Risk of Performance Errors due to Poor Team Cohesion and Performance, Inadequate Selection/Team Composition, Inadequate Training, and Poor Psychosocial Adaptation

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Human performance errors may occur due to problems associated with working in the space environment and incidents of failure of crews to cooperate and work effectively with each other or with flight controllers have been observed. Interpersonal conflict, misunderstanding and impaired communication will impact performance and mission success. The history of spaceflight crews regarding team cohesion, training and performance has not been systematically documented. Tools, training and support methods should be provided to reduce the likelihood of this risk and improve crew performance. – *Human Research Program Requirements Document*, HRP-47052, Rev. C, dated Jan 2009.

Shared diversions on the International Space Station, including musical performances and movie nights, provide rest and relaxation while promoting team cohesion.

Executive Summary

Evidence from space flight and ground-based studies supports the idea that performance and health are both influenced by several interpersonal factors that are related to teamwork, including: team cohesion, team selection and composition, team training, and psychosocial adaptation. Space flight evidence regarding performance and the effect of these psychosocial factors is more limited than evidence that is available from ground-based research. However, numerous NASA-funded and -supported reviews and reports (regarding space flight and space analogs) emphasize the need to consider the team as well as the psychosocial factors affecting the team (Ball and Evans, 2001; Hackman, 1996; Helmreich, 1985; NASA, 1987; Paletz and Kaiser, 2007; Vinograd, 1974). To date, no systematic attempt has been undertaken to measure the performance effects of team cohesion, team composition, team training, or psychosocial adaptation during space flight. As a result, evidence does not help us to identify specifically what team composition, level of training, amount of cohesion, or quality of psychosocial adaptation is necessary to reduce the risk of performance errors in space. Ground-based evidence demonstrates, however, that decrements in individual and team performance are related to the psychosocial characteristics of teamwork, and there are reasons to believe that ground support personnel and crew members experience many of the same basic issues regarding teamwork and performance (Hackman, 1996; Lautman and Gallimore, 1987; Vinograd, 1974).

Although evidence does not identify specific factors or how these factors are important, evidence that was reviewed in this report demonstrates that addressing the psychosocial characteristics of teamwork will promote crew health and performance. Before this knowledge can be effectively applied to long-duration missions, however, more research must be done to determine what practices (e.g., selection, training, coaching, psychological support) best address the psychosocial characteristics of teamwork in space flight. The BHP Element has identified the gaps in the knowledge that is related to these issues, and a review of these gaps is included in this report.

Introduction

Evidence that links crew selection/composition, training, cohesion, or psychosocial adaptation to performance errors is uncertain. This is mainly due to the fact that the research on performance errors is itself ambiguous. The study of performance errors implies that human actions may be simplified into a dichotomy of "correct" or "incorrect" responses, where incorrect responses or errors are always undesirable. Some researchers have argued that this dichotomy is a harmful oversimplification, and that it would be more productive to focus on the variability of human performance and how organizations can manage that variability (Hollnagel et al., 2006) (Category III[13]).

Two particular problems occur when focusing on performance errors: (1) the errors are infrequent and, therefore, are difficult to observe and record; and (2) the errors do not directly correspond to failure. Research reveals that humans are fairly adept at correcting or compensating for performance errors before such errors result in

[13]To help characterize the kind of evidence that is provided in each of the risk reports in this book, the authors were encouraged to label the evidence that they provided according to the "NASA Categories of Evidence."

- Category I data are based on at least one randomized controlled trial.
- Category II data are based on at least one controlled study without randomization, including cohort, case-controlled or subject operating as own control.
- Category III data are non-experimental observations or comparative, correlation and case, or case-series studies.
- Category IV data are expert committee reports or opinions of respected authorities that are based on clinical experiences, bench research, or "first principles."

recognizable or recordable failures (Hollnagel et al., 2006) (Category III). Most failures are recorded only when multiple errors occur and humans are unable to recognize and correct or compensate for these errors in time to prevent a failure (Dismukes et al., 2007) (Category III).

More commonly, observers record variability in levels of performance. Some teams commit no observable errors but fail to achieve performance objectives or perform only adequately, while other teams commit some errors but still manage to perform spectacularly. Successful performance, therefore, cannot be viewed as simply the absence of errors or the avoidance of failure (JSC Joint Leadership Team, 2008). While failure is commonly attributed to making a fatal error, focusing solely on the elimination of error(s) does not significantly reduce the risk of failure. Failure may also occur when performance is simply insufficient or an effort is incapable of adjusting sufficiently to a contextual change. The surest way to reduce the risk of failure is to achieve optimal performance. If NASA is to spend the same amount of money launching one of two crews and both crews have an equal risk of committing performance errors but one crew is more likely to perform more of the mission objectives (or otherwise perform better), it follows that the most desirable crew remains the highest-performing crew. From this point of view, the more critical question is: how can we optimize human performance during long-duration missions?

Fortunately, the evidence that links crew selection/composition, training, cohesion, or psychosocial adaptation to performance differences is more conclusive and more relevant to future human space exploration operations than is the evidence regarding performance errors. The list of what is known from existing research (ground-based, space analog, and space flight) is considerable. In light of the positive influences of team performance, we know that

- We can select individuals who are more capable of performing well in a team (Barrick et al., 1998) (Category III).
- Different team compositions better facilitate different types of performance (Mannix and Neale, 2005) (Category III).
- Training individual team skills and training teams together encourages better individual and team performance (Hirschfeld et al., 2006; Paris et al., 2000; Salas et al. Bowers, 2000) (Category II and Category III).
- Teams that are more cohesive demonstrate better performance than less cohesive teams (Grice and Katz, 2005) (Category II).
- Better teamwork increases the likelihood of recovery and survival in the event of a malfunction or error (Baker et al., 2006; Shapiro et al., 2004) (Category III).
- Members of more cohesive teams demonstrate better individual performance and report more physical and psychological resilience under duress (Kidwell et al., 1997; Palinkas, 1991; Podsakoff et al., 1997; Vallacher et al., 1974) (Category II and Category III).
- Individuals and teams perform better and maintain high performance and good health longer when they adapt more quickly and effectively to the stressors that are inherent in a psychosocial environment (Burke et al., 2006; Gunderson, 1966a; Lugg, 1977; Riggio et al., 1993) (Category III).
- Psychosocial factors that influence teamwork and performance in traditional work environments appear in the space exploration work environment (Kanas et al., 2000) (Category III).

Negative influences of team performance have also been researched. From the perspective of these, we know that

- Negative consequences (e.g., incomplete objectives; lost time) that are related to interpersonal stressors such as isolation, confinement, danger, monotony, inappropriate workload, lack of control,

group composition-related tensions, personality conflicts, and leadership issues have been observed on previous long-duration missions (Kanas and Manzey, 2003) (Category III).

- Interpersonal stressors, which are cumulative over time, pose a greater threat to performance and team success as work duration increases (Cropanzano, 2003; Halbesleben and Bowler, 2007; Rasmussen and Jeppesen, 2006; Staal, 2004; You et al., 1998) (Category II and Category III).

Selection, training, cohesion, and psychosocial adaptation influence performance and, as such, are relevant factors to consider as we prepare for costly, long-duration missions in which the performance objectives will be demanding, endurance will be tested, and success will be critical. During the selection of crew members, throughout their training, and during their psychosocial adaptation to the mission environment, we will have several opportunities to encourage optimal performance and, in turn, minimize the risk of failure. Researchers, who are faced with the very real prospect of needing to promote successful human explorations of the moon and Mars within the next 15 to 20 years, should not spend limited time and resources in attempts to quantify risks of failure or performance errors due to inadequate selection, training, cohesion, or psychosocial adaptation. Instead, these researchers should focus on how they can most efficiently optimize and support performance through selection, training, team building, and psychosocial adaptation. Human performance professionals currently possess the knowledge to be able to make this kind of research productive and operationally relevant within the projected time until launch. The evidence that is detailed in the following sections supports this argument.

The NASA HRP BHP Element is responsible for managing three risks: (1) risk of performance errors due to sleep loss, circadian desynchronization, fatigue, and work overload; (2) risk of performance errors due to poor team cohesion and performance, inadequate selection/team composition, inadequate training, and poor psychosocial adaptation; and (3) risk of behavioral and psychiatric conditions. While each of these is addressed in a separate chapter in this report, they should not be construed to exist independent of one another; they instead should be evaluated in conjunction with one another. Moreover, as the BHP Risks overlap with the Risks in other HRP Elements, they must also be considered in conjunction with these Elements as well. Refer to figure 2-1 for an example of possible overlaps.

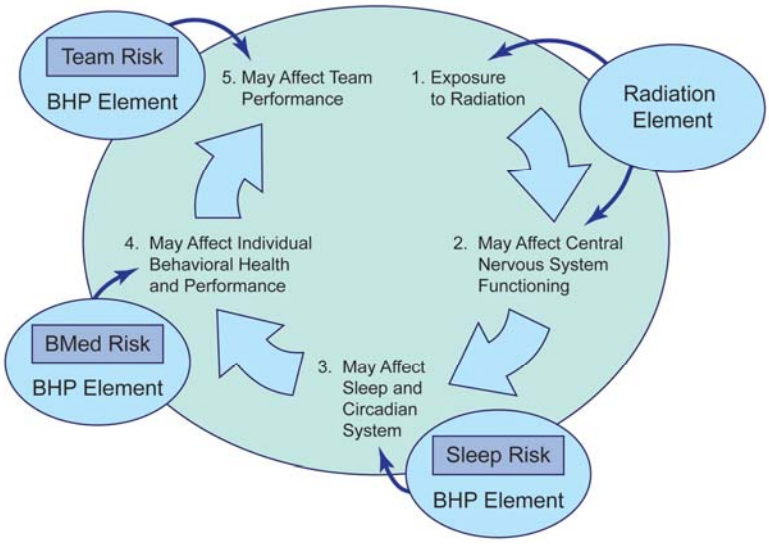

Figure 2-1. ***Example of possible BHP Risks overlapped with Risks in other HRP Elements.***

The BHP relationships with other Elements are further outlined in the HRP IRP (2008). The nature of the IRP implies that BHP is continually reviewing and updating integration points with other Elements. While research is designed to address identified gaps, it will be necessary to update and revise each of the BHP Evidence Reports that constitute this document and the IRP as the element gaps are closed and new gaps emerge.

Evidence

Individual selection and crew composition

Selecting Individuals to Perform in a Team

A team is defined as: "two or more individuals who interact socially and adaptively, have shared or common goals, and hold meaningful task interdependences; it is hierarchically structured and has a limited life span; in it expertise and roles are distributed; and it is embedded within an organization/environmental context that influences and is influenced by ongoing processes and performance outcomes" (Salas et al., 2007a, p. 189). From the NASA perspective, a team is commonly understood to be a collection of individuals that is assigned to support and achieve a particular mission. Thus, depending on context, this definition can encompass both the crew and the individuals who are assigned to support that crew during a mission. Regardless of the extent to which the term is used, the selection of a team can be both complex and difficult when considering individual differences that may influence the functioning of a team.

One way of selecting for teams is to identify those individuals who are best suited to work in teams, ensuring that each individual team member possesses the qualities and skills that lend themselves to optimal teamwork. For example, many organizations use competency frameworks to select individuals (e.g., IBM, GE, Verizon, Waste Management, Hanover, Shell, 3M, the United States Office of Personnel Management) (Rodriguez et al., 2002). Within these frameworks, a "team-working" competency may be found that measures how an individual supports other team members, shares knowledge with them, etc. Both space flight (Category III) and ground-based (Category I and Category II) evidence suggests that "teamwork" competencies help predict individual performance in teams.

Several efforts have been made, within space flight operations, to identify factors that are important for selecting individual crew members for long-duration space flight (Caldwell, 2005; Galarza and Holland, 1999; Hackman, 1996; Holland, 2000; NASA, 1987; Nicholas and Fouchee, 1990; Vinograd, 1974) (Category III and Category IV). Galarza and Holland (1999) conducted a preliminary job analysis to identify the skills that would be necessary for long- vs. short-duration missions to inform the initial astronaut candidate selection process (Category III).

Twenty experts (including astronauts) rated 47 relevant skills on criticality and rated an additional 42 environmental and work demands on their probability of occurrence. The environmental and work demands for long-duration space missions included group dynamics within a heterogeneous crew and with external groups such as ground control. The experts' ratings resulted in 10 broad factors that were deemed important for long-duration missions, including performance under stressful conditions, mental/emotional stability, judgment/decision-making, teamwork skills, conscientiousness, family issues, group living skills, motivation, communication skills, and leadership capabilities. These 10 factors overlap somewhat with those that were identified in previous peer-rating studies, which suggests both a job competence and an interpersonal dimension for astronaut performance (McFadden et al., 1994; Santy, 1994) (Category III).

In 1990, a European astronaut working group reevaluated selection criteria for the selection of European astronauts. Although astronauts had not been historically screened for interpersonal skills, this group included social capabilities as criteria for selection (Sandal, 1999) (Category III). Selection research within space flight is severely limited by a lack of job performance data that are available to researchers. This lack of performance data is due, in part, to the fact that such a limited number of astronauts is actually selected (around 340 U.S. astronauts over the life of the program), and that there is so much evolution in job duties and selection practices (from Project Mercury to the International Space Station Program). This issue is also related to the difficulty in identifying different levels of performance. Quantifying different levels of performance (i.e., optimal vs. adequate vs. inadequate) in relation to optimal selection methods or predictors is unrealistic with such small sample sizes. In such cases, it is unlikely that there are enough observable variances in performance to accurately quantify levels, and the levels thus quantified cannot be validated.

These issues are also relevant for other international space agencies, which also suffer from a lack of performance data and small sample sizes. For example, Russian researchers have long collected personality data on cosmonauts (Kanas and Manzey, 2008), but the empirical linking of personality factors to specific performance levels that are necessary to provide cut-scores or norms for selection still eludes these researchers, perhaps because of small samples or inadequate performance data. Typically, space agencies have not provided objective performance data on enough astronauts to create a reasonably sized sample on which to perform an analysis. This lack of data also obfuscates the ability to identify optimal selection criteria and methods for teams. Thus, we do not have a good idea of the specific individual skills and characteristics that would best predict successful astronaut teamwork. Future researchers who are evaluating crew selection for space flight will thus have to resort to more creative tactics when quantifying performance and validating predictors. For example, space agencies should, at a minimum, conduct studies that generalize and validate predictors among samples of teams whose work approximates some portion of the work that will be performed by astronauts.

In the meantime, 50 years of ground-based research on individual selection for work that is performed in teams, including small group research that is conducted in analog and/or extreme environments, informs astronaut selection for teamwork. Ground-based studies have identified many individual teamwork-related skills and characteristics. For new teams, picking individuals who are skilled at training and articulating their roles to others, compromising, and helping other team members take on their tasks as well as those who also understand effective team processes resulted in better-performing teams than when these individual skills were ignored at selection (Jones et al., 2000) (Category III). Individual values also make a difference, as teams that consist of members who value being on a team perform better than teams that consist of members who do not value being on a team (Bell, 2007; Salas et al., 2005) (Category II and Category III). Members who do not value being on the team are less likely to be motivated to learn team skills (Salas et al., 2005) (Category III). Evidence suggests that individual characteristics (in addition to individual skills and values) influence performance in a teamwork setting. Researchers who conducted a recent meta-analysis found that, in lab-based team studies, team performance was significantly positively related to average team general mental ability and average team task-relevant expertise (Bell, 2007) (Category I).

In the field studies that were considered, the Big Five personality factors (i.e., openness, conscientiousness, extroversion, agreeableness, and neuroticism) were also all significantly correlated with team performance (Bell, 2007). In a traditional work environment, Barrick et al. (1998) found that a team member who had a very low score on conscientiousness (as measured by the NEO PI-R[14]) impacted team performance by acting

[14]Refers to revised the NEO (neuroticism, extroversion, and openness to experience) personality inventory.

as the "weakest link," thus constraining team performance (Category II). In assembly and maintenance work teams, team averages on three personality factors (i.e., emotional stability, conscientiousness, and agreeableness) and general mental ability were positively correlated with supervisor ratings of team effectiveness. Team average general mental ability and two personality factors (i.e., extroversion, emotional stability) were also positively related to supervisor ratings of the ability of the team to maintain itself over time (Barrick et al., 1998). Another review suggests that in team environments, agreeableness and emotional stability are the personality characteristics that are most strongly associated with job performance (Stewart and Barrick, 2000) (Category III). A meta-analysis that was conducted across a range of occupations found that interpersonal facilitation was significantly predicted by three personality factors: conscientiousness, emotional stability, and agreeableness (Hurtz and Donovan, 2000) (Category II). All of these studies provide evidence that individual factors, such as personality and general mental ability, help predict the quality of performance in a teamwork setting. (Note that although the authors of this chapter reviewed the Russian personality literature, findings from these studies were not included in this report due to sample size issues and the fact that the conceptualization of variables (e.g., certain personality factors) were not similar, and were thus not comparable.)

Research on pilots offers further evidence that individual personality factors are relevant to selecting an individual who is capable of teamwork. In regards to interpersonal characteristics, a "right stuff" cluster that is based on the Personality Characteristics Inventory (PCI) is composed of high levels of expressivity (i.e., warmth, sensitivity), and low levels of negative instrumentality (i.e., arrogance/hostility) and verbal aggressiveness (i.e., complaining, nagging, passive-aggressive) (Chidester et al., 1991; Gregorich and Helmreich, 1990; Musson and Helmreich, 2005). A "wrong stuff" cluster, in regards to interpersonal characteristics, includes high levels of verbal aggressiveness and a low level of positive expressivity; whereas, a "no stuff" cluster includes low scores on expressiveness, instrumentality, mastery, etc. The "right stuff" cluster pilots were considered more effective by observers in a 1.5-day simulated trip with a crew than were the "low stuff" and "no stuff" pilots (Chidester et al., 1990). The results of U.S. Navy research in Antarctica suggest that while technical competence is necessary, it is also important to select individuals who exhibit "social compatibility or likeability, emotional control, patience, tolerance of others, self-confidence without egotism, the capacity to subordinate routinely one's own interests to work harmoniously as a member of a team, a sense of humor, and the ability to be easily entertained" as well as those who are practical and hard working (Stuster, 1996, p. 268) (Category III).

In summary, evidence suggests that individual factors should be considered when selecting astronauts for long-duration missions, but more research within the space flight context must be done to determine those factors that are most likely to support optimal performance and minimize errors that are related to astronaut teamwork (refer to Table 2-1 for a summary of presented evidence). More research must also be conducted in the analog context using arduous environments or simulation chambers that may resemble situations that are closer to those that are experienced by astronauts. By using both analog and space flight contexts to conduct this research, we may collect sufficient objective performance data so that the selection methods that are used may be examined within a team.

Table 2-1. ***Summary of Findings Presented for Selection***

Source	Predictor	Outcome	Context	Evidence Type
Sandal, 1999	Teamwork competencies	Improved individual performance in teams	Space flight	Category III
McFadden et al., 1994	Teamwork competencies	Improved individual performance in teams	Ground-based	Category III
Jones et al., 2000	Factors: Skilled at training and articulating their roles to others, at compromising, and at helping other team members as well as at understanding effective team processes	Higher team performance	Ground-based	Category III
Bell, 2007	Average team general mental ability	Higher team performance	Ground-based	Category I
Bell, 2007	Big Five personality factors	Higher team performance	Ground-based	Category I
Barrick et al., 1998	Team average general mental ability, and extroversion and emotional stability	Higher team effectiveness	Ground-based	Category II
Chidester et al., 1991	"Right stuff" personality cluster	Increased teamwork ability	Ground-based	Category II
Stuster, 1996	Personality characteristics (e.g., social compatibility, emotional control, patience, etc.)	Increased teamwork ability	Analog	Category III

Composing Teams to Perform

The selection process by which individuals are chosen for their good "teamwork" or interpersonal skills does not take into account several additional factors that meaningfully impact team performance. For example, many researchers suggest that the composition of a team has a major impact on how successful that team is likely to be. Kanas et al. (2001), who based their findings on the shuttle/*Mir* missions, contend that composing an interpersonally compatible crew is an important countermeasure for potential psychosocial problems. Although selecting a crew for interpersonal compatibleness is preferred, operational constraints have severely limited space flight research opportunities. Furthermore, there is no empirical evidence from either U.S. space flights or international space flights that indicates how best to compose crews that have both the right technical competencies and the right interpersonal mix to achieve optimal performance.

While literature on selecting individuals for team work abounds, there is little research literature on the composition of entire teams (Paletz, 2006). Most ground-based studies deal with teams that are already assembled and compare team-level features that are associated with high or low levels of team performance. For example, the teams that did not have any members who were particularly low in agreeableness or extroversion (personality factors) were found to be high-performing teams (Allen and West, 2005) (Category II). Likewise, high-performing teams had more moderate proportions of members who were more extroverted (Barry and Stewart, 1997) (Category II).

Although little empirical evidence exists that would inform the composition of teams, evidence suggests that team composition is a key differentiating factor between high- and low-success teams. One measure of team composition is the heterogeneity or diversity of team members. In one study, Harrison et al. (1998) studied two types of diversity in teams – surface-level (i.e., gender, age, ethnicity, tenure) and deep-level (attitudes, values, beliefs, cultural norms) diversity – and the effects of these two types of diversity on team cohesion. Their findings suggest that the effects of surface-level diversity weakens as group members spend more time together while the effects of deep-level diversity strengthens. Surface-level diversity includes heterogeneity in age, sex, race, and, to a lesser extent, how long the individual has been a part of an organization (i.e., tenure).

Heterogeneity, at a deep level, includes differences among members' attitudes, values, beliefs, and cultural norms. Information concerning deep-level factors is communicated through both verbal and nonverbal behavior patterns and is only learned through extended, individualized interaction (Harrison et al., 1998). Attitudinal similarity may facilitate communication as well as reduce role conflict as communication on the job increases and team members realize that they share similar conceptualizations of their organizations and jobs (Tsui et al., 1992). Although we do not know to what extent future Exploration missions will be based on international partnerships, it is important to remember that deep-level diversity is associated with differing cultural norms.

Several studies have reported that deep-level similarity is one of the most important predictors of team cohesion (Byrne, 1971; McGrath, 1984) and long-term performance (Edwards et al., 2006; Hirschfeld et al., 2006). In contrast, studies generally do not find support that surface-level diversity affects long-term performance; rather surface-level diversity affects short-term performance until team members have enough time to get to know each other, and the focus shifts away from surface-level differences. For example, Schmidt et al. (2004) found that perceptions of leadership effectiveness were significantly related to the general satisfaction of team members with their work, performance, and each other; but the authors of the study did not find any evidence that diversity in demographic composition variables (i.e., age, gender, tenure) was related to the satisfaction of team members (Category III). While some studies indicate that surface-level diversity affects performance and decision-making, these studies focus on short-term performance and decisions that require greater creativity (e.g. advertising decisions) (Bell, 2007; Harrison et al., 2003). The effects of surface-level diversity dissipate over time and are not likely to enhance the ability of a team to avoid "group think" or to continue creative problem solving; whereas the effects of deep-level diversity have little impact on short-term performance but become more salient the longer that a team exists (Harrison et al., 1998).

Research in identifying the right "mix" of team members indicates that different kinds of diversity have different consequences on team conflict and, in turn, on team performance (Pelled and Xin, 2000). An important distinction in team conflict literature is the distinction between interpersonal and task conflict (De Dreu and Weingart, 2003). Interpersonal conflict is generally found to be destructive of team performance, while task conflict, in moderate amounts, is generally found to promote task performance because team members may correct each other's misperceptions or argue out better alternatives (Pelled et al., 1999; Porter and Lilly, 1996). In a review of the literature, Mannix and Neale (2005) conclude that surface-level differences (e.g., demographics) negatively impact the short-term performance of teams as these teams initially experience more interpersonal conflict, but these differences have less impact on performance the longer that the teams are together. Deep-level diversity negatively impacts long-term performance only when teams are not provided with the training and incentives to manage interpersonal conflicts. When training and incentives for managing diversity are provided, deep-level diversity helps teams to maintain moderate amounts of the positive task conflict that supports team performance. Mannix and Neale (2005) suggest that giving teams ample time in which to train together and instructions on how to take advantage of multiple perspectives reduces the odds of interpersonal conflict stemming from either surface or deep-level diversity and increases the ability of teams to leverage the task conflict (Category III). Realistically, if future Exploration missions involve international partnerships, it may be difficult to schedule sufficient time for crew members to train together and learn to leverage their differing cultural norms. Future research should help to determine whether there are other viable means of training team members together (e.g., virtual training connections) that might also enable teams to take advantage of multiple perspectives and, at the same time, minimize interpersonal conflicts.

In summary, the relationship between deep-level diversity, conflict, leadership, and team performance is of more interest for long-duration missions than for surface-level diversity (refer to Table 2-2 for a summary of the evidence). However, the lack of extensive empirical research in these areas demonstrates the little that

is known about team composition and how the makeup of a crew may impact crew performance. Furthermore, the lack of empirical research conducted in a space flight or similar analog setting also brings into question the suitability of applying these findings of team composition to space flight. Thus, a further examination of crew composition, as it relates to optimal team performance, must be conducted (when in a space or similar analog setting) to help determine what deep-level diversity actually exists among crews, what deep-level characteristics impact astronaut performance, and what kinds of operational interventions (e.g., composition considering interpersonal compatibility, time spent training together, etc.) and leadership behaviors will promote optimal team performance.

Table 2-2. ***Summary of Findings Presented for Crew Composition***

Source	Predictor	Outcome	Context	Evidence Type
Allen and West, 2005	Lack of members low in agreeableness or extroversion	Higher-performing teams	Ground-based	Category II
Barry and Stewart, 1997	High proportion of members who were extroverted	Higher-performing teams	Ground-based	Category II
Harrison et al., 1998; McGrath, 1984	Deep-level similarity	Increased team cohesion	Ground-based	Category II
Edwards et al., 2006	Deep-level similarity	Higher long-term performance	Ground-based	Category II
Schmidt et al., 2004	Perceptions of leadership effectiveness	Improved general satisfaction of team with work, performance, and each other	Ground-based	Category III

Team skills training for the individual and the collective team

Long-duration space flights (i.e., flights that are in excess of 3 months), such as ISS missions, are so physically, mentally, and emotionally demanding that simply selecting individual crew members who have the "right stuff" is insufficient (Flynn, 2005). Training and supporting optimal performance, as well as selecting high performers, is a more effective and efficient approach than simply selecting high performers (Holland et al., 2007). Training involves imparting knowledge and/or teaching skills to a group of individuals. However, training team skills and supporting optimal performance entails more than educating astronauts about the technical aspects of the job. It also requires equipping those astronauts with the resources that are needed to maintain their psychological and physical health in an ICE environment over an extended period of time.

Performance levels are also a consideration in relation to training team skills. When considering optimal performance, any training design should be accompanied by an evaluation to determine the standards of optimal, adequate, or inadequate performance, and what skills help differentiate expert from novice teams. In this way, training can be validated by checking student progression and the performance of teams before and after training. It is therefore recommended that team performance standards and levels be documented in the space flight context before effective training is designed. To date, this type of information is unavailable to researchers, and acquiring such performance data requires a better partnership between research and operations.

Developing the right kind of training for team skills that will support astronaut performance is further complicated by other operational issues. To begin with, it is difficult to get an accurate picture of what knowledge and skills are required for successful performance. Not all tasks, or even types of tasks, can be anticipated. On an Exploration mission, new tasks may arise suddenly, so team training needs to be broad and flexible enough to support unexpected performance requirements. Another operational issue is that space exploration is a relatively new job, and not many

individuals have performed it, particularly for long-duration missions (only four individuals have lived and worked in space for 1 year). While all experienced astronauts are polled for this information on a regular basis, only a limited number of experienced astronauts can describe what kind of training they found useful on the job and what kind of training has not been critical to their performance. This situation makes describing successful performance reliably more difficult and evaluating the relationship between training and performance improvement more challenging, especially when considering the team context.

Astronauts are also required to live and work together. Performance expectations include maintaining a healthy psychological and social environment in addition to achieving technical objectives. Astronaut performance is largely team dependent. While some tasks are performed independently, many more tasks (e.g. robotics, extravehicular activities (EVAs)) require the simultaneous involvement of both crew members and ground support members. Subject matter experts within the various space agencies argue that teamwork skills are critical to accomplishing overall mission objectives safely. The Human Behavior and Performance (HBP) Training Working Group at NASA JSC recently articulated the training requirements that are necessary to promote ISS astronaut performance, and teamwork was one of eight primary categories of training requirements. The group recommended that ISS crew members complete at least one technical training event as a team (Human Behavior and Performance Training Working Group, 2007). Additionally, the NASA Mission Operations Directorate provides teamwork training as one of nine primary space flight resource management skills sets that are provided to flight controllers, directors, and crews during mission operations (Mission Operations Directorate, 2007).

As astronauts perform complex technical tasks that are at the forefront of modern science and human limitations, they currently complete a rigorous technical training curriculum that can span from 2 to 5 years. Adding requirements that allow them to practice or perfect skills is a critical concern for schedulers. If, as research suggests, teaching team members to exchange mental models and perceptions concerning performance can reduce the amount of time that is required to master a skill (Cannon-Bowers and Salas, 1998b; Edwards et al., 2006) (Category II), training team skills results in technical training efficiencies. Accordingly, a meta-analysis of 97 studies, involving 11 different types of interventions, that was conducted by Guzzo et al. (1985) found that training and goal-setting are the most effective organizational interventions that are aimed at increasing motivation and individual performance (Category II).

These findings support the idea that training is one of the best interventions for addressing the psychosocial characteristics of teamwork, and, as such, training offers NASA a great chance to promote crew health and optimal performance pre-flight, in-flight, and post-flight for long-duration missions. Evidence indicates that two facets of training are relevant to team performance: (1) individual training on teamwork and interpersonal skills, and (2) time training as a team.

Teamwork and Interpersonal Skills for the Individual

Space flight evidence regarding teamwork and interpersonal skills training is more limited than ground-based evidence. Prior to starting joint operations on the Russian space station *Mir*, NASA mission specialists provided a discussion and resource guide that defined effective teamwork and highlighted several individual strategies for ensuring team performance for the U.S. astronauts who were preparing for those long-duration operations (Galarza et al., 1999), thus implying that training teamwork skills was at least operationally relevant to long-duration missions.

Many training efforts in industry and in the military focus on developing the interpersonal skills of group members to enhance team performance. Arthur et al. (2003) classify studies in terms of three learning objectives: cognitive, interpersonal, and psychomotor skills. Four different training criteria were also identified:

reaction (self-report), learning (test performance, usually pencil and paper), behavior (on-the-job performance, supervisor ratings, or objective measures), and results (company-category productivity, profits, or return-on-investment). These researchers concluded that cognitive and interpersonal skills training have the largest positive effects on behavioral criteria. This indicates that interpersonal skills training specifically benefits job performance (Category II). Bradley et al. (2003) conclude that interpersonal skills training also contributes to good supervisor ratings of team performance in ongoing teams for both short- and long-duration tasks, and for short-term teams that are engaged in long-duration tasks (Category II). The interpersonal skills that contributed to performance include: role clarification, goal setting, identifying work priorities, group problem solving, team coordination, interpersonal relations and understanding, consensus building, and conflict management. Dependent measures that showed improvements included: cohesion, personal growth, motivation, team performance, work efficiency, and job satisfaction. It may therefore be suggested that interpersonal skills training relates positively to team performance.

Baker et al. (2006) investigated the impact of training teamwork skills on surgical team performance and errors; they found that the training significantly improved patient mortality rates and reduced the amount of surgical errors (Category II). Powell and Hill (2006) noted reductions in adverse patient outcomes, medical errors, nursing attrition, and conflicts after crew resource management (a form of teamwork and psychosocial skills training) was implemented in health care arenas (Category III). In a review of the factors that determine the ability of a team to adapt its performance to successfully handle changing conditions, Burke et al. (2006) found that training teamwork skills and cross-training team members resulted in the most adaptive teams (Category III).

In a laboratory simulation, researchers found that training that is designed to improve individual communication and interaction skills improves team performance under novel work conditions (Marks et al., 2000) (Category I). In a similar study that was done with 60 graduate students in assigned teams, Smith-Jentsch et al. (1996) found that training students how to be appropriately assertive and to speak up about team performance issues significantly improved the ability of a team to adjust its performance. Leedom and Simon (1995) found that providing United States Air Force (USAF) aviators with standardized, behavior-based training on teamwork increased team coordination and improved team task performance.

Other studies suggest that teams that are composed of team members who have more knowledge concerning teamwork perform better than teams that are composed of team members who have less knowledge concerning teamwork (Morgeson and DeRue, 2006; Hirschfeld et al., 2006). In a manufacturing organization, Morgeson and DeRue (2006) observed that individual knowledge concerning teamwork helped to predict team performance. In a field study of 92 teams (1,158 team members) in a USAF officer development program, Hirschfield et al. (2006) found that team member mastery of teamwork knowledge predicted better team task proficiency and higher observer ratings of effective teamwork.

Outside of the field and laboratory setting, however, we find little empirical evidence that relates interpersonal skills to the individual in a space flight or an analog setting. Nevertheless, the overall conclusion of the evidence that has been presented suggests that teamwork and interpersonal skills training promote team performance. Research must still help to determine the best kinds of interpersonal and teamwork skills training as well as the best implementation means for supporting optimal team (i.e., the whole mission team, including flight crew and ground control) performance prior to, during, and after long-duration missions. Furthermore, research must be conducted in analog and/or extreme environments and space flight contexts to examine interpersonal and teamwork skills training so that these findings may be extended to space flight.

Training Team Skills to the Collective Team

Space flight evidence regarding the effectiveness of team training in promoting team performance consists largely of professional opinion and anecdotal stories advocating the importance of team building for astronauts and ground support (Category III and Category IV). Nicholas (1989) argues that some problems that are encountered by crews can only be settled by training the crew as a whole in interpersonal, emotional-support, and group-interaction skills (Category IV). The authors of a 1998 National Academy of Science report on behavioral issues advise that crews and ground support personnel be trained together on interactive techniques prior to flight (National Research Council, 1998) (Category IV). Over the last 3 years, several space shuttle crews have specifically opted to complete ISS Expedition interpersonal training as a team to enhance their "cohesion and performance" (in personal communication, Shultz, 2007) (Category III).

Ground-based research supports the idea that employees who are interacting in stressful environments, with high workloads, or in environments that require coordination at a distance (similar to the manner in which ground support and flight crews operate together) need team training (Harrison et al., 2003; Ilgen et al., 2005) (Category III). In a study of 27 manufacturing teams (263 individuals) who had worked together for an average of 1.9 years, Austin (2003) found that team performance depended on how well individual team members could describe what knowledge resources the team possessed, and how those knowledge resources could be applied to new situations.

This finding supports the notion that giving team members an opportunity to learn about each other's task-related knowledge and skills supports team performance. Research indicates that more experience working together bolsters the performance of a team in a variety of ways, and that team training is one means of ensuring that team members gain some experience working together (Paris et al., 2000). For example, in a study of submarine attack crews, Espevik et al. (2006) found that knowledge concerning team members adds to the number of hits on target, over and above the contribution from operational skills (Category II).

In addition, Espevik et al. (2006) found that the more experience crews had working together, the less physiological arousal the crew experienced during attack simulations. In a study comparing 83 work dyads, Edwards et al. (2006) found that more time spent working and training with their team members made junior and minority team members more likely to contribute to the team, and that teams in which individuals contributed more information performed better than teams in which one individual provided larger portions of information (Category III).

More conflicts are generally associated with more stress, increases in errors, and decreases in productivity (Alper et al., 2000). In a review of 55 studies, Rasmussen and Jeppesen (2006) noted that every study found that the more time team members spent training together, the fewer conflicts and conflict-related performance deficiencies the team members experienced (Category III). This seems highly relevant when considering that current plans for astronaut teams include reducing the time that is spent training together. Reductions in team training will likely increase conflict and related performance decrements as the teams will be less able to create interpersonal ties and share mental models. Indeed, in a review of applied findings from the team performance training that took place in military settings, Cannon-Bowers and Salas (1998a) conclude that it is important for teams to practice complex or off-nominal situations together (Category III). Also, in a review of simulation-based training practices, Salas et al. (2007b) observe that more benefits can be accrued from team performance if teams are encouraged to practice complex and emergency simulations together than if team members are trained in simulations in random groups.

A meta-analysis of 37 work teams found that teams that have densely configured interpersonal ties are more committed to staying together and attain more performance goals (Balkundi and Harrison, 2006). The authors note that team training is one mechanism whereby team familiarity and the density of interpersonal ties can be increased; however, it is important to note that non-work-oriented team training may not be sufficient or worthwhile by itself. Studies with geographically distributed teams that compare task-based team training with more socially oriented time together indicate that team members who are familiar with one another socially, but have little to no experience working together as a team, do not realize the same performance benefits as teams that consists of members who are experienced in working together (Espinosa et al., 2007; Kirkman et al., 2006) (Category II).

In so far as team training requires that team members complete a task or objective as a team, it encourages better team performance (see Table 2-3 for a summary of the evidence that is cited). Interpersonal skills training that is intended to improve team member interactions and other teamwork skills training also encourages better individual and team performance. Although analog and space flight studies are not numerous, the other evidence, as reviewed above, indicates that training may be designed to promote flight crew and ground support team health and optimal performance. However, research is necessary to determine the most appropriate designs for preparing for, enduring, and recovering from long-duration missions. We thus suggest that team training is an essential component of achieving optimal performance, and recommend that steps be taken to examine team training, both at the individual and the group level, within the space flight context.

Cohesion

Festinger (1950) originally defined group cohesiveness as the strength of members' motivations to stay in the group and cited three primary characteristics: interpersonal attraction, task commitment, and group pride. As research accumulated, many attempts have since been made to operationalize and measure cohesion. Studies to determine the strength or willingness of individuals to stick together and act as a unit have most consistently assessed the level of conflict, degree of interpersonal tensions, facility and quality of communications, collective perceptions of team health and performance of the group, and the extent to which team members share perceptions or understandings concerning their operational contexts.

As researchers at the U.S. Army Research Institute (ARI) note in their recent review of cohesion as a construct, the definition of cohesion is ambiguous; therefore, the means of measuring cohesion is complex. The ARI authors conclude that "cohesion can best be conceptualized as a multidimensional construct consisting of numerous factors representing interpersonal and task dynamics" (note that this is the definition of cohesion that will be referred to in this report) (Grice and Katz, 2005). Despite the inexact, less-than-rigorous understanding of cohesion as a construct, the ARI researchers do note that anyone who has worked with or played on a team knows what a cohesive team looks like, and most believe that teams that are more cohesive usually perform better than less-cohesive teams.

Research also provides some understanding of what a cohesive team may look like. Members of cohesive teams sit closer together, focus more attention on one another, show signs of mutual affection, and display coordinated patterns of behavior. Members of cohesive teams who have established a close relationship are more likely to give due credit to their partners. In contrast, those who do not have a close relationship within a team are more likely to take credit for successes and blame others for failure (Thompson, 1967). It is also important to note that team cohesion is distinct from individual morale. Although an individual's low morale may influence team cohesion (and possibly vice versa), it is possible for a team to remain cohesive with low-morale members.

Table 2-3. ***Summary of Findings Presented for Team Skills Training***

Source	Predictor	Outcome	Context	Evidence Type
Guzzo et al., 1985	Training	Increasing motivation and individual performance	Ground-based	Category II
Guzzo et al., 1985	Goal-setting	Increasing motivation and individual performance	Ground-based	Category II
Arthur et al., 2003	Cognitive skills training	Improved job performance	Ground-based	Category II
Arthur et al., 2003	Interpersonal skills training	Improved job performance	Ground-based	Category II
Bradley et al., 2003	Interpersonal skills training (includes goal setting, group problem solving, team coordination, etc.)	Good supervisor ratings of team performance	Ground-based	Category II
Baker et al., 2006	Teamwork skills training	Improved surgical team performance and reduced errors	Ground-based	Category II
Powell and Hill, 2006	Teamwork and psychosocial skills training	Reductions in adverse patient outcomes, errors, etc.	Ground-based	Category III
Burke et al., 2006	Teamwork skills training	More adaptive teams	Ground-based	Category III
Marks et al., 2000	Communication and interaction skills training	Improved team performance	Lab study	Category I
Smith-Jentsch et al., 1996	Team skills training	Improved team performance	Lab study	Category I
Morgeson and DeRue, 2006	Knowledge about teamwork	Improved team performance	Ground-based	Category II
Espevik et al., 2006	Knowledge about team members	Improved team performance	Ground-based	Category II
Edwards et al., 2006	Time spent working and training as a team	Increased team contribution	Ground-based	Category III
Rasmussen and Jeppesen, 2006	Time spent training together as a team	Few conflicts and conflict-related performance deficiencies	Ground-based	Category III
Balkundi and Harrison, 2006	Teams with densely configured interpersonal ties	More committed to achieving performance goals	Ground-based	Category II
Espinosa et al., 2006	Teams with experience working together	Higher performance	Ground-based	Category II

Psychosocial experts within the space flight research community have articulated their concern that interpersonal conflicts and lack of cohesion will impede the abilities of crews to perform tasks accurately, efficiently, or in a coordinated manner during long-duration missions (Hackman, 1996; NASA, 1987; Vinograd, 1974) (Category IV). Indeed, although prescreening precludes individuals with personality or mood disorders from being selected, the likelihood that certain disorders may develop (i.e., poor psychosocial adaptation) due to poor cohesion and/or support is a concern that could ultimately decrease performance in space flight crews.

Space flight evidence regarding cohesion and performance is limited by a paucity of objective team performance data. However, case studies, interviews, and surveys that have been done within the space flight realm provide evidence that issues pertaining to cohesion exist and are perceived as threats to effective operations. For example, breakdowns in team coordination, resource and informational exchanges, and role conflicts (i.e., common

indicators of poor cohesion) were mentioned as contributors to both the *Challenger* and the *Columbia* space shuttle accidents (*Columbia* Accident Investigation Board Report, 2003; Launius, 2004) (Category IV). Likewise, interviews and surveys that were conducted with flight controllers reveal that mission teams are commonly concerned with team member coordination and communications, and that interpersonal conflicts and tensions exist (Caldwell, 2005; Parke et al., 2005) (Category III).

We must again turn to other sources of empirical evidence to inform us of this relationship because space flight research is lacking in this regard. The bulk of evidence (Category I, Category II, and Category III) that is surrounding cohesion and performance comes from non-space domains such as aviation, medicine, the military, and space analogs. Some reports have estimated that "crew error" in aviation contributes to 65% to 70% of all serious accidents (Lautman, 1987; Sumwalt and Watson, 2001) (Category III). Accident investigations and mishap reports note poor teamwork, communication, coordination, and tactical decision-making as significant causal factors in mishap samples (NTSB [National Transportation Safety Board], 1994) (Category III). Team breakdowns are repeatedly implicated in accidents (Merket and Bergondy, 2000; Nagel, 1988) (Category III). In medicine, research indicates that interpersonal conflicts, miscommunications, failures to communicate, and poor teamwork skills contribute significantly to the rate of medical errors (Baker et al., 2006; McKeon et al., 2006; Powell and Hill, 2006) (Category III).

Four meta-analyses (Category I) that were conducted across industries as well as types of performance teams (work, military, sport, educational, project, etc.) provide further ground-based evidence that cohesion is related to performance. The authors of the first of these meta-analyses (Evans and Dion, 1991) found a positive correlation between cohesion and individual performance, but their study did not include group performance criterion measures. Mullen and Copper (1994), in addressing these limitations in a subsequent meta-analysis, found that cohesion positively affects performance. They also found that this relationship was stronger in real (vs. ad hoc) teams, in small (vs. large) teams, and in field studies. Mullen and Copper (1994) noted that successful performance also promotes cohesion. Oliver et al. (2000) analyzed 40 years of military research, and noted positive relationships among cohesion and numerous performance outcomes, including individual and group performance, behavioral health, job satisfaction, readiness to perform, and absence of discipline problems. In the latest of the meta-analyses, Beal et al. (2003) re-analyzed the studies that were included in Mullen and Copper plus additional studies and found that, as the work required more collaboration, the cohesion-performance relationship became stronger and highly cohesive teams became more likely to perform better than less-cohesive teams. This conclusion coincides with Thompson's (1967) cumulated field study finding that cohesion facilitates team processes and team coordination among work teams in various industrial settings (Category III).

In a meta-analysis of 67 ground-based experimental studies, Gully et al. (2002) (Category I) note a significant positive relationship between performance and the generalized beliefs of team members concerning the capabilities of their team across different situations. While most of the research on team cohesion and performance deals with the positive aspects of team attitudes, several studies investigated level of conflict and negative attitudes concerning the team as indicators of cohesion. De Dreu and Weingart (2003) note an important distinction is between interpersonal conflict and task conflict; i.e., that defined, interpersonal conflicts are about relationship issues, whereas task conflicts are about how to handle tasks.

Interpersonal conflict is generally found to be destructive to cohesion and, in turn, team performance; whereas task conflict can improve task performance. Team members may correct each other's misperceptions, offer alternatives, and argue about how to solve a problem (Jehn and Mennix, 2001) (Category III). Interpersonal conflict is thus generally detrimental, as it appears to affect team cohesion. Some level of task-related conflict may be desirable, regardless of its affect on cohesion, because conflict can promote optimal performance. In

contrast, both aspects of cohesion (i.e., interpersonal and task-related) are generally found to influence performance positively. In a study that was conducted with Canadian military groups, path analysis showed that task-related cohesion was positively related to individual job satisfaction, interpersonal cohesion was negatively related to reports of psychological distress, and both types of cohesion were positively related to job performance (Ahronson and Cameron, 2007).

Research that was conducted within Antarctic space analogs also investigated conflict, cohesion, and performance. In one survey of Expeditionary crews conflict that was measured as inter-member hostility was related to the poor ratings of member effectiveness that were meted out by supervisors (Vallacher et al., 1974). In one Antarctic expedition, scientists reported that team members' perceptions of status contributed to conflicts and reduced perceptions of cohesion (Dutta Roy and Deb, 1999) (Category III). Wood et al. (2005) also collected data on human performance in Antarctica over a 10-year period, modeling individual and group effects on adaptation to life in this extreme environment using multilevel analyses (Category III). Positive team climate and cohesion helped to reduce interpersonal tensions, which, in turn, contributed to work satisfaction (Wood et al., 2005).

Cohesion studies that were conducted by the military and in the aviation industries have focused more on task cohesion and the role of shared mental models (SMMs). SMMs, which refer to implicit agreements in team member expectations concerning how things work and what behaviors will result in various conditions, are proposed to characterize cohesive work teams (Baker et al., 2006; Edwards et al., 2006; Hirschfeld et al., 2006). Studies that compare performance during simulated operations and training note that members of high-performing teams coordinate with one another frequently to establish, maintain, and adapt SMMs as the situation evolves (Edwards et al., 2006; Espevik et al., 2006; Wech, 2002) (Category II). Teams that have little to no training on developing or coordinating SMMs demonstrate more errors and are less productive as compared to teams that have received training on building SMMs (Edwards et al., 2006; Espevik et al., 2006; Hirschfeld et al., 2006) (Category II and Category III).

The authors of the studies that manipulate the stressors that flight simulation crews face have found that cohesive teams enhance their performance under stress by shifting from using more time-consuming, explicit coordination strategies to more streamlined, implicit coordination strategies to share mental models and information (Bowers et al., 2002; Driskell et al., 1999; Entin and Serfaty, 1999; Serfaty et al., 1998) (Category I and Category II). Effective teams share more task-critical information than less-effective teams, especially concerning the problem that is at hand, task goals, and team strategies (Bowers et al., 1998; Helmreich and Sexton, 2004; Orasanu and Fischer, 1992) (Category II and Category III). Moreover, members of effective teams tended to anticipate each other's needs and to volunteer information and assistance more frequently (Orasanu and Fischer, 1992; Serfaty et al., 1993) (Category III).

Leadership may also play a role in team cohesion. Although a vast amount of research exists concerning leadership characteristics and leadership and member interaction, as well as how leadership may relate to performance, many of the findings in this area of research are conflicting. Furthermore, many of the studies are conducted at the individual level, and the context in which much of this research has been conducted may not generalize to a space flight setting.

In general, leadership is defined as the ability to influence others toward achieving group goals (Avolio et al., 2003). Although studies have found evidence that supports a relationship between different types of leadership styles and individual performance and morale (Den Hartog et al., 2002; Howell and Avolio, 1993), research that examines leadership influence at the team level is more complex and findings are often mixed. However, the findings of one group of researchers who examined team leadership suggest that leaders who are within teams focus

on leadership in two primary domains: the task at hand (i.e., helping the team achieve a task-related goal), and the development of team members (the interpersonal aspect of team interaction) (Kozlowski et al., 1996). Their findings provide compelling evidence that leaders impact team cognition, motivation/affect, and team behavior within the team setting. This evidence makes the argument for the importance of team leadership research compelling. We therefore recommend further examination of team leadership in the context of a space flight or an analog setting to examine the effects of leadership behavior and team cohesion in relation to the effects on team performance.

In summary, space flight evidence indicates that cohesion is a relevant concern for long-duration missions (see Table 2-4 for a summary of the evidence presented). For example, the delays in communicating with ground team members that are inherent in long-duration flight are likely to impact two key factors of team cohesiveness: the quality of communication and the quality of leader support. However, we must turn to research outside of space flight to provide insight as to the connection between cohesion and performance.

Table 2-4. ***Summary of Findings Presented for Cohesion***

Source	Predictor	Outcome	Context	Evidence Type
Thompson, 2002	Cohesive team	Give due credit to members of team	Ground-based	Category II
Hackman, 1996	Lack of cohesion	Poor performance	Ground-based	Category IV
Merket and Bergondy, 2000	Lack of cohesion (team breakdowns)	Increased accident frequency	Ground-based	Category III
Baker et al., 2006	Lack of cohesion (interpersonal conflict, miscommunication, etc.)	Increased medical error	Ground-based	Category III
Mullen and Cooper, 1994	High cohesion (stronger for real teams)	Increased performance	Ground-based	Category I
Oliver et al., 2000	High cohesion	High individual and group performance, behavioral health, and job satisfaction	Ground-based	Category I
Thompson, 2002	High cohesion	Increased team coordination	Ground-based	Category III
Ahronson and Cameron, 2007	High interpersonal cohesion	Decreased psychological distress	Ground-based	Category II
Edwards et al., 2006	SMMs	Increased productivity	Ground-based	Category II and Category III
Bowers et al., 2002; Driskell et al., 1999	Implicit coordination strategies	More effective teams (more cohesive)	Ground-based	Category I and Category II

A large body of ground-based evidence shows that cohesion influences levels of performance, but this evidence is primarily correlational rather than causal. Cohesive teams are more productive than are less cohesive teams, and this situation could be because (1) more productive teams become more cohesive, or (2) more cohesive teams become more productive. Teams preserve their cohesion when they succeed rather than when they fail. Therefore, applied scientists advise that it is important to promote three essential conditions for team performance: ability (i.e., knowledge and skills), motivation, and coordination strategy. Team members need to have sufficient levels of interpersonal and technical skills to perform their jobs at the same time at which they are attaining team objectives. Team members must also be motivated to use their knowledge and skills to achieve shared goals. Team context, which consists of organizational context, team design, and team culture, must create conditions

to avoid problems such as social loafing, free riding, or diffusion of responsibility. These kinds of problems undermine team performance and can have detrimental effects on team cohesion (Thompson, 2002).

From the evidence, it cannot be said that a lack of team cohesion is statistically likely to result in numerous performance errors or an observable failure, but it does seem likely that ignoring the relationship between cohesion and performance will result in suboptimal performance (Grice and Katz, 2005). Although we know that many factors contribute to how cohesion is built and encouraged within a team and that cohesion is positively related to better performance, research cannot effectively determine, in a reasonable amount of time, what minimum level of cohesion is required to avoid catastrophic failure. Instead of investing research and time in such an endeavor, funding would be better used to test and identify effective means of building cohesion and promoting optimal performance in a long-duration mission context. This kind of research would generate enough immediate intellectual and operational benefits to justify the investment of funding.

Psychosocial adaptation

Long-duration space flight is a unique environment with unique conditions. On one hand, research suggests that it may offer salutogenic conditions, a termed that was coined by Antonovsky (1987) to convey the idea that, under certain conditions, stress could actually be beneficial and health promoting (Palinkas, 2003) (Category III). Indeed, space flight offers the thrill of doing what few people have done before and the challenges of discovery; these conditions foster the personal growth of individuals (Suedfeld and Steel, 2002) (Category III). Yet stressful conditions are also inherent to long-duration missions. Working in space involves danger, isolation, and confinement; therefore, space is understood to be an extreme work environment. Survival in space requires the provision of constant shelter or the wearing of protective gear, and it is also subject to equipment malfunctions. Crew members must adapt to a certain level of danger or threat to survive. They must also adapt to certain levels of isolation as contact with others (i.e., outside of the immediate crew) may be very limited and inconsistent at times, and isolation from family and friends may create social rifts and isolation that persist post-flight. Finally, space flight crew members must adapt to being confined to a limited living and working space. Ground-based research involving similar conditions (e.g., submarines, offshore oil rigs, polar stations) has found that such conditions are generally detrimental to psychological health and social well-being over prolonged periods (Braun and Sells, 1962; Britt and Bliese, 2003; Krueger, 2001; NASA, 1987). The exact mechanics are not well understood, but ground-based evidence suggests that social isolation is detrimental to individual health. Epidemiologists have noted higher mortality rates among socially isolated patients (House, 2001) (Category III), and physicians have described more issues with depression and somatic illnesses in conjunction with longer periods of relative social isolation among Antarctic expeditioners (Lugg, 1977; Lugg, 2005) (Category III).

Finally, long-duration missions may require crews and ground operations to operate more or less autonomously over the course of a mission as the degree of crew isolation oscillates in accordance with the distance that the spacecraft travels from the Earth. Crews are likely to have some periods of great control as well as some periods of very little control over what tasks are done, how the tasks are done, and when they are done. Ground operations are likely to necessitate total control at certain points in the mission, and have no opportunity to exercise any control during other parts of the mission. Shifts in operational autonomy are expected to impact psychosocial adaptation to space flight demands (Kanas and Manzey, 2008).

Researchers often conceptualize autonomy in relation to the job controls and demands that are found within a work environment (Theorell and Karasek, 1996). Ground-based evidence suggests that when job demands or personal risks are high and individual perceptions of control are low, health and performance suffer (MacDonald et al., 2001) (Category II). Furthermore, ground-based evidence suggests that under high-demand and low-control conditions, clarity in team member roles reduces the likelihood of individual strain and helps to ensure team co-

ordination and performance (Bliese and Castro, 2000; Schaubroeck and Fink, 1998). Other contextual factors also play an influential role. Specifically, ground-based research has demonstrated that high social support and strong communication among team members may decrease the impact of individual strain, thereby once again buffering any negative effects on team effectiveness and performance (Guzzo and Dickson, 1996; Theorell and Karasek, 1996).

Given all of the conditions and factors just described, the definitive point for research is that psychosocial adaptation is a multilevel construct that includes team and individual adaptation to the psychological and social demands that are inherent in an extreme environment and in teamwork. It is therefore important to understand how these factors (i.e., isolation, physical space, individual and group autonomy, etc.) influence psychosocial adaptation among crew members, as these factors ultimately will impact crew performance (Langfred, 2000).

Suedfeld and Steele (2000) conclude that the objective characteristics of an extreme environment are less important than are the subjective perceptions of the environment in regards to performance. In general, individuals who believe that they are well adjusted perceive fewer physical pains and less mental anguish, and, in turn, learn more and are more productive than individuals who believe that they are not well adjusted (Joshi et al., 1998; LePine et al., 2004; Mocellin, 1995; Staal, 2004; Williams et al., 1996) (Category III). Likewise, individuals who have formed interpersonal networks at work have more access to critical information and resources, and, in turn, are able to accomplish more than less socially adapted individuals who have smaller interpersonal networks (Balkundi and Harrison, 2006; Burke et al., 2006; Johnson et al., 2003; Schaninger, 2002). The process of psychological and social adjustment to environmental conditions and demands is known as psychosocial adaptation. It is important to note, however, that the relationships among psychosocial adaptation, health, learning, productivity, and performance are somewhat reciprocal at both the individual and the team levels (e.g., good health improves psychosocial adaptation and learning, satisfaction with learning and team performance improves psychosocial adaptation, etc.) (Burke et al., 2006; Buunk et al., 1993; House et al., 2003; Israel et al., 1989; Kramer, 1993; Vogt et al., 2008) (Category II and Category III).

The successful completion of technical objectives is not enough to consider an overall long-duration mission successful. The crew must also return home safely with psychological health intact; we are thus concerned with helping individuals and teams adapt quickly and effectively to long-duration space flight. Observations indicate that (1) individual factors help predict who is more likely to adapt effectively to the psychosocial requirements of long-duration missions (Gunderson and Nelson, 1963a; Kanas and Manzey, 2003; Lugg, 1977) (Category III), and (2) contextual factors help to predict how well individuals and teams may be able to adapt and recover under various conditions (Boyd, 2001; Lugg, 1977; Palinkas, 2003; Palinkas, 1991) (Category III). Focusing on these individual and contextual factors will help to identify ways in which to support pre-, in-, and post-flight performance and ensure mission success.

Predicting Individual Ability to Adapt

A significant challenge of collecting data in flight is that the data are collected from a small or limited number of subjects, and many measures of psychosocial adaptation require a comparatively large amount of a subject's time (e.g., extensive questionnaires on a repeated basis, repeated collection and storage of physiological stress data, etc.). The bulk of evidence that is available regarding adaptation to long-duration missions thus comes from space analogs, mainly from Antarctic expeditions. Findings from these Antarctic studies note that adapting is an individual process. Not all individuals successfully adapt to the psychosocial conditions of an isolated, a confined, and an extreme environment such as that in Antarctica; for these individuals, performance and health usually suffer. In an early correlational study comparing expeditionary groups, Gunderson and Nelson (1963b) found that a group rated as less effective also reported being more

bored, less compatible, less motivated, and less socially balanced than did a higher-performing group (Category III). To the extent that these perceptions can be viewed as indicators of adaptation, a better-adapted group appears to be a more effective group.

Regarding individual performance, Palinkas (1987) found no significant differences between group members who wintered-over and members of a control group in terms of long-term performance (Category II). Although wintering over (vs. completing a long-duration expedition without winter) does not appear to have a lasting effect on performance, poor individual adaptation to work requirements in Antarctica was associated with an exaggeration of perceived injustices (Lugg, 1974) (Category III), and a failure to perform well appears to affect continued adaptation. As one low performer became a social isolate as the result of his poor performance (Lugg, 1974), this suggests that the adaptation-performance relationship is reciprocal for at least some individuals (Category III).

Crocq et al. (1974) found that age was not correlated with adaptation among Antarctic expeditioners; however, some anecdotal evidence suggests that the youngest personnel sometimes have more difficulty adapting than the older personnel. Previous medical history and cognitive ability also predict adaptation among Antarctic expeditioners (Lugg, 1974). Crocq et al. (1974) also found that high cognitive ability has a positive relationship with adjustment. Low cognitive ability, however, does not necessarily indicate a correspondingly poor ability to adapt. The various personality characteristics of individual Antarctic station members and attitudes that they hold were found to predict adaptation. Individuals who were low in extroversion and assertiveness adapt better to life in Antarctica (Rosnet et al., 2000). As noted previously, however, ground-based evidence indicates that teams with more moderately extroverted members generally perform better (Allen and West, 2005; Barry and Stewart, 1997). Research must still determine how to balance individual extroversion at levels that are encouraging to both psychosocial adaptation and team performance. In fact, many characteristics influence adaptation, and several are likely to call for balancing within teams that are performing in extreme environments. As Gunderson (1966b) noted: "achievement needs, needs for activity, needs for social relationships and affection, aesthetic needs, needs for dominance or leadership, a sense of usefulness in one's job, and control of aggressive impulses to be particularly important for adjustment in small Antarctic groups (those groups with less than 5 persons)" (p. 4).

Generalizing the results that were found in Antarctica to those from space flight require caution. Firstly, any generalizations of Antarctic findings to space require the differences between the two environments to be taken into account. Group size, for example, is larger in Antarctica than it is on space flights. Given that group size has been seen to affect aspects of life in Antarctica, the degree to which Antarctic findings involving groups can be generalized to space might be limited. Secondly, any conclusions that are made regarding factors affecting performance in Antarctica are based on relatively few articles.

Ground-studies that were conducted in traditional work environments regarding psychosocial adaptation and performance offer a broader base of evidence and some insight into the general principles of psychosocial adaptation to work; however, the utility of these findings are limited by the critical fact that most employees, unlike long-duration mission participants, do not live exactly where they work. Ground-based studies support the conclusion that some individual factors predict an individual's ability to adapt. Gender may even play a role; the Vogt et al. (2008) study of stress reactions and hardiness among U.S. Marine recruits reveals that social support significantly bolsters the hardiness of women recruits after stress, but not that of male recruits. Caldwell et al. (2005) found that a small group of pilots and a control group of non-pilots who exhibited more cortical activity were less vulnerable to cognitive performance decrements and emotional distress related to 36-hour sleep decrements. Additionally, LePine et al. (2004) found that selecting adult learners who had a

positive attitude toward a complex training program reduced resulting reports of fatigue and exhaustion (Category II). Independent of any particular stressor or stressful environments, Greenberg et al. (1992) observed that individuals who have more self-esteem generally experience less anxiety under the same or similar conditions as individuals who have less self-esteem (Category II).

The existing evidence provides a starting point, but more focused research is needed to address the gaps in our knowledge. Achieving a better understanding of the individual factors influencing an individual's ability to adapt to long-duration space missions would generate at least two operational benefits: (1) individual factors that predict adaptability could be used to aid selection or assignment decisions, and (2) these individual factors could be used to customize psychosocial support and resources to fit individual and team needs pre-flight, in-flight, and post-flight for long-duration missions.

Contextual Factors Influencing Adaptation

Factors outside of the individual (e.g., duration of stressful conditions, coping resources available) can also help to predict individual adaptation. For example, a slow voyage to Antarctica and living and working in a larger station once in Antarctica predicts adjustment (Lugg, 1974) (Category III). Composition of the group and job skills of group members also predict adapting to the new environment (Lugg, 1974). Contextual factors influence adaptation by contributing to an individual's stress perceptions.

Stress is the disruption of homeostasis through physical or psychological stimuli that are known as stresssors. According to the *Merriam-Webster Dictionary*® (2007), stress is defined as "a physical, chemical, or emotional factor that causes bodily or mental tension and may be a factor in disease causation." Some stress is unavoidable, such as the stress of competition during a game, and some stress is good, as the inverted-U of the performance-anxiety relationship demonstrates (Abramis, 1994). However, some stressors are so acute that even small amounts cause serious performance decrements (Abramis, 1994) (Category II), and chronic (long-term) stress or many acute stressors lead to strain or burnout (Barnett et al., 2007; Freedy and Hobfoll, 1994; Hobfoll et al., 2001; van Gelderen et al., 2007) (Category II and Category III). Adler and Dolan (2006), for example, found that longer peacekeeping mission deployments for 3,339 military personnel were associated with increased reports of depression and post-traumatic stress syndrome (Category III). This indicates that there may be a limit to how long an individual can adapt to a particular environment or related stressors. From a space flight perspective, the Russian space station *Mir* operations indicate that astronauts and cosmonauts are capable of adapting to 6 months in orbit, but reports also indicate that many *Mir* participants who took part in longer-duration flights (in excess of 6 months) developed symptoms of fatigue, irritability, and minor disorders of attention and memory (Boyd, 2001; Kanas et al., 2001) (Category III).

There are individual differences in perceptions of and adaptations to particular stressors, and many different potential stressors are inherent in a long-duration mission. Two typical stressors (isolation and confinement) have already been discussed. More research is needed, however, particularly research involving ISS astronauts, to determine what stressors are most salient to crews and ground support during long-duration missions and how these stressors persistently affect team members post-flight. Research is also needed to determine what coping mechanisms and contextual factors best support psychosocial adaptation within the operational constraints of long-duration missions and when (i.e., pre-flight, in-flight, post-flight) they are likely to be most effective.

It is known, from extensive ground-based evidence, that social support improves adaptation to, resilience to, and recovery from various stressors in traditional and military work environments; and that the more social support provided before, during, and after work from more sources (e.g., family, friends, supervisors),

the better individuals cope in general (Anderson, 2003; Riggio et al., 1993; Seers et al., 1983) (Category II). Social support has traditionally been operationalized as any assistance that individuals receive from others through interpersonal interactions, including information, emotional care, or instrumental resources (Buunk et al., 1993b; Riggio et al. 1993). Individuals who receive less social support are more likely to commit suicide, have accidents, incur injuries, or develop illnesses over their life span than individuals who have more social support available to them (Buunk et al., 1993a; House et al., 2003; Israel et al., 1989; LaRocco et al., 1980; Nowack, 1991) (Category II and Category III). Ground-based research also indicates that social support plays a positive role in team functioning and performance, individual achievement, and employee safety (Bhanthumnavin, 2003; Buunk et al., 1993a; Buunk et al., 1993b; Heaney et al., 1995; Hearns and Deeny, 2007; Nowack, 1991; Schaubroeck and Fink, 1998; Seers et al., 1983; Settoon and Mossholder, 2002) (Category II, Category III, and Category IV). There is thus ample reason to consider social support as an important contextual factor promoting psychosocial adaptation for long-duration missions. Communication lags on longer-duration missions may stress the social support system more than previous experiences in space would lead us to expect. Flight operations would benefit from pre-identifying practical ways in which to provide and sustain social support systems in a long-duration mission context.

Based on the literature, long-duration missions in extreme environments (Antarctica or space) require mission participants to adapt or cope with several inherent emotional stressors (e.g., isolation from family and friends, limited communication opportunities, limited stimulation, shifting work demands and control, etc.) (Kanas and Manzey, 2003; Mocellin and Suedfeld, 1991; Natani and Shurley, 1947; Nelson, 1962; Palinkas, 1991; Vinograd, 1974) (Category III and Category IV). The evidence indicates that (1) optimal performance depends on coping with these stressors, (2) there is considerable individual variance in how, and how well, people cope, and (3) many contextual factors influence how well individuals and teams are able to cope and adapt (see Table 2-5 for a summary of these findings). On the other hand, there is not much evidence on how contextual factors influence an individual's ability to recover from work in similar environments. The critical point for long-duration space flight is to determine the viability and utility of these factors for supporting the psychosocial adaptation to training, flight, and recovery of a crew – by doing so, research will identify ways in which to reduce the negative health impacts that are related to perceived stress and help to optimize performance on long-duration missions.

Risk in Context of Exploration Mission Operational Scenarios

Given that we know selection/composition, training, cohesion, and psychosocial adaptation influence performance, many operationally relevant questions remain for research to address. These include: What mix of crew members is likely to perform best? What kind of team skills training and team training will be most useful for teams that are living and working together on a long-duration mission? What kinds of resources and support will facilitate psychosocial adaptation to a long-duration environment when outside intervention and facilitation is severely limited by communication lags?

Table 2-5. ***Summary of Findings Presented for Psychosocial Adaptation***

Source	Predictor	Outcome	Context	Evidence Type
Braun and Sells, 1962; NASA, 1987	Confinement and isolation	Decreased psychological health and social well-being	Ground-based	Category III
House, 2001	Social isolation	Increased mortality rates	Ground-based	Category III
MacDonald et al., 2001	High job demands and low personal control	Decreased performance	Ground-based	Category II
Joshi et al., 1988; LePine et al., 2004	Adjustment	Performance	Ground-based	Category III
Crocq et al., 1974	High cognitive ability	Lower adjustment	Ground-based	Category III
Rosnet et al., 2000	Low in extro-version and assertiveness	Higher adjustment/ adaptability	Ground-based	Category III
LePine et al., 2004	Positive affect	Increased ability to adapt (less fatigue)	Ground-based	Category II
Greenberg et al., 1992	Self-esteem	Less anxiety	Ground-based	Category II
Lugg, 1974	Voyage duration	Ability to adapt	Ground-based	Category III
Lugg, 1974	Composition of group and job skills of group	Ability to adapt	Ground-based	Category III
Barnet et al., 2007; Hobfoll et al., 2007	Stress	Decreased performance	Ground-based	Category II and Category III
Anderson, 2004; Riggio et al., 1993	Social support	Reduces stress	Ground-based	Category II
Bhanthumnavin, 2003; Buunk et al., 1993; Heaney et al., 1995	Social Support	Team functioning, team performance, individual achievement, and employee safety	Ground-based	Category II, Category III, and Category IV

As previously detailed in this chapter, ground-based evidence demonstrates that long-duration team composition would be hampered by poor selection, ineffective team composition, inadequate training, and poor psychosocial adaptation. A possible qualitative likelihood scale for performance errors during certain mission operational scenarios is as follows:

- Level 1 – will most likely not occur
- Level 2 – could occur
- Level 3 – will most likely occur

Using this scale, the likelihood of performance errors for each type of mission is displayed in Table 2-6 below.

Table 2-6. ***Risk of Context of Exploration Mission Operational Scenarios***

Levels of Risk	ISS Six-Person	Lunar Sortie	Lunar Long	Mars
Level 1				
Level 2	X	X		
Level 3			X	X

While crew members often engage in Expeditionary training activities (e.g., National Outdoor Leadership School [NOLS]) to promote team cohesion, there is no scientific evidence regarding what type and method of training offers the best means of promoting team performance for long-duration missions. As the number of crew members that are involved in long-duration missions increases (from three ISS crew members to potentially seven Mars mission crew members), the complexity of crew communications and the likelihood of inter-crew conflict increases exponentially. Anecdotal reports indicate that extensive training requirements and scheduling limitations make it difficult to set aside adequate time for crew members to train as a team. Increasing crew size and new operating systems (associated with the Constellation project) no doubt will create additional difficulties in training crew members as a team.

Poor cohesion, poor composition, inadequate training, and difficulties adapting will have more pronounced consequences during long-term lunar and Mars missions, where there will be fewer resources for mitigating the effect of these factors on performance. Prolonged or pronounced exposure to stressors, such as interpersonal conflict, may produce strain among crew members; and strain is associated with negative physiological and mental health consequences. These health risks may become compounded by the fact that lunar and Mars missions introduce additional restrictions and stressors compared to the mission experiences of astronauts to date.

Currently, the Spaceflight Human System Standards (Standard 5.2.3) states that training shall be provided on the psychosocial phenomena that will be experienced by crews and that additional training regarding crew integration and team dynamics may be included. The current standards are also found in the *Human Integration Design Handbook* (*HIDH*). However, these standards do not define such training or ensure that it will be available to crews prior to taking part in long-duration missions. Given the noted relationship between team composition, team training, cohesion, psychosocial adaptation, and performance, future space flight endeavors would benefit from specifying a “Fitness for Duty Standard” as well as “best practices” of psychosocial training and support for all crews prior to, during, and after flight.

Conclusion

BHP research provides the knowledge, tools, and technologies that support crew health to prevent or mitigate the risk of human performance errors due to poor cohesion and performance, selection/team composition, training, and psychosocial adaptation (Team Risk). These efforts are operationally driven, consistent with human health and performance standards as outlined in the *HIDH*, and aligned with major Constellation milestones. From this, BHP made a prioritized list of gaps and related activities and deliverables. Priorities were determined by considering the operational relevance of each deliverable as well as its role in risk reduction and the advancement of countermeasure development in light of crew needs during Exploration missions.

Veteran astronauts and ground control personnel have expressed the need for training requirements that will improve crew cohesion to reduce the likelihood of performance errors that are caused by inconsistent and suboptimal team dynamics. Some missions may have been jeopardized and, possibly, terminated as a result of interpersonal frictions in the past; therefore, the first priority of BHP insofar as team risk is concerned involves reducing the risk of team conflict and developing appropriate countermeasures. To this end, BHP is collaborating with the JSC Astronaut Office and flight surgeons to systematically collect information directly from the long-duration crew members. BHP is also evaluating conflict management and communication tools for use by crews during space flight, and will provide recommendations that are based on the outcome from these research tasks. BHP is also collaborating with the HBP International Working Group on an HBP competency model that will ensure adequate team training of astronauts by NASA and international space agencies. These efforts will address specific gaps including the following: What are the most likely and serious threats to team cohesion, performance, and crew-ground interaction? What are the most optimal ways in which to compose crews? What are the most optimal ways in which to train crews?

Long-duration missions to remote environments will increase astronaut exposure to extreme isolation and confinement, resulting in higher stress levels and an increased risk of crew morale deterioration. As the methods that are used to deal with crew stress could be critical to the success of the mission, the second priority of BHP insofar as Team Risk is concerned involves providing unobtrusive monitoring technologies for deteriorated crew cohesion, a situation that will ultimately decrease crew performance. The BHP gaps that address this issue are: What additional approaches and countermeasures exist to counter these threats? How can we monitor and measure these threats?

Evidence supports the important role of environmental context in influencing team performance. Research demonstrates that specific factors can influence both team cohesion and team performance; it is therefore important to examine and implement practices that will ensure optimal performance while considering these issues. Therefore, the third priority of BHP insofar as Team Risk is concerned addresses the examination of autonomy and communication. The BHP gaps that cover these issues are: How does increased autonomy impact crew cohesion, crew performance, and crew-ground interaction? What aspects of communication impact crew cohesion, crew performance, and crew-ground interaction?

In summation, the selection of crew members, team training and building, and the psychosocial adaptation of the crew to the mission environment present several opportunities to encourage optimal performance; but more research must be done, in the appropriate contexts, to inform mission designers of how to take advantage of these opportunities.

The BHP Element has identified gaps in knowledge and mitigation strategies that are related to these issues. To close these gaps, the BHP Element needs to pursue more rigorous, longitudinal research designs and a multi-method research program. Space flight history and data are required to identify the performance objectives that are most likely to be influenced by psychosocial team factors, to assess which factors are most salient on the job, to develop relevant measures of cohesion and psychosocial adaptation, and to determine the baselines of individual and team performance. Laboratory-based and space analog studies are needed to pilot countermeasures and monitoring technologies, and to help identify the safest and most efficient means of manipulating factors to optimize performance.

Finally, high-fidelity space analogs or current space flight studies are needed to test the utility of the tools and countermeasures that will be designed to promote optimal performance and support the psychosocial health of astronauts who are on long-duration missions. The funding and support of this research is justified by the poten-

tial benefits of knowing how to promote optimal performance. In essence, the surest way to reduce the risk of failure when we are unable to isolate and eliminate potential error sources is to achieve optimal performance.

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Glossary

Term	Definition
Cohesion	The strength or willingness of individuals to stick together and act as a unit.
Composition	The arrangement or mix of individuals into a group, team, or crew.
Crew	A group of astronauts who are assigned to a mission.
Diffusion of Responsibility	Phenomenon in which, because of the size of a group, individual responsibility is not assigned explicitly. For example, because of the size of the group, individuals allow something to occur that they would not allow if they were alone.
Cut-score	Cut-scores are selected points on the score scale of a test. The points are used to determine whether a particular test score is sufficient for a specific purpose.
Free Riding	Phenomenon in which an individual who is a part of a group allows others in the group to share his or her responsibilities rather than assume those responsibilities as his or her own.
Group	A collection of individuals into one place at one period in time.
Interpersonal Interaction	A communication exchange (verbal and nonverbal) between two or more individuals.
Performance	The execution of an action.
Performance Error	An act that deviates from an established code or a standard of performance.
Performance Standard	Specific requirements concerning how an action should be executed.
Personality	A person's unique set of behavioral or cognitive patterns (usually described using "Big Five" broad factors: openness, conscientiousness, extroversion, agreeableness, and neuroticism).
Psychosocial Adaptation	An individual's social, mental, and emotional adjustment to the stressors that are inherent in a particular environment or state of existence; quality of life as determined by an individual's subjective perception of his/ her situation.
Selection	The choice of one individual for a particular purpose or role.
Shared Mental Model [SMM]	Shared beliefs among team members concerning how things work and what actions will result in various conditions; An organized set of expectations for performance and common understanding of the resources that are available among team members.
Social Loafing	Phenomenon in which individuals make less effort to achieve a goal when they work in a group than when they work alone.
Strain	A state of injury that is induced by prolonged or pronounced exposure to tension or stress.
Stress	Tension resulting from factors that alter a current or expected state of equilibrium.
Stressor	A stimulus that causes stress.
Team	A collection of individuals who are working cooperatively toward a common goal or common set of goals; the collection of individuals who are assigned to support and achieve a particular mission.

Term	Definition
Team Skills Training	Educating or teaching an individual concerning the skills and knowledge that are associated with effective team performance.
Team Training	Educating or teaching skills to a team as a whole, rather than educating individual team members separately.
Training	The act of educating or teaching skills or knowledge; The skills, knowledge, or experience that is obtained through instruction or education.