SPACE

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Even on a bad day, looking down from orbit is a powerful and enjoyable experience, enhanced by the knowledge that time in orbit represents only a tiny fraction of one's life. You look down at Earth and you feel a sense of peace and solidarity. You look at the stars, and because they are not obscured by atmosphere, they are far more abundant than you realized, and they shine very bright. Later on you will reflect on this as one of life's greatest moments. Today astronauts and a few wealthy space tourists have been able to experience staying on the International Space Station. As representatives of humankind in space, astronauts have to get out there and tell people what it's like, and to encourage successive generations of children to consider careers in space. Perhaps the more people who can experience this view, the nicer we will all be to one another. Astronauts must speak authoritatively, without arrogance or a lack of humility. Each astronaut is an emissary who can share his or her experiences and educate people who will not have the opportunity to fly in space. This chapter is a part of that communication process.

Introduction

Over the millennia evolution and technology have allowed people to spread into almost every ecological niche on Earth, and in the last half of the twentieth century extended the human footprint into space. Less than seventy years after the first sputtering biplane took off humans had orbited Earth and made landings on the Moon. Space exploration began with American and Russian test pilots undertaking solo flights but by the mid 1960s, these gave way to two person flights which included remaining in orbit for days at a time, rendezvous, docking, and extravehicular activities. Before that decade was complete, these in turn gave way to three person flights, including the Apollo flights that took the first men to the Moon.

In the US the Moon landings were followed by the Apollo Applications Program which included the Apollo-Soyuz Test Project, a brief respite from the cold war that brought astronauts and cosmonauts together in space. This was followed in short order by the US Skylab Program, which included three three-person crews living in space for up to 84 days (Cooper, 1976). After Skylab, the U.S. awaited deployment of the orbiter. Also known as the space shuttle, this bus to space made it possible to carry relatively large crews and substantial cargo to orbit, but with an effective mission cap of about two weeks. In the 1970s, also, the Russians began launching a series of Salyut space stations that eventually led to the larger and more sophisticated Mir. Astronauts joined cosmonauts there from 1993-1995 in anticipation of the ISS (Burrough, 1998). For about ten years now the ISS has been both under construction and occupied. Except when hosting visitors from the shuttle or the occasional tourist, the ISS typically has three crewmembers on board and each tour of duty lasts about three months.

From the beginning, physicians, human factors engineers, and psychologists expressed concerns regarding people’s abilities to withstand the physical, psychological, and interpersonal demands of working in space (Grether, 1962; Kanas and Fedderson, 1971; Sells, 1966). The most urgent questions involved human abilities to withstand ballistic and orbital flight, and perform crucial tasks, such as systems monitoring and conducting simple experiments (Voas & Zedekar, 1963). At that time it was possible to draw on decades of pilot performance in high altitude, high speed test flights, the experiences of high altitude balloonists, and the performances of trained animals ensconced in nose cones of available rockets (Brady, 2005; Burgess & Dubbs, 2007; Ryan, 1995; Weitekamp, 2004; Wolfe, 1979). Over time, missions shifted in the direction of increased crew size, increased crew diversity (or heterogeneity of group composition), and increased mission duration. The white male solo test pilot was no longer the best model. The transition from visiting space to living and working in space raised many new questions about astronaut safety, performance, and morale, and broadened thinking about the psychology of spaceflight (Ball & Evans, 2001; Commission on Space Biology and Medicine, 1987, 1998; Connors, Harrison & Akins, 1985, 1986; Harrison, 2001, 2005; Harrison, Clearwater & McKay, 1989, 1991; Helmreich, 1983; Helmreich, Wilhelm & Runge, 1980).

Everyone, including today’s astronauts, admires the feats of the first astronauts to go into orbit and the Apollo crews that went to the Moon. They provided a springboard for the shuttle and space station astronauts who followed. Today’s missions may not always grab the headlines, but they are incredibly complex and prepare us for a return to the Moon and perhaps a mission to Mars. The Mercury Seven were found to have the “right stuff” for highly dangerous, solo flights (Wolfe, 1979). The “right stuff” for today’s astronaut is different than for the first astronauts because the mission is different (Helmreich, 1983; Connors et al., 1985). Astronaut crews fly and work on the ISS but their success is based on the hard work of many teams on earth, including mission control teams. Despite the occasional hardship there is a tremendous sense of satisfaction at being an astronaut, and achievement following a mission (White, 1987; Harrison & Summit, 1991; Suedfeld, 2005).

The Environment

The external environment in outer space is lethal and for the most part improvident. Anyone who ascends to orbit must survive tremendous acceleration and deceleration (although less so than in the early days), loud noises, vibrations, wild temperature swings, vacuum, glaring light, astonishing darkness, and in some cases, poisonous atmospheres and corrosive dusts. Survival depends on the integrity of the spacecraft and the space suit and the reliability of the life support systems. Habitability or quality of life in space has improved dramatically since the earliest days of flight (Woolford & Mount, 2006). Still, there remains substantial danger, and some hardship and discomfort. Amenities that are procured easily on Earth may be in short supply or unavailable in space.

As is true of other remote worksites, astronauts and tourists must bring almost everything they want with them. Given space, mass, volume limitations, very few personal items will arrive on a later cargo flight. It is not always easy to forecast future personal needs and preferences. Here, the partnership with ground crew is important. Support personnel, who have worked with all the United States astronauts on the ISS, help novice astronauts think through their needs. Over time astronauts have brought lots of different things and left them at the ISS for the next team. An example is music that soothes the soul of the first user is available for the benefit of subsequent crews.

Humans are still relative neophytes in space exploration, and today’s spacecraft and equipment are designed for highly qualified and well-trained professionals. The ISS, for example, is very much a work in progress. The space station serves many purposes: a laboratory for learning about life in space, and the site for experiments that range from highly complex and sophisticated to simple demonstrations for elementary school children. Ongoing construction is truly international, as the different countries’ space agencies send up modules that are assembled and tested by international crews. The ISS is also the destination for those few space “tourists” who can afford the trip and meet the training requirements. The relatively new efforts to provide a safe and quality experience for tourists will help improve technology and, on the basis of their personal experiences, tourists are likely to provide robust support for a vigorous and innovative space program. Right now, no astronaut could afford to buy his or her way into space: compared to people who pay tens of millions of dollars for a flight, astronauts are regular people who feel fortunate to have the opportunity to experience spaceflight.

Today’s astronauts and cosmonauts benefit from tremendous advances in nutrition and dietetics. Space food has come a long way over the years, and on the whole food is attractive and tasty, especially compared to early flights. The occasional cargo ship will bring fresh fruit, always welcomed aboard. Of course, food preferences vary across cultures and from person to person, so at some point an astronaut is sure to encounter a meal that is smelly and not to their liking. Although variety is taken into account when stocking the pantry, some items will end up in short supply and eating the same stuff again and again becomes annoying. Located at Johnson Space Center, the Space Food Systems Laboratory designs, develops, evaluates and produces flight food, menus, packaging, and food-related ancillary hardware for the shuttle and station, while the Advanced Food Technology group there emphasizes research on the nutritional, psychological, safety, and acceptability requirements. Both of these programs must meet their goals while minimizing mass, volume, power, waste and trace gas emissions (Ferrando, Paddon-Jones & Wolfe, 2002; Lane & Feeback, 2002; Perchonok, Swango & Toerne, 2001).

Operations and science are the most prominent types of work conducted in space. It’s not possible for pilots and scientists to be fully trained in each other’s specialties, but it is both possible and useful for each to understand the importance of each others’ contributions, support one another, and strengthen the integrity of the crew as a whole. There are medical doctors who are astronauts, but every ISS mission has an astronaut who serves as medical officer, even if he or she is not a physician. This role of medical officer is one example of the extra training that each astronaut will receive outside his or her specialty. Similarly, physician-astronauts will learn many skills outside the medical arena. Astronauts and cosmonauts participate regularly in biomedical research and are beginning to participate in psychological research, such as surveys (Kelly & Kanas, 1992, 1993ab). Many have taken part in studies of sleep and circadian rhythms (Mallis & DeRoshia, 2005).

Physical Factors

One of the more striking differences between working on the ISS versus working on earth is the experience of microgravity, popularly known as “weightlessness” In the public’s imagination this enables people to “fly.” The first experience of microgravity confirms the status of spacefarer. Microgravity is associated with both freedom and frustration – tools float away, some people experience space sickness, and it is necessary to follow an active exercise program to avoid cardiovascular de-conditioning and decalcification. Astronauts and cosmonauts adapt to microgravity, but it may take three or four months before “floating” seems normal. After that the occasional sudden recognition that one is “upside down” is not particularly distressing. Technical discussions often ignore the fact that the experience of microgravity can be fun, even exhilarating. Here consider an analogy between a child learning to swim and an astronaut experiencing microgravity. The prospects seem daunting but the actual experience of floating in the ocean or space is rewarding.

Personal hygiene is complicated in microgravity, especially since water is scarce. On the ISS water droplets float: taking a shower while the water clings to the body is not as relaxing as a shower on earth. The most usual choice is a sponge bath. Also, astronauts have to clamp themselves to the toilet, which contains a strong suction fan and device. The ISS has one hygiene facility and one bathroom. With the normal three person crew, it’s not that hard to work out a schedule. Astronauts learn each other’s patterns and simply coordinate: for example, using one of the facilities before another astronaut wakes up. But when six astronauts are present, the limited facilities are inconvenient and annoying, and it’s necessary to stand in line.

Microgravity affects the entire body, including the internal organs, and it can take a while for certain systems, such as the digestive system, to adjust. This means problems like bloating and constipation. Astronauts have to think twice about taking over the counter medicines that they might normally gulp with impunity. Because of microgravity medicines may have unexpected and unwanted consequences. Following adaptation to microgravity it is effortful readapting to 1-g on return to Earth. Apart from maintaining a vigorous exercise program not much can be done about this. Psychologically, it’s great to go up there and great to come back home; motion sickness or temporary disabilities may be unpleasant but they should not and do not dominate thinking.

Relatively high doses of radiation are another hazard of space flight. Two forms of radiation are worrisome: solar particle events and deep space radiation. Radiation can have adverse medical effects but there are strategies for minimizing the risk. Generally, it is less of a concern on brief shuttle missions than on long space station missions because the latter mean greater cumulative exposure. NASA tracks the radiation from solar flares and ISS crewmembers receive advance warnings. Ground-based experts work with the astronauts to minimize exposure to these flares. When the experts warns crews of impending solar flares, the astronauts move to parts of the ISS that are better shielded from radiation, and avoid both extra vehicular activity (EVA) and looking out the window. Safety requires the combination of mission control expertise, careful detail work and accurate predictions communicated to astronauts who then take appropriate steps. Cumulative exposure from two or more extended duration missions may lead to medical disqualification from future flights. Hence, there is always personal concern about dosage and keen interest in the verdicts of the dosimeters.

Psychological Factors

For years, medical experts, human factors engineers, and psychologists have identified many factors that could impair performance or undermine well-being (Connors, Harrison & Akins, 1985, 1986; Flynn, 2005; Kanas & Fedderson, 1971; Lindsley, 1972; Santy, 1994; Shepanek, 2005; Sipes and Vander Ark, 2005). These include constant exposure to risk, deprivations and hardships, high workloads, boredom, and temperature extremes – to name a few. Astronauts must endure isolation from family and friends, close confinement with other people, and the ever-present possibility of a collision, system failure, or other disaster. Other types of stressors are associated with the astronaut's career. From the earliest days of the space program, astronauts have served as societal exemplars living under intense public scrutiny, carried heavy workloads on Earth as in space, and undergone prolonged absences from home for training and other purposes. They must withstand the usual hassles of trying to succeed within large bureaucracies, worry over flight assignments, and readjust to their families when they get home. Generally, the worry has been that stress could undermine performance at a crucial time, or that minor inefficiencies and mistakes could cascade into major problems. Today, psychologists understand that whereas spaceflight conditions might cause problems in performance or psychosocial adaptation, they also produce positive psychological consequences as experienced by our lead author (Harrison & Summit, 1991; Suedfeld, 2005; White, 1987).

Research by Nick Kanas and his associates has yielded some interesting observations (Boyd, Gushin, Weiss et al., 2007Kanas, 1985, 1991; Kanas et al., 2006). These researchers studied three areas of psychosocial adjustment during space missions, administering emotional state and social climate questionnaires to 17 U.S. and Russian ISS crewmembers and 128 mission control personnel weekly from four weeks before launch until two weeks after landing. Results were similar to results from an earlier Shuttle-Mir study using different astronaut and ground participants. Displacement in directing frustration was demonstrated and was stronger for the isolated crewmembers than for mission control personnel. For crewmembers "Leader support" subscale was related to the "Cohesion" subscale but "Leader control" subscale was not. Both leadership subscales were related to cohesion for mission control personnel.

Space may be silent, but the ISS is not. Noise is a problem. According to the ISS Acoustic Measurement Program, "The acoustic environment on board the ISS has become one of the highest crew habitability concerns" (NASA, 2008). As of November 2005, noise levels were between 62 to 69dB in the work area and 55 to 60dB in the sleep compartments (Young, 2006). Some modules are noisier than others and it is easy to wonder about long-term effects on hearing. On the other hand, the sounds of the Space Station can be reassuring, because they prove that life support equipment, communications devices, and the like are working. In many cases it is silence that is ominous. New or unexpected noises grab attention; astronauts want to know what the noise is and what it implies for the mission. It's necessary to track down and understand the reason for any unexpected changes in noise patterns.

Given noise, other astronauts working nearby, and the excitement of the mission, it can be difficult to get enough sleep. There is always a lot of work to be done, but the demands are such that this doesn’t usually interfere with sleep. There are sleeping quarters in the ISS, but it can take a month or so to get used to sleeping in microgravity. On Earth we are acclimated to blankets, pillows, and mattresses, which press down upon us. Microgravity eliminates this kind of stimulation; down here, even sleeping uncovered in a hammock we press down on the netting. While sleeping, astronauts use sleeping bags that are anchored so that they do not drift around the interior of the spacecraft. Techniques for simulating sleep on Earth include applying bungee cords to create pressures, or holding a rolled up garment next to your head to simulate a pillow. These simulations can help astronauts sleep more easily in the early stages of adaptation, but over time they learn to sleep under conditions of microgravity.

Astronauts know full well that they will have to accept isolation and confinement. They recognize that over a long period of time they are likely to get into conflict with another crewmember, and before getting into a serious argument ask themselves “Is it worth it?” Normally on the ISS there are only a couple of other people around and since it is impossible to get away so one is forced to live with consequences of conflict. If you don’t agree with other crewmembers, the trick is to be assertive in such a way that it does not break up the team. One tactic for minimizing conflict with a second crew member is to tell a third crewmember your opinion, and ask this third party to explain your position to the second crew member. This can defuse a potentially explosive situation, because the emissary is in a better position to present the issue in a non-threatening and low-key way.

In a potentially conflict-laden situation the emissary has to be aware of both sides of the issue, and free of personal emotional involvement.

The multiple cultures of international crewmembers complicate communication and can lead to misunderstandings (Ritsher, 2005). The presence of an inexperienced member on board adds to the potential conflict. Sometimes following a conflict it helps to retreat or have a small bit of private time, and other times reflection is helpful for putting an emotional reaction into constructive words. Oftentimes when each person really understands the other’s point of view a conflict recedes. It’s important to take a step back and, at the same time, not let conflicts smolder.

Certainly astronauts miss family and friends on Earth. Departing on an extended mission they realize that someone close might die, and are particularly sensitive to this when people of whom they are fond have a serious illness or are in a convalescent hospital. Communication with family and loved ones is available but limited. There are two ways of actually talking to people at home. One is by means of a speakerphone, and the other is a “privatized” conversation involving a handset. The speakerphone is a lot easier, but of course other people can listen in. Older readers may remember when the arrival of a telegram usually signified bad news. When a contemporary astronaut receives an announcement of a “privatized” call, it is easy, as well as disconcerting, to think that something must have gone wrong. In most cases it is the astronauts who have to take the initiative for a conversation. If people on Earth want to speak with an astronaut they have to send an e-mail to schedule it – the trouble here is that e-mails are one-way communications, and highly impersonal. Furthermore, where privacy is assured on the handset, there is always a suspicion that a third party will read e-mail.

The emotional tone of the telephone conversation is crucial. It certainly helps if spouses do not expect the astronaut to micromanage home life from space, or dwell too long on problems that the astronaut can do nothing about. Of course there is unpleasant news that astronauts need to know, and they do want to be consulted on important matters. But they hope for a positive, upbeat conversation that does not impose many new burdens on them, and, when some kind of conflict arises (which it most assuredly will) want the opportunity to work it out. Trust the people on the ground to do the best they can, and always appreciate their cheerfulness. One of the worst things is for astronauts and spouse to lay guilt trips on each another.

As in any deployment situation, the people left at home take on an extra burden. The Earth-bound spouse has to take on both parental roles, maintain the house, pay the bills, and assume all the other duties of home life, while worrying about a partner who is circling Earth every ninety minutes over one hundred miles above. Astronauts are not unique in this because business travelers, military personnel and many other people are separated from their families for work related reasons. The extent of this problem is seen by the US military, which has developed a website to aid spouses of deployed personnel (Bell & Schumm, 2008).

It helps if spouses have their own careers or interests as these endeavors help prevent obsessing over the welfare of the deployed astronaut. Spouses that work some place other than NASA have the advantage that the flight isn’t always in the local newspaper or the topic of daily conversation. On return, time seems to slow down a bit, and returnees may have a slight sense of letdown. Things change over three months, and it is necessary to accept this reality. Family members give lots of support when astronauts are away, and it is important for astronauts to give back to families upon their return. For example, after return astronauts have a few weeks of “rehabilitation” and then hit the road again. They might consider inviting the spouse to accompany them on a particular trip.

Adaptation

The shift from civilian to astronaut is somewhat gradual, even though acceptance by NASA and achieving the new title “astronaut” may seem abrupt. Although it is no longer necessary to be a test pilot to fly in space, many of today’s astronauts have aviation experience or prior membership in elite teams that work long shifts under dangerous and stressful conditions. Activities prior to NASA can serve as stepping stones to initial space missions, much as early space missions, for example on an orbiter, prepare people for later missions on the ISS. Experiences in such fields as aviation help develop a sense of trust in one’s companions as well as learn both leadership and teamwork, but preparation can begin as early as childhood hiking and camping.

Lots of astronauts have a history of childhood adventure and academic achievement that continues into adulthood. Our first author’s childhood highlights included camping out with the family, and exploring the world around us. Early outdoor activities have expanded into adult recreations of triathlons, windsurfing, snowboarding and hunting with bow and arrows. Her choice to accept a position at the US Naval Academy was the beginnings of her Navy career. Subsequent to graduation, she completed helicopter combat school, was deployed several times (often as part of an elite helicopter rescue team) and then went back to Navy Test Pilot School. She applied to be an astronaut, an opportunity that would let her explore the fringes of space just outside of earth’s boundaries. Selected as a NASA astronaut candidate in 1998, she now serves as Deputy Chief, Astronaut Office. As a member of the International Space Station Expedition 14, she spent 195 days in space. Prior to joining NASA, her frequent deployments in hazardous surroundings gave her a deep appreciation of working as a member of a team. Hazardous duty had taught her to have healthy respect of the dangers of spaceflight, but also gave that extra boost of confidence that is helpful for meeting new challenges. Her biography demonstrates the gradual transition from an earthbound career to a spacefaring job. Most astronauts have had many adult years of achievement, followership, working in teams, and leadership in their field of endeavor. Even after acceptance into the astronaut corps, years of training will precede the first spaceflight.

For most missions, launch and recovery are the riskiest parts; all US spaceflight related deaths have occurred during launch or recovery. Preparing to go into space, especially the first time, it is easy to be a little nervous and desire to get affairs in order. Launch is the moment that astronauts have been waiting for and there’s a sense of encountering the unknown. The proper mental set includes a willingness to challenge oneself and try new things, and openness coupled with a love of nature. Experiences such as military deployment or work in extreme environments help many astronauts prepare for this incredibly exciting moment---and for the possibility that this moment may be one of the last moments in the astronaut’s life.

Technology

Since the earliest days of spaceflight technology has kept people alive and well. This technology ranges from complicated life support and escape systems to the once popular powdered orange beverage Tang. Powerful computers, advanced tracking and communication systems, thermal tiles, special tools, expensive cameras and gizmos of all kinds ranging from such major implements as the remote manipulator or “Canadian Arm” down to special hooks and snaps have helped, and will always help, people adapt to space.

It’s important to think of the ISS as a test bed. Some of the design features are wonderful, others less so. On the ground, almost everything seems like a good idea, but it has to be proven in space. Both the really good and really bad features stick out. The ISS was never meant to be perfect; equipment is continually undergoing redesign and evaluation. For example, one hatch may be large but difficult to close; another may be small but easy to close, so redesign can lead to what we really need: large hatches that are easy to close. Good hatches make it a lot quicker and easier to move from place to place, or to transfer equipment and supplies from one module to another. Many of the problems are very small ones – a balky switch, a valve that doesn’t quite work. When astronauts remember that they are field-testing, whether it be equipment, procedures, or international living, it is much easier to adapt. Today’s ideas can be used to improve the next generation spacecraft and off-world habitats.

Space suits are a crucial technological aid. These are like any unusual clothing that eventually seems natural, so you do get used to them. Certain parts of the suit are hard – for example, the gloves – and you can expect some abrasion- for example, around the knuckles. Check your undergarments very carefully; something like a falling sock cannot be adjusted on a space walk. Make sure the suit is donned as carefully as possible; a wrinkle will be very uncomfortable. This donning and working in space suits is another area where experience helps. There are ways to adjust the temperature, but it can be very hot or very cold during a spacewalk.

Today, behavioral researchers are seeking new technology for identifying high levels of stress in space. David Dinges and his associates are developing an optical computer recognition program to identify stress from facial expressions (Dinges et al., 2005). Another strategy is the computer analysis of speech, which detects unmistakable evidence of impaired mental functioning (Lieberman et al., 2005). In one incident, these researchers were monitoring the speech of climbers ascending Mt. Everest and found in one subject’s speech evidence of oxygen deprivation and muddled thinking right before he fell to his death. Other researchers are developing tests that astronauts can give to themselves (Kane, Short, Sipes and Flynn, 2005; Shephard & Kosslyn, 2005). In this manner, astronauts can assess their own mental efficiency before undertaking difficult elective tasks, and nobody other than the person who has taken the test knows the results. Yet other researchers are using dramatic film clips and computers to provide mental health resources to people in space (Carter et al., 2005). They are developing a “virtual space station” which serves as a portal to multi-media based training, psychological assessment, and guidance resources. This includes informative vignettes, background reading, helpful hints and other resources to help users manage conflict and alleviate depression. The two advantages of this approach are first, nobody other than the individual user knows that the portal has been entered, and second, users on Mars missions will not be frustrated by communications delays associated with tapping behavioral health resources based on Earth.

Selection and Training

Over the history of the US space program psychiatric interviews have been used to eliminate people who show of evidence of neuropsychiatric dysfunction, but other than that, psychological testing has played an uneven role (Jones & Annes, 1983; Santy, 1994). The early Mercury astronauts underwent extensive testing, and then for a while psychological tests were abandoned. Emphasis was on eliminating people that were not likely to do well in space (select out) but there was no systematic effort to identify people who might bring something special to a mission (select in). In the 1990s, Galarza and Holland began developing a scientifically defensible select-in process that would screen for personal abilities to help people live and work within a small teams under conditions of isolation and confinement (Galarza &Holland, 1999ab). By using highly qualified subject matter experts, job analysis, and documented validation techniques they sought to meet the high standards for selection established by the Society for Industrial and Organizational Psychologists. Today, all astronaut candidate applicants spend several hours completing psychological tests and then undergo extensive psychological and psychiatric interviews. The current selection process resembles other high-risk job selection procedures, incorporating highly validated tests that are quantitatively scored along with in-depth semi-structured interviews.

What kinds of qualities are sought? Different space programs have sought different qualities at different times and have used different methods for selection (Santy, 1994; Harrison, 2001). However, whether the list of desired attributes is short or long, it often boils down to three main qualities. These are ability (technical proficiency and sustained motivation), stability (freedom from psychological dysfunction and strong emotional control) and social compatibility (the ability to work well as a member of a team and get along with mission controllers and other NASA employees).

ISS missions require people who can learn from more experienced crew members, and then, after these senior crewmembers go home, are good mentors for the next replacements. That is, it is an asset to be a good follower and a good leader, since there is going to be a constant rotation of people and hence experience levels. Susan Helms, with four shuttle missions and one ISS expedition has written that her philosophical leanings are, “The good of the team is more important than the good of the individual” (Helms, 2000$^{)}$). Exemplary individual performance is not enough; each crewmember must be a good team player.

NASA has always provided extensive and effective training: of individuals, of crews, of support personnel, and of everyone working together. At the outset NASA developed an amazing array of training devices and techniques and the US space agency has done nothing but improve its equipment and methods ever since. From the astronaut’s perspective, training is good because it is a great warm up for what they will experience up there. Making the training harder makes the job easier. Extensive training has both upsides and downsides. A long training flow is bad for home life but helpful for the mission when there are not enough people on the ISS to complete all the required tasks. As the number of astronauts living and working on the ISS increases it is less important for everyone to learn everything and training time can be reduced.

Each ISS astronaut spends around half of his or her four years of mission specific training in Russia. Most of this time is at the Gagarin Cosmonaut Training Center (GCTC), which is the Russian training center for cosmonauts, international astronauts, and space participants (also known as space tourists). The training also includes time away from the GCTC, experiencing life in a different culture small town. Reducing international travel will reduce the burden in such areas as separation from family, but it will also reduce some of the benefits coming from cross-cultural exchanges.

Psychological Coping

Keeping busy, physical workouts, constructive use of free time and reaching goals all help to reduce stress. Maintaining a personal diary or journal can also be helpful. Writing things down helps you think things through, but these have to be private, confidential journals if they are to be effective. Having conversations with people who know you provide helpful reality checks. Recognition that earlier astronauts and cosmonauts have had to face boredom, loneliness, and other issues is also a source of strength.

Apart from elective private diaries, ISS astronauts in flight write weekly journals that go on line. Sometimes astronauts have to push themselves to do this task as the writing came out of weekend time. Yet, whenever someone would write back, the realization of the impact on other people is motivating and rewarding. E-mails that say “I loved the cooking session” or “I really liked the geography quiz” tell the astronaut that he or she is on the right track. Knowing that other people join in psychologically, and feel that they are a part of the mission gives a great feeling. In a similar vein, our lead author found ham radio passes tremendously rewarding. Conversing with children and hearing the excitement in their voices had a powerful and rewarding emotional effect.

There are relatively few astronauts but since all astronauts train and live in the same location, the number doesn’t see quite as small to them. When an astronaut leaves the geographical area where all work and live they become few in number proportionate to the rest of the population and attract much more attention. On the whole, describing their experiences to other people is generally enjoyable as well as part of their job. At one level astronauts are celebrities, but they are also people. There is more to life to being an astronaut, and it’s not much fun when the other parts of their lives are not allowed to come to the fore. Like other people, astronauts enjoy their varied roles and like to discuss different parts of their lives – how the kids are doing at school, the spouse’s recent accomplishments, home improvements, and so forth. It is frustrating when other people’s focus on occupation forces astronauts to keep the other aspects of their lives submerged. Also, the astronaut status can disadvantage other family members. When other people think of an astronaut’s relatives not as individuals in their own right but as the spacefarer’s husband, sister, daughter, and so forth the relatives’ own personalities are obscured. Occasionally astronauts jar people away from this one-dimensional view with a statement like “I want to see the Red Sox win the World Series.” This reminds others that fundamentally, astronauts are people too.

Even though they know there is a lot of media coverage of astronauts on the ISS, astronauts do not always appreciate the extent to which other people are paying attention to them. Members of the public worry about astronauts and wish them well. Our first author is an American of Indian heritage, and she was touched to learn that many people in India prayed for her. Following her ISS mission she visited India, and the enthusiastic welcome was humbling, but also empowering, since people listened to her positive message about space.

NASA offers psychological support before, during, and after missions (Sipes & Fiedler, 2007; Sipes & Vander Ark, 2005). Preflight preparation includes training and briefings in such diverse areas as self-care, conflict management and cultural awareness and field training. Families are prepared in briefings on crew care packages (containers of personal items that are sent to the astronauts on resupply missions) and family conferences. In-flight psychological support services include extensive communication with people on the ground, psychological support hardware and software, and semi-monthly video conferences with a behavioral health clinician. Roughly a month before the end of their mission astronauts are briefed on the kinds of stresses that are likely to arise on their return home. After they come back astronauts undergo a series of debriefings intended to fine-tune the psychological support program as well as benefit the returnees. Astronauts and their families can use counseling and other psychological support services at any time.

Research Issues

Two types of behavioral research support astronauts in space. These are space-based and ground based. Ground-based research can take place in more-or-less standard laboratory settings, in mock-ups and simulators, and in spaceflight analogous environments. The latter are terrestrial settings such as Antarctic outposts, submarines and sailing vessels that capture risk, hardship, isolation, confinement and other environmental characteristics that are associated with space. For the foreseeable future, research using astronauts in flight will be only a small part of the overall effort. One reason for this is that there are simply not enough astronauts to participate in the many projects that need to be done, and the other is that researchers need to use simulators and analogues to prepare for new missions such as exploring the surface of Mars. Antarctica provides a wonderful site to do this (Harrison, Clearwater & McKay, 1989, 1990).

A successful overall research program must be interdisciplinary, broad-based, and address individual, team, and organizational issues. It must meet the priorities of NASA management, researchers, and operational personnel. It requires broad recognition of the significance of psychological issues, and absolute guarantees of confidentiality to anyone who might choose to participate. The most productive research topics are those that are of interest to operational personnel, and the results easily translated into quantitative mission requirements understandable to engineers. Additionally, a successful research program cannot proceed by fits and starts, but requires continuity (Harrison, 2005).

Until recently, NASA's *Bioastronautics Critical Path Roadmap* (Charles, 2008) was the Space Agency’s framework for “identifying, assessing, and reducing the risks of crew exposure to the hazardous environments of space.” This web-based document, listed five cross-cutting areas spanning life support, habitability, and space medicine: Human Health and Countermeasures, Autonomous Medical Care, Behavioral Health and Performance, and Advanced Human Support Technologies. It presented a brief description of current knowledge and the behavioral questions that need to be addressed to support future space missions. It listed current methods for addressing the risks and projects new countermeasures in the form of new standards, requirements, technologies, and practices.

Rest, sleep, and biological rhythms were prominent because they affect alertness, vigilance, energy levels, endurance and many performance related variables. Whereas people require an average of eight hours of sleep per night, people in space average about six hours and may have less before critical operations. Our biological clocks, which evolved on Earth, are geared to or “entrained” to the 24 hour day. In space, these may lose synchronization with the external environment, for example, as sunrises and sunsets occur every 90 minutes or so in orbital flight or on the Moon or a planet that does not rotate once every twenty four hours. On Earth following trans-meridian flight we experience this “jet lag.” How can we prevent this in space or at least minimize adverse consequences there?

A second major research area is the human-machine interface. In space, performance may flounder due to poorly designed equipment and tools, poorly programmed computers, impractical or overly complex procedures, hard to read displays, and cumbersome or insensitive controls. Other problems include glare or poor illumination, a complex or visually confusing environment compounded (under conditions of microgravity) by an unstable frame of reference; and the loss of hard-won skills as a function of time since learning or rehearsal.

Failure to adapt to the unusual psychological and social environments of outer space is another area that requires further research. Garbled communications, a lack of cohesiveness or team spirit, weak leadership, isolation from family and friends, crowding, social withdrawal, interpersonal hostilities and troubled relations with mission control are potential threats to mission success. Frustration is likely for highly motivated, goal oriented individuals whose work is hampered in space by cramped quarters and missing tools and supplies that would handy on Earth. Not only must astronauts adapt to the “normal” space flight environment they must be able to handle problem situations, such as the breakdown of a power supply, failure of a resupply ship to arrive on time, inability to communicate with the ground, the death of a friend on Earth, fire, collisions, and other emergencies.

In 2008, the NASA Human Research Program (HRP) evolved from the Bioastronautics Critical Path Roadmap. The HRP was a direct result of NASA's refocus on space exploration which occurred in 2004. Six elements comprise the HRP, all geared to research leading to procedures to lessen or mitigate the effects of the space environment on human performance. It is clear that the HRP takes a problem-solving approach to spaceflight with the emphasis on the negative aspects of space environment. To support the program, HRP developed two documents, The HRP Integrated Research Plan and the HRP Requirements Document (Grounds, 2008). These two documents extensively list the requirements and the research plan to meet those requirements. The new HRP approach is substantially different from its predecessor, the Bioastronautics Critical Path Roadmap. The HRP is not intended to mitigate risks associated with the ISS. The ISS is used as a platform to conduct research aimed at mitigating risks to the exploration missions. Some of the research may identify countermeasures, engineering or operational solutions that would enhance the ISS and reduce risk in use of that platform. In those cases, the HRP identifies the necessary deliverables and insertion points for the ISS. However, the focus of this document is to identify deliverables necessary to complete the exploration (Lunar and Mars) missions.

NASA has laid out some very specific schedule milestones for implementation of the Vision for Space Exploration (VSE). The shuttle retirement in 2010, the launch of the Orion crew exploration vehicle in 2014, and the first lunar sortie by 2020 together create urgency for the acquisition of knowledge. The use of the Shuttle and ISS platforms, in several cases, is critical to obtaining the required knowledge to build products supporting longer, more challenging missions. In some cases, research is accelerated to take advantage of the availabilities of those vehicles.

In the time between the ending of shuttle missions and the commencement of Orion missions, a very human question arises. How do we help both ground and astronaut personnel adjust to the hiatus in flight that will occur between the times we stop flying to the ISS and before the new spacecraft are operational?

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