991; Palinkas et al. 2000ab, Stuster, 1996; Wood, 2003). The first explorers reached the South Pole shortly after the turn of the 20^{th} century. By mid-century there were permanent bases and Operation Deepfreeze scientists there began conducting scientific studies of life in isolation and confinement (Oedholm & Gunderson, 1974; Rasmussen, 1973). In 2000 the new South Pole station opened - a capacious and attractive facility distinguished by its tall aluminum silo. Thus, in approximately 100 years, Antarctic habitats made the transition from crude, temporary camps to modern, comfortable facilities, a transformation that may await us in space. Yet, today in Antarctica the “outside” environment is as harsh as ever, and during the austral winter some polar communities (e.g. McQuarrie Island) remain in total physical isolation.

Researchers can also study spaceflight-analogous *situations* – that is, tasks or activities that mimic or approximate those that we anticipate in space. The exemplar here is computer-based simulation studies of tasks comparable to those that could arise in flight (Brady et al., *in press*). Such studies can take place in the laboratory or field and may involve teams at separate locations. For example, the teams may interact via computer to mount a fictional expedition to rescue “lost” crewmembers. The skillful researcher can vary communications patterns (audio or audio-visual, unidirectional or bi-directional, immediate or delayed) and can preprogram events, such as the loss of a direct route to a destination, that affect task difficulty and interpersonal tensions. Such games or simulations may make it possible to collect immense amounts of data (including samples of verbal and nonverbal behavior and psychophysiological responses), and some of these games may prove suitable for training astronauts.

The degree of correspondence between analogue and space environments depends upon both the analogue environment and the space mission. For example, it is conceivable that work conducted in Antarctica’s Dry Valley is a better prototype for Mars surface exploration than the work conducted on board an orbiting space station. To some extent, clever researchers can increase the degree of correspondence, for example, by serving NASA food in the underwater habitat Aquarius (Blume et. al., 2004). Jack Stuster was one of the first to systematically relate specific analogues and specific space missions (Stuster, 1984, 1996) and current research at Johnson Space Center seeks quantitative means for expressing such relationships (Peacock & Schaffer, 2004). The degree of correspondence between simulators and analogues on the one hand and space environments on the other is an empirical issue, and an important one for behavioral research. One tactic, suggested by Peter Suedfeld, is to compare people's experiences within environments, rather than compare the environments themselves (Suedfeld 1987, 1991, 2003). That is, rather than rely on an environment's superficial resemblance to spaceflight, we should focus on the motivational and emotional states and behaviors of people within them and how these psychological and behavioral responses approximate those that occur in space. Also, we need better ways to translate findings from analogue environments into specific recommendations for flight.

Analogue environments offer many advantages. Ethical, legal, and medical standards prevent subjecting research participants to undue risk and stress. People willingly enter analogue environments where they are exposed to noxious and dangerous conditions that compare to those that we need to understand behavioral health in space. They join the submarine service, or go to the South Pole, for their own reasons. If they volunteer informed consent, they can be studied under conditions that would be unethical if they were created in the laboratory. For example, it would be extremely difficult to get Institutional Review Board approval to experimentally induce hypoxia in a hyperbaric chamber, but it is acceptable if high altitude mountain climbers agree to be tested during their ascents. Thus, naturally occurring adverse conditions that are associated with some analogue environments make it possible to conduct behavioral research that would otherwise be unethical.

Although by everyday standards some analogue environments are harsh and dangerous, they are still relatively safe compared to space. Spaceship simulators can be exited in a matter of seconds, and they never really crash. Maritime disasters still occur, but given the number of vessels that roam the oceans they are few and far between. Submarine losses are rare except in war. A snow tractor may break down, but does not require the constant flawless functioning of hundreds of thousands if not millions of parts. If the tractor does break down, its occupants may be able to trudge back to camp or at least radio for help. Mountain climbers who contract altitude sickness can be retrieved by helicopter, and divers who rise to the surface too rapidly can be decompressed in hyperbaric chambers. Analogue environments are not risk free – people still perish there – but over the years we have refined stringent safety precautions and emplaced demonstrably reliable rescue procedures.

Analogue environments permit us to reach a balance between control and realism. This is in comparison to many laboratory settings that allow great control but are unrealistic, and to spaceflight where researchers may have little control over an environment that is the gold standard for operational authenticity. An alternative way of phrasing this is that analogues offer a trade-off between internal validity (the logic of the experimental method and the strength of the results) and external validity (the extent to which the results can be extended to astronauts in space).

Compared to spaceflight environments, most analogue environments are relatively accessible. At any point in time, very few people are in space, but many people are in analogue environments; thus there are far more research opportunities in analogue environments. Behavioral researchers can and have traveled to analogue environments, but (unlike physicians) they have not yet conducted first-hand research in space.

Closely related to accessibility is economy. Compared to research in space, research in simulators and analogues is inexpensive. Shuttle and Station mock-ups cost only the tiniest fraction of “the real thing.” The price of sending researchers and research subjects to Antarctica may be high by normal standards, but it is negligible compared to the cost of hurtling them into orbit.

Analogue environments and situations can and will continue to play a role for NASA and help build our understanding of life in space. However, we must always be mindful that analogue environments and tasks are at best *approximations* of those that we find or anticipate aloft. NOAA’s Aquarius is not the same as an orbiting space station, and research outposts in Antarctica are not the same as future outposts on Mars. There are differences among subject populations (for example, astronauts and sailors) as well as environments and tasks. For instance, with the exception of brief periods during parabolic aircraft flight and the partial approximation of weightlessness in a neutral buoyancy chamber, analogues do not offer microgravity with its important immediate and long-term effects such as space motion sickness, cardiovascular and muscular deconditioning, and mineral loss. Thus, we must never let convenience lull us into concluding that findings obtained from analogs can always be extrapolated to space. We must never lose sight of the need to conduct research in space itself.

Recommendation 4. A successful overall behavioral health program will require a broad perspective, multiple convergent research strategies, ingenious measures, and a variety of settings, including space itself.

Recommendation 5. Research in space itself should employ measures that make minimal demands on astronauts’ time, engage their interest, and work within the constraints of the highly engineered space environment.

Recommendation 6. Researchers who study analogue environments should more systematically relate specific analogue environments, populations and tasks to specific spaceflight situations.

THE BIOASTRONAUTICS CRITICAL PATH ROADMAP AND BEHAVIORAL HEALTH

The Bioastronautics Critical Path Roadmap is an overarching framework for the thematic research areas that were stressed in the New Directions Workshop.[2] This is NASA's guide to supporting people in space (http://criticalpath.jsc.nasa.gov). The Roadmap lists Human Behavior & Performance along with eleven other critical disciplinary areas spanning life support, habitability, and space medicine. Within the Human Behavior & Performance sections of the Roadmap, we find specific reference to psychosocial adaptation and behavioral health:

"Errors in critical tasks, breakdown in crew communication and dynamics, and the accumulated stress from living and working in an isolated, confined and closed environment could jeopardize crew health and safety as well as mission objectives. Risk factors include: poor psychological adaptation; sleep and circadian rhythm problems; human/system interface problems; and behavioral illness (depression, anxiety, trauma, or other neuropsychiatric dysfunction). Deliverables include: unobtrusive monitoring of stress levels, coping strategies, performance and sleep; crew screening and performance criteria; techniques to ensure sleep quality; real-time workload analysis and planning; expert decision-making and VR systems; and guidelines for diagnosing and treating in-flight behavioral illness."

These sections of the Roadmap describe four ways that human performance can fail: (1) because of poor psychosocial adaptation; (2) because of sleep and circadian rhythm problems; (3) because of human system interface problems and ineffective habitat, equipment design, workload, or in-flight information and training systems; and (4) because of neurobehavioral dysfunction. At the Workshop, the first and last of these points – psychosocial adaptation and neurobehavioral dysfunction - dominated the discussion.

PSYCHOSOCIAL ADAPTATION

Human performance failure due to imperfect adaptation to the space environment, poor interpersonal relationships, faulty group dynamics, and inadequate pre-mission preparation equates with human performance failure due to poor psychosocial adaptation. There are five critical questions under this risk.[3]

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[2] All references in the present document refer to the Roadmap as of February 2004.

[3] Critical question numbering corresponds to numbering in the Critical Path Roadmap. Numbers in parenthesis indicate priority with 1 representing the highest.

Roadmap Section 6.01 *What are the fundamental behavioral and social stressors during long duration missions that will most likely affect crew performance, both individual and team? (1)*

The major stressors of life in space are danger, isolation, confinement, and the lack of most everyday amenities. Microgravity is a stressor because it makes it difficult to work efficiently. Intermittent or situational stressors include the breakdown or malfunction of equipment, extravehicular activity or other periods of intense workload, loss of communication, invidious status distinctions (e.g., old timers and newcomers, astronauts and payload specialists), cultural conflicts, and the inability to respond promptly and effectively when family emergencies occur. Conference participants noted that future missions will impose new challenges, including extended surface operations, and, in the case of Mars, unprecedented transit times, lengthening communications delays as the crew proceeds towards Mars, and, eventually, the loss of visual contact with Earth.

Roadmap Section 6.02 *What factors contribute to the breakdown of individual and team performance, and team coordination with mission support with regard to scheduling, prioritization of work activities, and control of guidelines? (1)*

Individual factors (physical and mental fatigue, mental health problems, motivational decline, social withdrawal, inability to cope with overload or to respond flexibly under stress), small group factors (poor communication or leadership, lack of coordination, intra-group conflict), organizational factors (lack of sufficient regard for behavioral issues, failure to accept implications of behavioral health research) and cultural factors (including the possibility that crews on extended missions will develop cultures that in some way conflict with those of their parent communities) can contribute to performance deterioration. Consistent with the systems concept, Barrett Caldwell (2003) noted:

"Mission operations in the early years of the 21st Century have developed into a set of complex, multi-team task settings incorporating multiple mission control teams and flight crews interacting in novel ways…we must confront issues in information exchange, delay management, and local culture shifts that are fundamentally distinct from those spanning the 40 years from Mercury to Shuttle."

Melissa Mallis reported that astronauts are typically subject to high levels of fatigue and disrupted circadian rhythms (Mallis, 2003). Sleep disturbances are common in analogue as well as space environments, and their effects are cumulative. The adverse effects of chronic sleep deprivation are more evident in objective than subjective measures; thus, as in the case of someone who is suffering from hypoxia, a sleep-deprived person's performance may be degraded but the person feels well and is unaware of their performance lapses. Mallis proposed as a countermeasure an Astronaut Scheduling Assistant, a computer program that would organize activities, increase efficiency, and thereby reduce fatigue.

Judith Orasanu discussed the intersection of poor interpersonal relations and faulty decision-making (Orasanu, 2003). She noted that, according to the National Transportation Safety Board, faulty tactical decision-making is the most frequent contributor to aviation hull (fuselage) loss errors. Naturalistic decision-making research looks at “how experienced people make decisions in natural environments... features of naturalistic decision making include: dynamic situations, multiple shifting goals, ambiguity, uncertainty, time pressures, teams [and] organizational contexts." The goal of this research is to assemble convergent evidence showing how people actually make good decisions. Effective decision strategies, states Orasanu, require: "(1) understanding and verifying the problem, (2) assessing time and risk, (3) avoiding a rush to judgment, (4) using 'worst case' rather than 'best case' reasoning, (5) planning for contingencies, and (6) 'managing the situation,' that is, setting priorities and thinking through conflicts."

Cultural factors also affect behavioral health. Culture exists at many levels: national, organizational, professional, and small group (crew). Cultural differences, as reviewed by Jennifer Boyd Ritsher, can at once cause problems and mask their existence (Ritsher, 2003). Differences between national cultures may be reflected in their respective groups of astronauts, but we cannot expect a one-for-one correspondence because the differences may be offset to some extent by similarities at subcultural levels (for example, the shared professional culture of astronauts/ cosmonauts or the culture of a specific mission or crew). Areas of concern identified by Ritsher include cultural values, emotional expressiveness, and levels of well-being. Cultural differences among crewmembers have a wide range of effects and may, for example, lead to different criteria for behavioral health. Current research strategies run the risk of overlooking important early warning signs of behavioral health problems. NASA would benefit from better ways to detect cultural frictions earlier, while they are still mild and resolvable.

Recommendation 7. Research on psychosocial adaptation and behavioral health should proceed at multiple levels: individual, group, and organizational. It is particularly important to improve our understanding of the interactive effects of these different levels on individual and team performance.

Roadmap Section 6.03 *What behaviors, experiences, personality traits, and leadership styles in crewmembers most contribute to optimal performance? How are these factors related to team performance? (2)*

Roadmap Section 6.04 *What crewmember behaviors, experiences, personality traits, and leadership styles that optimize performance can be identified during the selection process and be used to select and assemble the best teams for long duration missions? (2)*

Robert Biersner's humorous comment on the many desiderata for deep-sea divers may be equally appropriate for astronauts (Biersner, 1984). After citing intellectual brilliance, courage, perseverance, social adaptability, humility and other positive qualities, he concludes: "those who are most suited to work at watery depths should be able to walk on the surface as well."

Three criteria identified early in the course of Antarctic exploration may be equally useful for space (Harrison, 2001). These are: (1) sustained competent performance, (2) emotional control (both in the sense of good mental health and the ability to remain calm under stress), and (3) social compatibility. Although selection procedures for spacefarers have varied across time and cultures, many of the interview procedures and tests that have been used to screen candidate astronauts tap these basic qualities. Selection must occur at both the individual and group levels, and the goal is to select the best team for a specific mission. At this point we may be better at selecting out candidates who have liabilities than we are at identifying people who can bring unique strengths to the task (Santy, 1994).

Although potentially useful, standardized psychological tests have a spotty record in astronaut selection; one concern is that if such tests were widely advertised, candidates could prepare to do well on them, even as graduating college seniors enroll in commercial Stanley Kaplan courses to better their chances on the Graduate Record Examination. Still, standardized tests may yield far more reliable and valid data than do less formal selection procedures, and, because of their quantitative nature, provide a firmer foundation for a database than do more qualitative selection techniques.

Gloria Leon described how social compatibility and style can affect group process and performance (Leon, 2003). She examined the interplay of gender and individual differences. Typically, in comparison to men, women make more positive than negative assertions, prefer cooperation to competition, and are more likely to express concerns about other people's interpersonal problems. All-men's groups tend to be more competitive and members tend to be "bottled up" in that they are unlikely to share concerns with one another. In mixed-gender groups, women sometimes assume the role of peacemaker and this reduces competition, but there is no expectation on the part of men to listen to women's concerns. In many all-women groups, concern about other team members is a significant source of distress. Leon added that whereas gender differences are important and we should never lose sight of them, we must also recognize individual differences in their strength and expression.

Recommendation 8. It is time to study an expanded role for standardized psychological tests in astronaut selection.

Roadmap Section 6.17 *What are the systems of knowledge, psychosocial support methods, attitudes, and behavior towards mission operations used by agency management, ground controllers, crewmembers and their families? How do these systems influence individual and group performance and behavior? (2)*

Workshop participants applauded the recent expansion of the behavioral sciences mission and the emergence of a behavioral science department at Johnson Space Center (Fiedler and Carpenter, 2003). Dr. Frank E. Carpenter and his small group provide an extensive array of psychological support services for flight crews and their families. These services are varied, proactive, and tailored to individual needs (Vander Ark and Sipes, 2003) but the small team may be severely taxed after a catastrophe. These resources are part of a larger effort to optimize crew behavior and performance during preflight, in-flight, and post-flight phases of a mission. This program illustrates the use of behavioral science to support flight operations. The new behavioral science department will benefit from continued augmentation and refinement, and through reaching increasingly larger proportions of its potential clients. The recent addition of a professional staff member to serve at the juncture of research and operations is particularly welcome from the perspective of this Workshop.

It would be useful to develop a cumulative database to monitor the effectiveness of the behavioral sciences department and other efforts. David Musson pointed out that a cumulative database would provide many useful opportunities for operationally relevant research, including analyses of trends in recruitment and attrition, and follow-up studies of performance and post-flight readjustment (Musson, 2003). Problems in establishing such a database include assuring the consistency of assessment instruments over time, variations in data acquisition from one year to the next, and managing changes in theory and practice that occur over the life of the database.

Recommendation 9. It would be useful to further strengthen the behavioral sciences department at Johnson Space Center as the major conduit for communication between research and operations.

Recommendation 10. It is time to establish a cumulative database to track variables that affect psychosocial adaptation, behavioral health, and performance.

NEUROBEHAVIORAL DYSFUNCTION

Human performance failure due to such conditions as depression, anxiety, trauma, or other neurobehavioral dysfunction is the second Critical Path Roadmap category that was a focal point for the workshop. In the Critical Path Roadmap, avoiding these failures equates to Behavioral Health. It poses six questions that cluster into two general areas: (1) the consequences or effects of the spaceflight environment on intellectual, emotional, and interpersonal functioning [**6.15, 6.16, 6.19**] and (2) techniques for monitoring these consequences and countermeasures against them [**6.13, 6.14, 6.20**].

Spaceflight's Impact on Personal and Interpersonal Functioning

Roadmap Section 6.15*. What are the acute and long-term effects of exposure to the space environment on human cognition and performance capabilities, including the processes of sensation and perception, learning, vigilance, cognition, problem solving, decision-making, and motor skills? (1)*

Roadmap Section 6.16 *What are the acute and long-term effects of exposure to the space environment (microgravity, isolation, stress) on the nervous system (at the cellular, or organic level) and on related neurobehavioral mechanisms, including neurobiology related to behavior and mood regulation? (3)*

Roadmap Section 6.19 *What are the acute and long term effects of exposure of the space environment on human emotion and psychological responses, including emotional reactivity, stress responses, long term modulation of mood, and vulnerability to affective disorders? (2)*

For two reasons it is very difficult to assess the number of critical psychological incidents and their level of impact on space missions. First, accounts by popular writers may be sensationalized and hence lead to an overestimation of behavioral health problems (Douglas, 1991). Second, a code of silence and medical confidentiality may lead to an underestimation of behavioral health problems.

In his review, Nick Kanas identified a number of interpersonal issues that can affect safety, performance, and well-being during extended space missions (Kanas, 2003). These include crew diversity (in terms of culture, gender, personality, and career goals), a lack of crew cohesion, sub-optimal leadership, and crew-ground interactions. In a survey of astronauts and cosmonauts who flew aboard Mir or who participated in a 135-day Mir simulation, Kanas and his associates found evidence of interpersonal conflicts, including a tendency of crewmembers to displace tension and conflict onto mission control which in turn displaced its negative emotions to NASA management. Many of the critical psychological incidents that occurred were resolved on board, and although some crewmembers reported declining leader support over time the study found little support for the hypothesis that interpersonal relations would degrade as a function of time on orbit.

Marc Shepanek identified both individual and group problems in analogue environments (Shepanek, 2003). Significant individual problems include: insomnia, exhaustion, boredom, withdrawal, impulsive behavior, helplessness in the face of bad situations at home, depression, and rage. Significant group problems include: friction among subgroups or factions, individuals not doing their share and thereby increasing stress on their peers, dysfunctional leadership, perceived favoritism in the allocation of resources, and changing sexual partnerships. Shepanek reports incidents of the following in space: decreased energy and capacity for intellectual pursuits, memory impairment, lowered productivity, diminished problem solving ability, decreased individual and team efficiency, increased hostility toward other crewmembers and mission control, lowered attentiveness, fatigue, anxiety, sleep disorders, boredom, withdrawal and increased need for privacy, miscommunications, excessive concerns about health, and impulsive behaviors.

Peter Suedfeld recognized that problems exist but added that there are many positive consequences of life in challenging environments (Suedfeld, 2003). These relate to the natural environment (grandeur, vastness and beauty of space, views of Earth as a pale blue sphere), the capsule environment (safe haven, comfort, opportunities for improvisation), crew membership (belonging to an elite group, working for superordinate goals) and post-mission life (new skills and values, self confidence, continuing camaraderie, and "bragging rights"). Positive consequences may counteract fatigue, ease interpersonal relations and in other ways help maintain behavioral health. The medical model that is the bedrock for the Critical Path Roadmap does not adequately recognize people's positive, striving qualities: their successes and triumphs, the many ways that they gain from meeting and overcoming challenges. As William K. Douglas noted years ago: "We search for analogues of the space environment and see in those analogues only examples of human frailty. We do not see the far more prevalent examples of human greatness" (Douglas, 1991, p. 86).

Positive psychology, according to Seligman and Csikszentmihalyi (2000), emphasizes the many positive features that make life worth living, such as awareness, responsibility, creativity, mastery, choice, determination, perseverance, resilience, optimism, gratitude and spirituality. Unlike earlier efforts to expand psychologists' views of humans (e.g., the humanistic psychology movement of the 1950s and 1960s) positive psychology has a strong research component. Positive psychology moves the discipline beyond a negative bias and seeks to explore and cultivate human strengths and virtues, but without confusing optimism with realism.

Suedfeld described a loose relationship between perceived environmental stress and personal outcomes - the same harsh environment that one person finds threatening another person may find a welcome challenge (Suedfeld, 1987, 1991, 2004). Mocellin, Suedfeld, Bernardez and Barbarito (2000) found that levels of anxiety among people who were working in isolated polar regions did not differ appreciably from people who were working in "less stressful" environments. Joanna Wood and her associates found that whereas subjects were able to generate longer lists of negative than positive aspects of life in Antarctica, they were more likely to experience the positive than the negative effects that they had enumerated (Wood, Hysong, Lugg & Harm, 2000). Still other work suggests that, judging by objective measures, Antarctica is less stressful than is commonly supposed, and that people who work there develop coping skills that help them maintain good health and career success years after they return to everyday life (Palinkas, 1991). Like coping skills, certain personality characteristics such as hardiness and resilience may moderate the effects of stress on performance and well-being (Suedfeld, 1991).

Based on his interviews with astronauts and cosmonauts, Frank White posited an "overview effect," that is, powerful emotional experiences that occur when pondering Earth from space (White, 1987). Expanding the role of positive psychology in spaceflight behavioral health could provide us with a more balanced view of life in space, serve as a buffer against the adverse effects of spaceflight, increase the range of inducements and satisfactions for people who venture there, and add new incentives for future missions.

Noting that we "need as many methods as we can get," Gary Steel compared actuarial and case study methods for predicting reactions to stress (Steel, 2003). Among other things, he points out that although actuarial studies may be useful for a first cut, rarely do they tap enough variables so that we can predict how a specific individual will perform on a specific mission. A statistically-based prediction ("She will probably do OK") does not sit well with someone who is responsible for a multimillion dollar mission. An experienced astronaut, who has worked along with the candidate and gives "two thumbs up" indicates an unequivocal recommendation and, according to Steel, is quite likely to be right. Steel points out that "the person, the setting, and the time, taken independently, are not the proper units of analysis for human behavior. Instead, it is the amalgam of these elements that should be the basis for research." Steel develops strong arguments for case studies, but points out that few people understand the difficulties inherent in conducting such studies properly.

Certain age-related psychiatric problems are unlikely to occur in space because their onset is not typical in the age range of most astronauts. Some of the problems that do occur in the 30-60 year age range are bipolar disorder, depression, obsessive-compulsive disorder, and panic. Genetically determined disorders pose little risk if potential cases can be eliminated on the basis of family histories and genetic screening. Conference participants generated an extensive list of clinical concerns including: psychotic disorder, bipolar disorder, dissociative disorder, impulse control disorder, somatoform disorder, factitious disorder, paraphilia, abuse or neglect of a child or adult, narcolepsy, personality disorder (inflexible, maladaptive and enduring patterns of interaction), delirium, dementia, amnesia, cognitive disorder due to general medical condition, adjustment disorder, depressive disorder, anxiety disorder, eating disorder, sex or gender disorder, and substance abuse or dependence (Shepanek, 2003). Mild depression is common in analogue environments and has been identified in space: it may be all but inevitable for crews that set out for Mars.

Recommendation 11. NASA should expand research on stressors and their effects. We need a better understanding of the link between specific stressors (alone and in combination) and specific outcomes, taking into account possible moderating variables such as personality traits (hardiness, resilience) and coping skills.

Recommendation 12. Although the concern of the Critical Path Roadmap is possible dysfunction leading to failure of a mission we need to know more about the positive aspects of spaceflight that are inherently rewarding, act as incentives, and strengthen commitment to the space program.

Monitoring and Countermeasures

We now turn to those portions of the Bioastronautics Critical Path Roadmap that pertain to means for monitoring and assuring psychosocial adaptation and behavioral health

***Roadmap Section 6.13**. What model(s) of behavioral health and task performance best predict problems and provide guidelines for effective treatment of illness (e.g., depression, anxiety, trauma, and psychiatric dysfunction)? (2)*

***Roadmap Section 6.14.** What are the best countermeasures for rapidly recognizing and managing neurobehavioral dysfunction, emotional and stress-related dysfunction, neuropsychiatric dysfunction, and social psychological dysfunction, and how does the spaceflight environment affect their implementation? (2)*

***Roadmap Section 6.20** What are the best methods of in-flight recognition, monitoring, and management of neurobehavioral dysfunction, including cognitive and performance dysfunction, emotional and stress-related dysfunction, neuropsychiatric dysfunction, and social psychological dysfunction? (1)*

Regular monitoring of behavioral health would make early intervention possible if a problem arose and could also generate inputs for a cumulative database that would at once constitute a research resource and a valuable reference for future missions. From a crew's perspective, however, surveillance is an unwelcome activity. It can be construed as an invasion of privacy and, because it could lead to intervention, a threat to personal freedom. The results of the surveillance could generate adverse publicity, and ultimately lead to disqualification from future missions. A fellow crewmember who served as an "informer," even as a part of his or her official duties, would be seen as untrustworthy and a threat to cohesiveness. Under close surveillance, the sense of "life in a fishbowl" is itself a source of stress. Thus, there are many reasons that crews might prefer to keep their difficulties "within the family."

Recognizing tradition and preference, admitting that many psychosocial problems are minor and easily contained within the crew, and acknowledging that the very process of surveillance can produce unwanted side-effects, we must nonetheless seek reliable, valid ways of identifying problems before they escalate out of control. Methods and procedures used for operational monitoring must meet the same requirements as those used for research: they should be lightweight and compact, as unobtrusive as possible, make minimal demands on astronauts' time and, hopefully, engage the astronauts' interest. There would be an advantage if, rather than being under the control of "outsiders," such devices were deployed to help the astronauts monitor their own adaptation and performance (Dinges, 2003).

Christopher Green and Robert Armstrong described how, within ten years, "generation after next" technology will allow us to observe "in-brain" activity as well as performance during training and operations (Green & Armstrong, 2003). They discussed how current emergent brain imaging methods utilizing near infrared spectroscopy (NIRS), magnetoencephalography (MEG) and functional magnetic resonance imaging (fMRI) have been adapted to observe in-cabin operator performance of ground vehicles and airplanes. This technology allows researchers to visualize anatomy and neurochemistry of both cortical and deep-brain nuclei that sub-serve emotions, as well as the white matter tracts connecting them. Already MEG and fMRI have been applied to drivers of both normal and racing cars and studies are underway of decision-making when the individual is under stress, distracted, or under the influence of drugs. The technology is currently being adapted to the aviation environment, and would require but a small extension for application in space.

Robert Kane discussed WinSCAT, the Space-Flight Cognitive Assessment Tool for Windows (Kane, 2003). Developed for Medical Operations at Johnson Space Center, WinSCAT gives crewmembers the means to monitor their neurocognitive status in space. WinSCAT, which is loaded into laptop computers already destined for service in space, is based on selected items from the Automated Neuropsychological Assessment Metrics (ANAM) test system, adapted to fit NASA’s needs and specifications. Validation studies involve cognitive alterations secondary to clinical conditions, the effects of environmental factors such as fatigue, and high altitude, and drug-related changes.

Several research programs conducted under the mantle of the National Space Biomedical Research Institute hold great promise for monitoring fatigue, stress, and other possible threats (Dinges, 2003). One of the attractive features of these research programs is that participating investigators at different institutions provide one another with strong mutual support. Noting that many standard techniques are simply too unwieldy to apply in space, their goal is to produce “novel, practical, unobtrusive, scientifically valid approaches to detecting stress.”

Dinges described his own collaborative development of an optical computer recognition system that continuously tracks facial expressions and identifies non-verbal indicators of stress. The goal is to permit temporally dynamic identification of even small changes in facial expression despite significant motion of the head. This requires fitting a 3-dimensional computer-generated "virtual mask" to the subject’s face. Deformations of this mask would reveal the non-verbal indicators of stress. Progress on this task depends upon advances in mathematics and computer technology as well as in behavioral science. A second technique described by Dinges is Phillip Lieberman’s work on an unobtrusive speech-based computer algorithm for detecting cognitive impairment associated with hypoxia and stress. These changes, some of which are subtle, are rooted in neural functioning. The changes are rarely recognized by the impaired person, and are also impossible to voluntarily suppress or “fake.” Summarizing this and other work, Dinges concluded:

"These different and complementary objective approaches to detection of neurobehavioral distress in space flight are in various stages of proof of principle development and validation. They potentially afford redundant ways to ensure that neurobiological problems that occur in spaceflight (regardless of the cause) are quickly identified and treated before they result in a loss of high-level performance capability in a crewmember. As such, they are intended to be personal aids to astronauts, helping them recognize when their stress (especially during performance demands) is increasing to levels that warrant a countermeasure."

Recommendation 13. Many governmental agencies are interested in supporting high performance teams in demanding environments. NASA would do well to keep in close touch with relevant projects sponsored by other government agencies.

Recommendation 14. To minimize the problems associated with remote surveillance, we should develop devices that help astronauts monitor their own psychosocial adaptation, behavioral health, and performance.

Not only will future missions expose new types of astronauts to new combinations of conditions, when psychiatric problems do arise (and they probably will) there will be no prospect of a speedy return to Earth. The problem may have to be managed on board for many months. To maximize psychosocial adaptation, we select people who are expected to do well in space, provide them with training to further “bring them up to speed,” place them in the most congenial and supportive habitats that we can devise given engineering constraints, and develop supportive work schedules, rules, and procedures. Nonetheless, there will be times when a crew will have to intervene or seek outside help to manage a behavioral problem. Training to recognize and then respond appropriately to behavioral problems could include both crew and ground personnel and cover topics such as cultural diversity, social interaction, and mental health (Kanas, 2003). Including psychoactive drugs in the medical kit is useful, but these may be difficult to administer properly in space and their effects in the space environment may be unpredictable. Only a relatively small selection of drugs could be carried on board, the crew is unlikely to have titration procedures to regulate dosage, and the drugs can themselves produce side effects that degrade performance.

Today’s astronauts spend some of their lives in outer space, but like everyone else they spend part of their lives in cyberspace. The question then becomes how we can use tools like the cell phone, computer and Internet (and their successors) to promote behavioral health.

Telepsychiatry could be used by itself or as an adjunct to peer group support and medication. Presumably, this would be accomplished through videoconferencing over a secure channel. However, even minor transmission delays interfere with verbal interaction, and these delays could be prolonged and awkward in the case of a Mars mission.

Computer-assisted therapy (CAT) includes direct on-line therapy (e.g. via e-mail), programs that function as therapeutic consultants, and software that operates independently of the therapist. Low cost, ease of data collection, and suitability of certain types of therapy for delivery at a distance (psychoeducation, cognitive-behavioral therapy, and desensitization) are among the benefits of computer-assisted therapy. Although CAT cannot duplicate the kind of dialogue that is used in clinician-administered psychotherapy, patients generally accept the software and some studies have revealed positive outcomes. Both therapists and patients may resist this type of therapy, at least when alternatives are available. Even in CAT there is a role for the live therapist: monitoring the patient's progress with the cybertherapist.

Recommendation 15. We need more research on conducting therapy at a distance, such as by teleconferencing or by computer. This research should factor-in communications delays and other requirements of future space missions.

Recommendation 16. As efforts continue to revise the Bioastronautics Critical Path Roadmap it is important to include topics that might be overlooked because they fall between the foci of different study groups (such as human factors engineering and behavioral health).

BUILDING SUPPORT FOR BEHAVIORAL HEALTH

Some of the long-time researchers and operational personnel invited to the New Directions in Behavioral Health Workshop expressed mixed feelings about participation. On the one hand, they had strong personal commitments to the field and believed that behavioral health should be strongly represented within NASA. On the other hand, they had attended other conferences and workshops that covered similar topics, and had sat on panels and written recommendations urging NASA to make a greater investment in behavioral health. If past efforts were met with negativity or led nowhere, why try again? It is not surprising, then, that much of the discussion focused on identifying forms of resistance or "barriers" to behavioral health research and application and seeking ways around them.

RESISTANCE TO BEHAVIORAL HEALTH RESEARCH

Four major forces deter progress in space-related behavioral health research and application. These include the importance that NASA accords good public relations, the astronaut culture, the engineering culture, and some current limitations in the field of behavioral health.

NASA and Public Relations

NASA was formed in 1958, after the Soviets had launched Sputnik and triggered the great "space race." Public relations have always been important to NASA, in part to maintain national morale and in part to gain support for its mission. In his book *Space and the American Imagination*, Howard McCurdy points out that, even before NASA was formed, scientists such as Oberth and von Braun drew on powerful images already present in American popular culture to engage public support (McCurdy, 1997). In this way, space travel became continuous with Columbus arriving in the new world, immigrants settling the Wild West, and explorers working their way to the South Pole.

NASA, notes McCurdy, sought to control the astronauts' images as tightly as a movie studio might control the image of a movie star. The press was very much a part of the "cover-up" – not of mental illness or criminal behavior, but of the minor flaws that make us human. Reporters from *Life* magazine, who had special access to the original astronauts, knew of shaky marriages, infidelity, and excessive drinking, but never reported these because reporters who strayed too far from NASA's version of reality risked losing their accreditation. Under such conditions, it is not surprising that NASA would be less than receptive to researchers who might ferret out psychiatric problems or make dire predictions regarding future space missions.

In her book, *Choosing the Right Stuff: The Psychological Selection of Astronauts and Cosmonauts* former NASA flight psychiatrist Patricia A. Santy describes the termination of behavioral research projects, the destruction of valuable records, the suppression of reports, and the silencing of dissenters (Santy, 1994). Workshop participants hope that with the advent of the National Space Biomedical Research Institute and modestly increased NASA funding of behavioral research the situation has eased. Still, there may be lingering beliefs that the risk of tarnishing NASA's image is more dangerous to the overall program than the possibility of a human malfunction in space. Topics such as "sex in space" may be avoided because they are too controversial, and gender issues were not included in *Safe Passage* because they were deemed too sensationalistic (Brady, 2003).

The Astronaut Culture

Astronauts are self-sufficient, hard working, and success-driven. They have a strong desire to avoid appearing “less than optimal” or “needing help.” We can expect them to be private about their personal issues and also to be protective of one another. There may be strong norms of secrecy about things that go wrong (sometimes referred to as “collective amnesia"). Similarly, in reviewing past missions, astronauts may have tendencies to accentuate the positive. Although astronauts may recognize that their participation in behavioral health research could contribute to the success of future crews they must weigh this against near-term disadvantages. Research translates into requirements, and new requirements can make life difficult and even lead to disqualification. NASA’s interest in good public relations, coupled with the astronauts’ high capabilities, reinforces beliefs that “we have incredibly healthy people out there,” a belief that is shared by the 100,000 or so workers who support the astronauts and by the general public. All of this directs attention away from crucial psychosocial and behavioral questions.

The Engineering Culture

A behavioral health program will not get far within NASA without acceptance on the part of engineers. A common attitude within engineering cultures is “let’s get on with the metal bending.” Behavioral issues, if not cavalierly dismissed, tend to be ignored or are deemed easily solved by means of long-established engineering conventions. (Since conventions vary from country to country, this solution is less than optimal for international crews.) Human factors engineers and behavioral health specialists may not be welcome at the planning table because they absorb resources and make demands that both complicate the design process and extend time to completion. The problem is exacerbated to the extent that each person who does participate in the planning process sees himself or herself (irrespective of credentials) as an expert in human behavior who has no need to consult with credentialed professionals. If behavioral health as a field is to flourish in NASA, it must establish itself as a viable specialty in an engineering culture. One reason why this is difficult right now is that the field offers little in the way of clear, firm principles that can be translated into operational requirements that have undeniable benefits (Kanas, 2003).

Current State of the Field of Behavioral Health

As a discipline, behavioral health is in its infancy, and the problems that it addresses are multifaceted, interactive, and complex. Compared to behavioral health, other areas of concern, such as protection against radiation, seem simple and straightforward. Because issues of psychosocial adaptation are so challenging, there are no simple answers. Behavioral problems seem endless and even as we move towards the solution of one problem, another "pops up" to take its place. Many of the questions seem fuzzy and imprecise, and, whereas engineers want numbers, behavioral health researchers can rarely provide them. Findings may take the form of highly qualified recommendations that are not easy to translate into quantitative requirements. From the operational perspective, there are also limits to the kind of behavioral health services that we can currently provide. These limits reflect the engineering and flying environment and the views of our international partners. Only so much interior volume, so much privacy, and so many amenities can be provided in space. Our international partners may have different views of who is ready to fly in space.

In a sense there is a "Catch 22": because behavioral health researchers lack financial support they have yet to generate very many useful operational principles; because they have yet to generate useful operational principles, behavioral health researchers have difficulty attracting funding. Those of us who are behavioral researchers must never lose sight of the hard questions that we must ask ourselves. What can we actually do for operational personnel? What can we actually deliver? How do we make the transition from problem to research, and from research to countermeasure?

FOSTERING COLLABORATION

Nobody wants a mission to run afoul of problems due to poor behavioral health. Different constituencies – NASA management, engineers, researchers, flight support personnel and astronauts – may have shared values, but the strength of these values (and the order of their priorities) may vary from constituency to constituency (Palinkas, 2003). Different constituencies are likely to have different conceptions of their own and other constituencies: for example, as patients or as a research subjects, as therapists or researchers. It is time to bring different constituencies to the table under an egalitarian model that defines each participant as a partner. There are several pathways to successful collaboration, including social marketing and cultural diffusion. The path to success may be a long one, and one that is marked by conflict and compromise.

The New Directions in Behavioral Health Workshop suggests that it is time to embark on this path, forge new alliances, break the impasse and move into a new era of behavioral health. This must begin now with a level of funding that is likely to get useful results, and continue over the years so that we can materially reduce the risks associated with a return to the Moon and an expedition to Mars. Desirable characteristics for an overall program include: (1) *systems thinking* encompassing flight crews, support personnel, families and communities, (2) *active collaboration* involving NASA managers, researchers, operational support personnel and astronauts, (3) *convergent evidence* based on assembling theories, research findings, and case histories that collectively bridge our ever-present but ever-shifting knowledge gaps, (4) *developmental thinking* spanning recruitment, selection, training, on-site support, reintegration into the home community and long-term follow up, and (5) *continuity* in the sense of seamless progress across generations of researchers and practitioners (Harrison, 2003).

Recommendation 17. The Workshop represents one step towards a strong behavioral health research program. We must expand the number of researchers and operational personnel involved in the discussion, and also provide opportunities for small, focused, in-depth discussions of specific topics.

Recommendation 18. A sustained and pervasive behavioral research program will require regular, dedicated and ample funding. Management support for behavioral health should be continuous as a matter of course, not a reflection of an occasional need.

CONCLUSION

Human adaptation to spaceflight has always been a consideration within the space program, but as flight parameters have changed, so has the range of behavioral health issues. The expansion of questions has outpaced the growth of research. Over the past few years there have been significant changes in theory, research methods, and practical means for supporting people in space. From both the scientific and practical perspectives, behavioral health and related factors require constant vigilance and periodic reassessment.

Developments since the last Committee on Space Biology and Medicine completed its deliberations about five years ago, and the recent release of *Safe Passages*, position us to sharpen our focus on psychological, interpersonal, and cultural adaptation to space. The issues mentioned in this report are only a sampling of the many topics that deserve closer consideration. The Workshop was not intended to compete with the decennial committees appointed by the National Research Council or to establish an inflexible agenda for NASA behavioral health research. The goal was to provide a useful resource that encourages research and applications that will advance NASA’s efforts to support humans in space as, under presidential mandate, we return to the Moon and voyage to Mars. Our intention was to build on past successes (Harrison, 2001; Kanas & Manzey, 2004: Suedfeld & Steel, 2000) and attract fresh new talent, to strengthen collaboration between researchers and practitioners in guiding behavioral health research in useful directions, and to stimulate further innovation and creativity. We hope that the legacy of this Workshop and the forthcoming special issue of *Aviation, Space and Environmental Medicine* based on the Workshop presentations will be: (1) revitalized, continuing, and fruitful dialogue among researchers and practitioners, (2) a larger, more diverse pool of high quality proposals in response to RFPs, and (3) an archival record of the Workshop that will benefit managers, researchers, and operational personnel. Workshop participants appreciated the opportunity to discuss these issues and thank NASA for making this Workshop possible.

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Appendix I
NEW DIRECTIONS IN BEHAVIORAL HEALTH
UNIVERSITY OF CALIFORNIA, DAVIS
DECEMBER 2-3 2003

TUESDAY, DECEMBER 2

0800 Depart Hallmark Inn for Walter T. Buehler Alumni and Visitors Center

0830 Welcome to Campus

Provost and Executive Vice Chancellor Virginia Hinshaw
Vice Chancellor – Research Barry Klein

0845 NASA and Behavioral Health – Chair, Desmond Lugg

NASA and Behavioral Health **–** David Tomko
Behavioral Health: The Propaedeutic Requirements **-** Joseph V. Brady
Towards a Grand Strategy for Behavioral Health **–** Albert A. Harrison

1015 Break

1030 Research and Operations – Chair, Stephen Vander Ark

Overview of NASA-JSC Human Behavior and Performance Group Activities **-** Christopher Flynn
Behavioral Sciences: A New Department and an Expanded Mission - Edna Fiedler and Frank Carpenter
Comments – Roger Crouch

1200 Catered Box Lunch

1300 Analog Environments - Chair, Brian Peacock

Behavioral Health in Antarctica: Implications for Life in Space – Desmond Lugg
Life, Survival and Behavioral Health in Small, Closed Communities
10 Years of Studying Isolated Antarctic Groups – Joanna Wood
Analogue Prototypes for Lunar and Mars Exploration – Jack Stuster
Crew Endurance Management in the Bering Sea – Carlos Comperatore

1500 Break

1515 Stress and Performance Management - Chair, Mary M. Connors

From The Right Stuff to Positive Psychology: Myths and Realities in Space – Peter Suedfeld
Watching People Think in Transportation-Related Venues: Decisions Under Stress – Christopher Green and Robert Armstrong
Objective Detection of Neurobehavioral Distress – David Dinges
Sleep, Performance and Alertness Management – Melissa Mallis

1715 Return to Hallmark

1900 Dinner at Seasons

WEDNESDAY, DECEMBER 3

0800 Depart Hallmark Inn for Walter T. Buehler Alumni and Visitors Center

0815 Interpersonal and Group Dynamics - *Chair, Colm Kelleher*

Multi-Team Dynamics and Distributed Expertise: Coordination Between Mission Operations and Flight Crews – Barrett Caldwell
Naturalistic Decision Making – Judith Orasanu
Men and Women in Space – Gloria Leon
Whole Lot of Parts: Transactional Stress in Extreme and Unusual Environments – Gary Steel

1015 Break

1030 Behavioral Health On Orbit - Chair, Douglas Vakoch

Interpersonal Issues in Space: Shuttle-Mir and Beyond – Nick Kanas
Assessing Cognitive Health – Robert Kane
Cultural Factors and The International Space Station Program – Jennifer Ritsher

1200 Catered Buffet Lunch

1300 Increasing Collaboration Between Research and Operations - Chair, Edna Fiedler

Quandaries for Researchers and Subjects – Marc Shepanek
Developing a Behavioral Health Data Base – David Musson
Psychological Support – Steve Vander Ark and Walter Sipes
Models of Collaboration for Research and Operations in Space – Lawrence Palinkas

1500 Break

1530 General Discussion and Review of Next Steps - Chair, Albert A. Harrison

Roger Crouch
Edna Fiedler
Des Lugg
Marc Shepanek
David Tomko
Peter Suedfeld

1700 Return to Hallmark

1830 Dinner at Soga's

Appendix II

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