Psychosocial Issues during an Expedition to Mars

In *The New Martians,* the crewmembers undergo a great deal of psychological and interpersonal stress during their return home, in part prompted by the actions of a mysterious presence on board. Of course, no one knows for sure if such a presence will actually materialize during a real Mars expedition! But psychosocial issues will nevertheless affect a Mars crew due to the isolation, confinement, and long separation from family and friends that will characterize such a mission. In what follows, many of these issues will be reviewed, followed in each section by illustrations from the novel.

1 Psychological and Interpersonal Stressors On-orbit

Much is known about the psychosocial issues that affect astronauts in space from anecdotal reports, scientific studies performed in space analog environments on Earth (e.g., Antarctic, space simulation chambers, submersibles), and experiments conducted on missions involving orbiting spacecraft. Although some of this information can be extrapolated to a Mars mission, one must be cautious in taking this leap from the Earth and its environs to a planetary body deep in space, since new stressors will affect the crewmembers that are not present closer to home. But we must begin somewhere, so let's first examine some of the psychological and interpersonal stressors in the near-Earth environment [1]. These are summarized in the left hand column of Table 1.

Isolation and confinement occur in all space missions and force the crewmembers to interact together in a small space far away from home. Danger is part of the mission, whether from a micrometeoroid impact, a malfunction in an important piece of equipment, a fire, or any number of other factors. Monotony can also occur, although there are also periods of high workload during spacewalks and emergencies. Personality conflicts can interfere with

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Table 1 On-orbit and planetary psychological and interpersonal stressors

On-orbit stressors	Additional stressors on a Mars mission
Isolation and confinement	Cultural issues
Possible danger	Selection Issues: who will go?
Monotony	Effects of long-term microgravity
High workload (e.g., spacewalks, emergencies)	Effects of long-term radiation
Personality conflicts	Extreme isolation and loneliness
Crew size	Dependence on machines and local resources
Time effects	Limited social contacts and novelty
Leadership roles	Leisure time
Crew-ground communication	Lack of support due to communication delays
Crew heterogeneity	Increased autonomy
Common language	Earth-out-of-view phenomenon
Cultural issues	Family problems at home

crew cohesion and performance. The best crewmembers for long-duration space missions are those who are comfortable working alone on an activity when diligence is called for, yet at the same time are team players who enjoy relating with their colleagues during meal and leisure times [1]. Crewmembers undergo up to two years of pre-launch training, although currently there are relatively few opportunities for behavioral health experts to observe them for signs of incompatibility before they are sent into space. The number of people comprising a crew may be important. In studies of unstructured groups on Earth, it has been shown that odd-numbered groups form a consensus better than even-numbered groups, and larger groups are more cohesive than smaller groups, since people can usually find a person or two with similar interests to counter feelings of isolation [2].

In missions lasting six weeks or more, time effects have been observed. For example, crewmembers in space or in space analog environments have been found to exhibit significant psychological and interpersonal difficulties after the halfway point of their mission. The idea is that some crewmembers arrive at this milestone with relief that things are going well, only to realize that there is still another half to go before they will be home. It is not so much the number of days that have transpired, but the perception of "halfway" that has the most psychological relevance. Some investigators have described the presence of a "third quarter phenomenon," characterized by increased homesickness,

depression, irritability, and decrements in crew cohesion shortly after the halfway point [3].

To examine time effects, our research team conducted two NASA-funded international studies of psychological and interpersonal issues during a series of on-orbit missions lasting 4–7 months to the Mir and the International Space Stations. The Mir study sample consisted of 5 American astronauts, 8 Russian cosmonauts, and 42 American and 16 Russian Mission Control personnel. The ISS study sample consisted of 8 American astronauts, 9 Russian cosmonauts, and 108 American and 20 Russian Mission Control personnel. Subjects completed a weekly questionnaire that included items from a number of well-known measures that assessed mood and group dynamics. Both studies had similar findings, so in a sense they replicated each other. In both studies, there were no significant changes in levels of emotion and group interpersonal climate over time. Specifically, there was no evidence for a general worsening of mood and cohesion after the halfway point of the missions, and no evidence for a third quarter phenomenon [4, 5]. It should be noted that some individual crewmembers showed evidence for such a decrement just after the halfway point of their missions, but others showed no such effect or even experienced an improvement in emotional state during the second half. Our belief is that the absence of general negative time effects in our studies was the result of supportive actions taken by flight surgeons and psychologists in Mission Control, which included the sending of favorite food and surprise presents on resupply ships and increased communication with family and friends on Earth. Such actions helped to provide novelty and counter the effects of isolation, loneliness, and limited social contact. The celebration of mission milestones and holidays likely contributed to the maintenance of morale as well.

Research in the Antarctic and other isolated and confined environments on Earth suggests that the identified leader has at least two major roles in a group [1]. The first deals with setting the agenda and getting the work done: the task role. The second deals with supporting the team and paying attention to group morale: the support role. These aspects of leadership become especially important at different times during the mission. For example, during emergencies, the task role is crucial, whereas during monotonous periods, the support role becomes more relevant. Ideally, the commander of a space mission is comfortable with both roles and knows how and when to use them. We studied the impact of leadership roles on group cohesion in both our Mir and ISS studies. We found that the support role of the mission commander was significantly and positively related to group cohesion among crewmembers. In our Mission Control subjects, both the task and support roles of the team

leader were significantly related to cohesion in the ground-based work groups [4, 5].

During on-orbit and lunar missions, the communication between the crewmembers and people on Earth is very important for morale. In a survey of 54 astronauts and cosmonauts who had flown in space, Kelly and Kanas found their respondents to rate a sense of shared experience and a mutual excitement for space flight as two factors that significantly helped their communication with Mission Control personnel [6]. They further acknowledged the value of contact with loved ones on the ground as having a positive influence on mission performance. Crew heterogeneity is also an important factor. Space missions typically involve people of both sexes, diverse professional and experiential backgrounds, and different life experiences. In the long run, such diversity can be beneficial, since it provides novelty and stimulation later in the mission when people begin to tire of the routine and look for something new to talk about. However, diversity can also be stressful, especially initially when people are adjusting to individual differences. One important counter to the negative effects of heterogeneity is for all of the crewmembers to fluently speak a common official mission language. This not only enhances efficient communication of ideas during work activities and emergencies, but it also improves bonding with fellow crewmembers through a better understanding of the connotations of their speech and the meaning behind their comments and jokes. In their survey, Kelly and Kanas found that 100 % of the respondents acknowledged that it was important for space crewmembers to be fluent in a common language, with 63 % rating it as "very important" [7].

Stuster examined a number of interpersonal stressors that affected space crews working on-orbit [8]. He performed a content analysis of personal journals from ten ISS astronauts that were oriented around issues that had behavioral implications. He found that 88 % of the entries dealt with the following categories: Work, Outside Communications, Adjustment, Group Interaction, Recreation/Leisure, Equipment, Events, Organization/Management, Sleep, and Food. The crewmembers reported that their life in space was not as difficult as they expected prior to launch, despite a 20 % increase in interpersonal problems during the second half of the missions. It was recommended that crewmembers be allowed to control their individual schedules as much as possible.

Examples from the Novel: In *The New Martians*, the crewmembers have been away from Earth for two years. All the excitement from their exploration of the Martian surface is past, and they are tolerating the boredom of the long return home. By now, they have adjusted to each other's personality quirks. Fortunately, nearly everyone has at least one other person on board who shares some demographic or work-related characteristic to give them support. It has

helped for the crewmembers to be fluent in English (the designated mission language), although Juliette, the French computer engineer, struggles with some words, and Tolya, the Russian pilot, speaks with an accent. To avoid monotony, the crewmembers look for things to do to occupy their time. Tolya especially has few critical tasks to perform since his piloting skills won't be used until they get closer to Earth, and he experiences some boredom. John, the commander, is sensitive to the ennui that has enveloped the crew and is exercising his supportive leadership role. Together with Katya, the mission physician, they monitor the crew and encourage stimulating activities, such as celebrations and parties. John also finds it useful to write e-mails home to his family. In one discussion, Katya reminds John that some people working under isolated conditions may experience depression after the halfway point of their mission. This seems to be the case for this crew, until a number of dangerous events occur that shake them out of their monotony and produce periods of high workload that are needed to overcome the emergencies.

2 Cultural Issues

A particularly important issue during all multinational space missions pertains to cultural issues. People from different national groups interact differently and have certain expectations from other people. Take, for example, cultural norms. People from Mediterranean countries are typically behaviorally animated and comfortable being physically close to one another when speaking, whereas people from Northern European countries are more reserved and have less tolerance for someone gesticulating close to them, which they may perceive as boorish behavior or as a sign of aggression. During space missions, organizational culture also is important. Space programs vary in their degree of formality and their dependence on procedures and redundant equipment located on board (e.g., American space program) versus simply calling in experts on the ground to resolve problems and suggest on-the-spot repairs (e.g., Russian space program). An astronaut or cosmonaut used to one system may have difficulty adapting to another.

We found some cultural differences in our Mir and ISS studies. Crewmembers scored higher in cultural sophistication than Mission Control personnel. Russians reported greater language flexibility than Americans. Americans scored higher on a measure of work pressure than Russians, but Russians reported higher levels of tension on the ISS than Americans [9, 10].

Other research teams have also taken a look at how cultural factors affect space travel. Tomi et al. examined potentially disruptive cultural issues affecting space missions in a survey of 75 astronauts and cosmonauts and

106 Mission Control personnel [11]. The subjects rated coordination difficulties between space organizations as the biggest problem. Other problems included communication misunderstandings and differences in work management styles. Sandal and Manzey surveyed 576 employees of the European Space Agency and found a link between cultural diversity and the ability of people to interact with one another [12]. Especially important were factors related to leadership and decision-making.

Examples from the novel: The *MarsExplore* crew consists of two Americans (John and Mike), two Russians (Tolya and Katya), one French woman who spent time working in the United States (Juliette), and a Chinese man (Jango). Although this crew makeup was determined by a number of political, budgetary, and work-related factors, there is a reasonable balance in terms of cultural diversity, with nearly every crewmember having at least one person who could identify with his or her cultural background. A notable exception is Jango. Not only is he the only Asian, but his selection was strongly influenced by the desire to placate China so that this country would participate rather than compete with the mission. Adding the facts that Jango is a social introvert and had a very modest upbringing, he is clearly in a position to feel culturally isolated and even be scapegoated by the other crewmembers. It would have been helpful if another Asian crewmember, perhaps from China or Japan, could have been included in the expedition, but the mission tasks and the engineering demands of the vehicles restricted the crew size to six.

3 Psychological and Interpersonal Stressors Unique to a Mars Expedition

Specific stressors related to a long-duration planetary expedition, such as to Mars, are listed in the right hand column of Table 1. Again, cultural issues continue to be very important, since such a mission likely will be multinational. Nechaev et al. surveyed 11 cosmonauts regarding their opinions of possible psychological and interpersonal problems that might occur during a Mars expedition [13].They found the following factors to be rated highly: isolation and monotony, distance-related communication delays with the Earth, leadership issues, differences in space agency management styles, and cultural misunderstandings within the international crew.

In terms of crew selection, not everyone in the astronaut corps will volunteer to be away from family and friends for a two to three year mission, so this may skew the selection process to specific types of individuals (e.g., single people or people without small children). Little is known about the physical, cognitive, and psychological impact of long-duration microgravity and high

radiation in deep space, as well as the 38 % Earth gravity that the crew will experience on Mars. The crewmembers will be millions of miles away from Earth, and this will increase their sense of isolation and loneliness to levels higher than in any previous space mission.

People on a Mars expedition will be heavily dependent on their computers and other machines on board for basic life support and operational activities, such as navigation and propulsion. The psychology of this dependence and the ergonomic characteristics of the human-machine interface are important issues to be considered in designing the space vehicles that will be used. Since not all supplies and fuel can be stored on board, the crew will need to depend on local resources in the atmosphere and the surface of Mars to chemically generate water and fuel for the return home. So again, the ease of use and reliability of the relevant equipment will be critical.

Direct human contact will be limited to just the crewmembers, and ennui may result from the lack of novelty and the predictability of interacting with the same people for years. This will make leisure time activities important, and provisions will need to be available to cover a variety of free time activities. These will also need to be flexible enough to account for changing interests.

With the long distances involved in a Mars expedition, delays in crew-ground communication and the inability to send needed resupplies in a timely manner will seriously impair the kind of supportive morale-enhancing activities that occur during on-orbit missions. Given the separation in time and space from Mission Control, there will be high crew autonomy, and the crewmembers will need to be trained to develop their own work schedules and deal with operational and medical emergencies themselves.

Our research team studied the effects of high autonomy and communication delays in three space analog environments on Earth: a submersible vessel located off the coast of Florida, a remote location in Canada where a group of people simulated a Mars exploration, and a Mars analog habitat in Russia [14, 15]. Based on these three studies, we concluded that high work autonomy (where the crewmembers planned their own schedules) was well-received by the crews, mission goals were accomplished, and there were no adverse effects. During the high autonomy periods, crewmember mood and self-direction were reported as being improved, but in one setting Mission Control personnel reported more anxiety and work role confusion. Another research team (Roma et al.) studied the effects of autonomy in groups performing space-related interactive tasks on computers, and they also found evidence that suggested these groups functioned well under conditions of high autonomy [16].

No human being has ever been in the position of viewing the Earth as an insignificant dot in the heavens, the so-called “Earth-out-of-view phenomenon” [1]. The impact of seeing your family and friends and the location of

your birth and upbringing reduced to that distant dot may enhance the sense of isolation and homesickness. It is also possible that more profound effects will occur, such as depression, psychosis, or even suicidal thinking. We must be prepared for the occurrence of such reactions to this unprecedented event.

One important issue related to family life is how to inform an astronaut of bad news from home. In their survey, Kelly and Kanas reported that 18 respondents were of the opinion that negative information (such as a death in the family) should be withheld until a space traveler completed the mission, whereas another 22 stated that it should not be withheld [6]. Five additional respondents gave no clear opinion but volunteered that information could be withheld on short-duration space flights but perhaps should be disclosed during long-term missions. Kelly and Kanas opined that when disclosed, bad news from home should be tempered with support and should probably be delayed until after the completion of a critical mission activity.

Examples from the novel: The *MarsExplore* crewmembers were highly motivated to participate in this mission, although Jango had some reservations and John began to realize the toll his frequent absences were taking on his family. Nevertheless, the crewmembers adapted reasonably well to the mission and to each other. Moving in microgravity was sometimes turned into a social activity (e.g., microgravity dancing during parties), and accumulated radiation exposure was controlled but still resulted in this being the last space mission for the crewmembers, a fact they had adjusted to.

One issue that bothered several of them was giving up so much control of life support and operations to CARS, the central computer. This dependence on a machine affected the psychological reactions of the crewmembers. Sometimes they referred to CARS with a masculine pronoun, as if it was a person. At other times, they suspected CARS of having independent motivation and malevolent intent. This idea was fostered to explain a number of computer problems, but still the human-machine interface was an issue throughout the mission. Machines were also helpful in filling leisure time, such as with Jango and his computer games and John and his baseball rankings. But other leisure time activities did not depend on machines, such as Juliette's knitting and the chess game and its aftermath involving Tolya and Juliette! Machines were useful in communicating with people back on Earth, despite the delays it took for verbal or e-mail messages to traverse the long distances involved.

This communication delay was very frustrating, especially for John as he tried to maintain his ties with his family and when he needed advice from Mission Control. The crew had a great deal of autonomy, but this did not seem to be an issue for them. The Earth-out-of-view phenomenon was dealt with by having a telescope on board with which the crewmembers could clearly see Earth and its features. This was a popular activity, especially for

Mike. Two major family problems occurred: the death of Katya's sister, and the "Dear John" e-mail the commander received from his wife. Both events were communicated to the affected crewmembers during non-critical times, and they turned to fellow crewmates for emotional support.

4 Psychological Impact of a Mars Expedition

Astronauts react to psychological and interpersonal stressors in a variety of ways, which are summarized in Table 2. In terms of psychological and psychiatric reactions, the most common relate to simply adjusting to being in space. Living and working under the conditions of microgravity, isolation, and separation from family and friends at home is a novel experience, and most people need time to accommodate. Typically, this occurs within the first few weeks after arriving in space and becoming oriented to the new environment. But some astronauts have experienced clinical symptoms such as anxiety or depression as part of their adjustment. For example, one astronaut beginning a long-duration space mission reported symptoms of clinical depression due to the isolation he felt on-orbit and his separation from his wife [17]. Most of the time, such symptoms go away with support from crewmates and familiarity with the new surroundings. Rarely, a brief course of tranquilizers or counseling from the ground may be needed.

Russian flight surgeons and space psychologists have identified a serious form of adjustment reaction called asthenization, which is related to a psychiatric disorder called neurasthenia [18]. This disorder is defined as a weakness of the nervous system that produces fatigue, irritability and emotional lability, attention and concentration difficulties, restlessness, heightened perceptual sensitivities, palpitations and blood pressure instability, physical weakness, and sleep and appetite problems. Although first described as a neurotic condition in the late 1800s by the American George Beard, there is controversy as to the existence of neurasthenia, since it is not recognized in the current American psychiatric diagnostic system. Instead, its symptoms are incorporated in diagnoses related to anxiety and depression, such as adjustment disorder or chronic fatigue syndrome. However, neurasthenia appears in the diagnostic system used in Europe, China, and Russia. Russian psychologists and flight surgeons have viewed asthenization as an adaptation that affects most cosmonauts going into space, and they have developed a number of countermeasures to deal with it.

Our research team looked for the presence of asthenization by conducting a retrospective analysis of our Mir and ISS data to see if there were any correlations between the results from our mood measures and scores developed by six

Table 2 Effects of psychological and interpersonal stressors on space crewmembers

Psychological/psychiatric	Interpersonal
Adjustment disorders	Group tension and loss of cohesion
Asthenization	Withdrawal and territorial behavior
Somatoform disorders	Lack of privacy and personal space
Psychoses: schizophrenia, bipolar disorder	Scapegoating/subgrouping
Suicidal/homicidal Intent	Displacement
Post-return problems	Sexual attraction/tension

space experts who had experience treating this syndrome [18]. We found that all of the negative mood scores were significantly lower than the scores from the expert prototypes, suggesting that there was no evidence for the existence of clinical asthenization in our samples. However, in a separate analysis we hypothesized that Russian crewmembers would experience a significant correlation between fatigue (the hallmark of asthenization) and depression, whereas American crewmembers wouldn't show such an association [19]. Instead, they likely would experience depression in the context of anxiety, which supports a culture-bound pattern of mood that is consistent with the American model of neurotic depression. Our results confirmed these associations and suggested that patterns of mood states in space crewmembers may reflect national cultural norms. Further work in this interesting area needs to be done.

Somatoform (psychosomatic) disorders also have been reported from space. These consist of distressing physical symptoms that suggest the presence of a medical condition but which are not fully explained by a real physical problem. Instead, they are due to underlying psychological issues. For example, a cosmonaut wrote in his diary that he experienced tooth pain following anxious dreams he had of a tooth infection and his concern that nothing could be done about such an infection while he was on-orbit [1].

Problems related to psychotic conditions (e.g., schizophrenia, bipolar or manic-depressive disorder), which are thought to have genetic or familial determinants, or to suicidal and homicidal intent have not been reported during space missions. This probably reflects the success of the psychiatric screening that is done on people applying to be astronauts or selected for important space missions. However, such severe psychiatric disorders have been reported in astronaut applicants, as well as in up to 5% of people working in some space analog environments [1].

Post-return personality changes and psychiatric problems have affected returning space travelers. Some astronauts have experienced humanistic or even spiritual changes, coming home as more sensitive, people-oriented individuals as a result of seeing the Earth from space without national boundaries and

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