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The Role of Meaningful Work in Astronaut Health and Performance during Long-Duration Space Exploration Missions

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Executive Summary

This report constitutes the third deliverable for NASA Contract Number NNJ15HK13P titled "Meaningful Work." This report is presented in four different sections. The first section reviews academic research on meaning in life and meaningful work, as well as research on boredom and monotony. The second section reviews prior research on the role of meaningful work and boredom/monotony in the adjustment and performance of astronauts and personnel in analog environments. The third section presents the results of an operational assessment of interviews with nine subject matter experts (SMEs; astronauts, explorers, astronaut trainers, mission planner, flight director) on the role of meaningful work in the adjustment and performance of individuals in isolated, confined, and extreme (ICE) environments. The final section includes recommendations for interventions designed to enhance the perception of meaningful work on long-duration space exploration mission (LDSEM), and directions for future research on meaningful work as a stress mitigation strategy for astronauts on LDSEM.

The key conclusions from the report regarding the role of meaningful work for astronauts on LDSEM are described below according to whether they are based on the literature reviews or the operational assessment of SMEs. Recommendations for future research are then briefly highlighted.

Conclusions from the Literature Reviews

- Theories of meaning in life highlight that all individuals have the need to find purpose in their life, a set of values for judging right and wrong, the need to demonstrate competence in life domains, and the need for positive self-worth. Most of these needs can be fulfilled at work, depending on how work is structured, and organizational practices. Mission planners and key personnel in mission control can help structure work tasks to help astronauts fulfill these needs on LDSEM.

- Work is more likely to be perceived as meaningful when employees utilize a variety of skills, complete an entire project rather than one component of a project, and have freedom or control over how they complete their work. Prior authors have emphasized the importance of astronauts on LDSEM having some autonomy over their work schedule and having the ability to participate in personally meaningful scientific projects.

- Employees differ in their work orientations, or what makes work worth doing (Pratt et al., 2013). Employees can work to earn a paycheck (job orientation), to demonstrate achievement and success (career orientation), or because of factors intrinsic to the job (calling orientation). The calling orientation is further broken down into experiencing satisfaction in the work itself (craftsmanship orientation), knowing that their work helps others (serving orientation), or quality connections between members of a team (kinship orientation). Astronauts likely exhibit most of the calling orientations, and potentially the career orientation. Astronauts likely differ in the degree to which they possess different work orientations.

- Organizational practices to strengthen the meaning experienced by employees with different work orientations include valuing, highlighting, and rewarding the importance of high standards of quality (craftsmanship orientation); highlighting the impact of the employee's work, as well as the organization's, on other people (serving orientation); and highlighting and encouraging strong bonds between the employee and other team members (kinship orientation). Given the likelihood that astronauts possess a significant degree of all three calling orientations, astronauts and support personnel should determine strategies for enhancing all three orientations during LDSEM.

- Related to the concept of meaningful work is the notion of employees thriving at work (Spreitzer et al., 2005). Thriving occurs when employees approach their work with high energy levels and the belief that they are continuously learning and developing. Thriving is most likely when employees are performing "agentic behaviors", which reflect behaviors that have a purpose, involve exploration and boundary testing, and when employees are "heedfully relating" to others. Heedful relating means employees are paying attention to those around them, and are aware of how their actions work with the employee's to accomplish group goals. Agentic behaviors occur when employees have autonomy over their work, are encouraged to share information, and perceive a climate of trust, respect, and support in the organization.

  Given astronauts' strong motivation for exploration and the primary purpose of LDSEM being exploration, team members should be primed to thrive on the operation. Mission leaders can create the operational environment necessary for thriving by enhancing autonomy, encouraging a climate of information sharing and respect, and providing mechanisms for personal and professional development during the mission.

- Prior research has highlighted the importance of focusing not only on the potentially negative mental health outcomes of long-duration missions, but also the possibility for "salutogenic" or positive outcomes resulting from performing effectively under difficult conditions. Prior researchers have documented positive growth among astronauts following long-duration missions, including increased self-confidence, appreciation for life and the beauty of the Earth, and stronger relationships with family.

  Additional research is needed using designs that assess actual growth on positive domains as a result of different missions. However, acknowledging the benefits that astronauts have experienced on these missions may inform interventions that utilize the increased strengths to address the stressors certain to be encountered on LDSEM

- A large number of researchers have identified boredom and monotony as stressors that will likely be encountered during LDSEM. Recent research indicates boredom occurs when individuals want to be engaged in a satisfying activity, but are unable to do so. Boredom is characterized not only by low arousal states such as dejection, but also high arousal states associated with agitation. Boredom is likely to result when individuals fail to sustain their attention on mission-relevant tasks, and has been linked to performance errors in pilots and other high stress occupations.

A number of authors highlight meaningful work as an antidote to boredom on LDSEM, with recommendations for astronauts to engage in meaningful personal hobbies and personal scientific experiments. Recommendations for reducing boredom also include having mission critical tasks occur during transit phases of the LDSEM, as well as scheduling training on mission-relevant activities during these phases.

Conclusions from the Operational Assessment

- When responding to a question about what was most meaningful about their work, SMEs mentioned contributing to humanity, contributing to the mission, and exploration. In addition, many SMEs mentioned overcoming challenges and using their skills and abilities on experiments as meaningful. These responses were consistent with the different sources of meaning identified in the literature reviews, and highlight the importance of helping astronauts realize the impact their involvement is having on LDSEM.

- When asked about the characteristics of tasks that contributed to meaningful work, the most frequent responses were the tasks using a variety of skills and not being monotonous, feeling personal control over their schedule and autonomy in the execution of tasks, and understanding the importance of the experiments that were conducted even if they did not understand all parts of the experiment. The SMEs also mentioned the importance of being acknowledged and given genuine feedback by the principal investigator and by ground control, and understanding how the task contributed to the "big picture" of the mission.

- When asked about factors that decreased engagement in meaningful work, the SMEs identified having to do tasks with no explanation of why, not understanding the purpose of a task or experiment, and a lack of communication regarding the experiments. The SMEs also discussed misperceptions between ground control and the crew and the combination of a decrease in novelty and time away from family. Regarding the latter factor, the focus was on whether the time away from family was justified by the increasingly monotonous tasks being performed.

  These responses highlight the importance of timing interventions to increase perceptions of meaningful work at those mission points where perceptions of monotony increase. The responses also indicate the benefits that will result from any interventions which increase the perception of a greater connection between the astronaut and his or her family (e.g. the potential for virtual reality to bring the family to the astronaut, the family being briefed on the importance of what the astronaut is doing).

- When SMEs were asked about the best indicators that an astronaut was experiencing a prolonged state of boredom, the most common responses were a change in voice (i.e. level of enthusiasm), social withdrawal (e.g. pulling away from social activities like shared meals), changes in sleep patterns (e.g. insomnia), and a slip in performance (e.g. errors, falling asleep during a task). These indicators may be used to time interventions designed to increase the meaningfulness of operational activities.

- Many of the recommendations SMEs had for increasing engagement in meaningful work were supported by prior research. The top recommendation included having astronauts make better utilization of real time social media, while at the same time not making the use of social media a requirement for astronauts. The sentiment was that most astronauts would find the use of social media meaningful if they learned how to use it properly, but that differences existed among the astronauts regarding their enthusiasm for the approach. Social media has the potential to allow astronauts to be aware of the impact their work is having on the broader society.

  The second most popular recommendation included a combination of autonomy and structure, where some tasks were scheduled to occur at critical times, whereas other tasks could be completed within a given time frame and scheduled by the astronaut. Additional recommendations included building teams so that different people could occupy different roles based on their expertise, conducting training in transit so it occurs closer to the actual performance setting (and does not prolong time being spent away from family prior to the mission), ensuring astronauts have identified hobbies and personal experiments for free time, and ensuring tasks fall within the expertise of astronauts and they know why they are performing tasks.

Directions for Future Research

- Develop and evaluate the reliability of a short measurement instrument to assess the perceived meaningfulness of or thriving at work suitable for multiple administrations during long-duration missions.

- Identify individual differences among astronauts in their work orientations, and consider tailored interventions to enhance meaning on LDSEM based on the primary work orientations that characterize the astronaut.

- Test different ways of training astronauts on the use of social media to reach out to the broader scientific community and broader humanity, and test the effectiveness of social media use as a mitigation strategy under prolonged periods of boredom and isolation.

- Examine whether an intervention involving reflecting on the potential benefits of participating in long-duration missions could be used to sustain motivation during periods of boredom and monotony.

- Identify ways in which family and friends can contribute to an astronaut's engagement in meaningful work during long-duration missions. Possibilities include more detailed briefings for family and friends regarding the nature of the astronaut's work on the mission, and specific feedback from family and friends regarding the work being conducted.

- Examine the use of unobtrusive measures as indicators of prolonged boredom-monotony, including speech parameters (e.g. level of enthusiasm), indices of social activity (e.g. amount of social interaction), and performance errors.

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Overview

"[T]he single most important psychological factor on a long-duration flight is to be meaningfully busy. And if you are, a lot of other things sort of take care of themselves."

– Norman E. Thagard, the first U.S. Astronaut on Mir (cited in Slack et al., 2014).

Numerous authors have noted the physical and psychological demands that will be placed on astronauts participating in long-duration space exploration missions (LDSEM) to Mars and other locations (Kanas, 1998; Leon et al., 2011; Otto, 2007; Peldszus, Dalke, Pretlove, & Welch, 2014; Rosnet et al., 1998; Stuster, 1996, 2010; Vanhove, Herian, Harms, & Luthans, 2014; Vessel, 2014). The psychological demands likely to be encountered during LDSEM include life-threatening situations, confinement, lack of privacy, boredom, interpersonal conflict, and family separation, among others. Given these demands, the Human Research Program (HRP) at NASA has determined that the risk status of adverse cognitive or behavioral conditions and psychiatric disorders (BMed) that may occur during a planetary mission, such as Mars, is Uncontrolled (Red). In addition, recent analog studies of individuals participating in long-duration periods of isolation and confinement, including the MARS 500 simulation (Basner et al., 2013), indicate that reports of overall stress may be higher in long-duration missions than in prior space missions. Therefore, even if the demands of LDSEM do not result in psychiatric disorders among astronauts, the potential exists for the development of significant mental health symptoms that may compromise the astronaut's health, well-being, and performance.

The present report examines how engagement in meaningful work throughout the LDSEM may decrease the demands associated with boredom and monotony, as well as buffer astronauts from the negative consequences associated with other stressors likely to be encountered on these missions. Employees consider their work to be meaningful when it serves an important purpose or is otherwise seen as significant by the employee. Prior research has examined the importance of meaningful work in the motivation, health, and performance of employees in diverse occupations (Dik, Byrne, & Steger, 2013; Rosso, Dekas, & Wrzesniewski, 2010). In addition, Britt and Bliese (2003) found that engagement in meaningful work buffered military personnel from deployment-related stressors, including lack of sleep, living in an austere environment, and family separation (see also Britt & Adler, 1999). Finally, prior authors have noted (but not empirically examined) the importance of meaningful work in the adjustment of astronauts during difficult missions (Peldszus et al., 2014; Rosnet et al., 1998; Stuster, 1996, 2010; Vanhove et al., 2014; Vessel, 2014).

In addition to the present report addressing meaningful work as an antidote to boredom and monotony during LDSEM, the report also addresses the role of meaningful work as a contributor to thriving under difficult mission conditions. Britt and Jex (2015) recently argued that demands encountered at work have the potential to positively influence the performance and development of employees when they are approached with the right mindset. Employees who believe they are

involved in meaningful work will be more likely to proactively address the demands that are encountered, and to view these demands as challenges to be mastered, as opposed to threats to well-being and performance (Britt, Adler, & Bartone, 2001; Parker, Bindl, & Strauss, 2010). Astronauts have been described as action-oriented individuals who have high achievement motivation and enjoy dealing with challenges that arise. Therefore, astronauts who believe they are involved in meaningful work will not only be less likely to experience negative outcomes associated with the demands likely to be encountered on LDSEM (e.g. mental health symptoms, boredom, performance errors), but will also experience positive consequences from successfully mastering the challenges in executing mission-relevant tasks under difficult operational conditions (Ihle et al., 2006; Kanas et al., 1996; Leon et al., 1994, 2011; Ritsher et al., 2005; Suedfeld & Brcic, 2011).

In order to thoroughly address the role of meaningful work in the adjustment and performance of astronauts during LDSEM, the present report is divided into four different sections. The first section provides a review of academic theory and research on meaningful work, including a brief discussion of theories addressing overall meaning in life, definitional issues involved in studying the meaning associated with work, and models of meaningful work and boredom in employee settings. The second section addresses prior research highlighting the role of meaningful work with astronauts and personnel in analog settings (e.g. submariners, winter-over personnel in Antarctica, expeditioners). The third section describes the results of operational assessment interviews that were conducted with subject matter experts (e.g. astronauts, astronaut trainers, mission control personnel) regarding the role of meaningful work in the adjustment of astronauts during LDSEM, and recommendations these experts had for using meaningful work and other strategies for countering the boredom and monotony likely to be encountered during these missions. The final section of the report provides recommendations for future research on the role of meaningful work in the adjustment and performance of astronauts on LDSEM.

Section 1: Review of Academic Theory and Research on Meaningful Work

A number of theories have emerged from psychology and organizational behavior that address the role of meaning in life and in work. In this section, theories addressing meaning in life more broadly are first discussed. These theories are useful because they acknowledge individuals derive meaning from sources other than their job, and recognizing the role of family and other areas of meaning in life has implications for interventions designed to promote astronaut adjustment and performance during LDSEM. This section then addresses definitional issues in the field of meaningful work, measures of meaning at work, and models of meaningful work, boredom, and organizational constraints in organizations. This section concludes with an overall model of meaningful work in organizations that can be applied to astronauts engaged in LDSEM.

Theories Addressing Meaning in Life

Frankl's (1946) Will to Meaning. One of the early influential analyses of the importance of finding meaning in life's circumstances was that of Victor Frankl, a holocaust and prison camp survivor who addressed how he found meaning in extremely difficult conditions. Frankl (1946/1963, 1969) wrote extensively regarding the drive humans have to find meaning in their lives, and the psychological problems that can result when meaning is lacking. He believed that meaning in life was ultimately a function of taking responsibility for one's choices and decisions, and cited purposeful work, love, and demonstrating courage when faced with significant adversity as providers of meaning for individuals. Frankl also developed logotherapy to help individuals cultivate meaning in their lives by taking responsibility for the choices they make.

Two of Frankl's central contributions to the study of meaning in life were to highlight the importance of the quest for meaning in the adjustment of individuals, and the recognition that meaning can come from multiple sources. Astronauts participating in LDSEM will be motivated not only by the meaning associated with participating in an exciting and dangerous mission, but also by the implications of the mission for their family and significant others. Insuring that the astronaut's family is taken care of, and that the astronaut is confident that his or her relationships with family members will not be adversely affected by the mission, will allow the astronaut to positively focus on the meaning provided by the mission.

Baumeister's (1991) Four Needs of Meaning. Baumeister (1991; Baumeister & Newman, 1994; & Wilson, 1996; Baumeister & Wilson, 1994), in his book and articles on meanings of life, argued that individuals will consider their lives as meaningful when they have satisfied four different underlying needs: purpose, value and justification, efficacy, and self-worth.

The need for purpose emphasizes that individuals are pursuing goals or end-states of fulfillment that are seen as having value. Events in life take on meaning because they help to satisfy end states desired by the individual. For example, going to college would be seen as meaningful because it satisfies an individual's need for purpose if it facilitates the goal of becoming an accountant. Getting married would be seen as meaningful if it facilitates a state of fulfillment of being happy or content.

The need for value and justification refers to having a framework for making ethical decisions of what is right and wrong, and individuals being able to justify their actions to themselves and others. Events become meaningful when individuals apply their moral framework to a situation, and behaviors become meaningful when they are seen as reinforcing a moral code. For example, individuals would find meaning in volunteering as a Big Brother or Big Sister if they believe in the value of helping others who are less fortunate than themselves. The need for efficacy is relatively straightforward, referring to the need individuals have to demonstrate an ability to affect their environment, and demonstrate competence in areas they value. Being able to properly perform critical tasks at work would provide meaning to an individual as a function of meeting that person's need to demonstrate efficacy.

The need for self-worth refers to feeling good about oneself, and this need can be met by the individual outperforming others and being recognized by others as having desirable attributes. The need to belong is closely tied to the need for self-worth, as researchers have recently argued that self-esteem is closely linked to whether individuals believe they are securely included in social groups and relationships (Leary et al., 1995). Baumeister and Leary (1995) have also posited that individuals have a fundamental need to belong to important social groups and relationships, and recent evidence supports the hypothesis that a sense of belonging to important groups enhances the experience of meaning in life (Lambert et al., 2013). According to Baumeister's model, individuals need to satisfy all four needs in order to experience life as meaningful, and the failure to satisfy one or more needs will result in the experience of psychological distress and insignificance. Baumeister's approach has been influential in the development of models of meaningful work discussed in a later section.

Antonovsky's (1987) Sense of Coherence Theory. Antonovsky (1987) conceptualized Sense of Coherence as individuals possessing the resources of comprehensibility, manageability, and meaningfulness. Comprehensibility refers to understanding life's circumstances and having an explanatory framework for events that happen to the individual. Manageability refers to the belief that stressful situations can be addressed through the individual's coping repertoire. Meaningfulness refers to the belief that the experiences and actions of the individual are connected to and serve a broader purpose. Antonovsky (1987) argued that individuals with a stronger Sense of Coherence respond better when under stressful conditions, because they are better able to utilize the resources available to them, including reaching out to others for support and addressing the problem directly (see also Antonovsky, 1993).

Antonovsky (1993) developed a scale to assess Sense of Coherence, and research using the measure typically combines the scores on the three sub-dimensions into an overall score. The measure is related to health outcomes, with the measure being more strongly related to indices of mental health than physical health (Ouellette & DiPlacido, 2001). Nelson and Simmons (2011) have argued that the Sense of Coherence construct represents an individual difference variable that is capable of allowing employees to positively respond to various workplace stressors.

Terror Management Theory. Developed by Greenberg, Pyszczynski, Solomon, and their colleagues (Greenberg et al., 1990; Rosenblatt, Greenberg, Solomon, Pyszczynski, T., & Lyon, D., 1989), Terror Management Theory has the basic assumption that because humans are uniquely aware of their eventual death, they are required to develop strategies and mechanisms to reduce the existential anxiety created by awareness of their own mortality. The authors argue that the cultural worldviews that individuals and groups develop, as well as our desire to be securely attached to important groups, largely arose to protect us from the anxiety created by our mortality. A number of experimental studies have been conducted showing that people are more likely to embrace their own groups and beliefs, as well as denigrate outgroup members, when their mortality has been made salient (e.g. by writing about what happens when they physically die, to describe the emotions felt when thinking of dying, completing a Fear of Death scale; see Greenberg et al., 1990; Rosenblatt et al., 1989).

Terror Management Theory has generated a large amount of research, much of it supporting the argument that making mortality salient results in a variety of attempts to solidify personal worldviews and distance ourselves from outgroup members. Criticism of the model has centered on whether important beliefs such as self-esteem occur primarily because of a need to protect ourselves from the awareness of our own mortality, or because of some other need, such as the need to insure we belong to important social groups (see Leary, 2004). Furthermore, just because individuals respond to manipulations of mortality salience with an increased bolstering of important beliefs does not mean that mortality salience is the primary motivator for the presence of those beliefs. Still, Terror Management Theory has important implications for how individuals may respond when they are reminded of their own mortality. Especially considering the potentially life-threatening situations likely to occur on a LDSEM, it is possible that mortality salience on such missions could result in astronauts reinforcing the importance of their personal beliefs, and potentially distancing themselves from fellow astronauts who share different beliefs. Awareness of this possibility might help prevent interpersonal conflict following life-threatening events on LDSEM.

Meaningful Work: Definitional Issues

Moving from theories and research addressing meaning in life more generally to models of meaningful work, we first address several conceptual distinctions in defining meaning and how it is operationalized in research. We will discuss several distinctions that were outlined in a review of the meaningful work literature by Rosso, Dekas, and Wrzesniewski (2010) in detail, including: meaning compared to meaningfulness, the difference between meaning *in* work and meaning *of* work, and strategies to influence meaningfulness *in* work compared to meaningfulness *at* work. In addition, we will discuss research efforts focused on the sources of meaning versus the mechanisms of meaning.

The first primary distinction is differentiating meaning from meaningfulness (Rosso et al., 2010). Meaning is typically viewed as an outcome, where in a work context, meaning would be the outcome of an individual's evaluation and interpretation of work in his or her life (Pratt &

Ashworth, 2003). It is an individual's conclusion on what work means to them, such as if work is viewed as just a paycheck or fulfilling some personal or spiritual calling (Pratt & Ashworth, 2003; Rosso et al., 2010). Although meaning is not inherently positive, the concept is usually connected to positive experiences of work, where people find positive meaning in their jobs (e.g., Wrzesniewski & Dutton, 2001).

Meaningfulness goes beyond meaning (i.e., whether or not meaning is present) to the amount of meaning an individual feels or perceives (Pratt & Ashforth, 2003). This distinction may be important to understand, as different individuals could both experience meaning in the same job or work tasks, but not experience the same levels of meaning. While a task may be somewhat meaningful for one employee, it could be extremely meaningful for another (Rosso et al., 2010). Rosso et al., (2010) further noted that the two concepts of meaning and meaningfulness are often combined when referring to "meaning of work".

The next distinction is between the meaning of work and meaning in work. Meaning in work refers to how meaningful one's work is to them or the amount of meaning that is experienced. Meaning of work refers to the ways in which work is experienced as meaningful (Dik, Byrne, & Steger, 2013). The meaning of work is more focused on the specific ways that the content of work may contribute to meaning in work.

The final distinction is between meaningfulness in work and meaningfulness at work. This is typically discussed in terms of strategies to cultivate meaning among employees. As discussed in more detail below, meaningfulness in work may be viewed as a function of the roles and tasks that employees complete. Meaningfulness at work focuses on experiencing meaning in the context of the work environment (Pratt, Pardies, & Lepisto, 2013). Thus, organizations may influence the meaningfulness experienced in work by altering the actual tasks that employees do, while organizations may influence meaningfulness at work by controlling contextual factors that may contribute to meaning.

Most research in the realm of meaningful work has focused on one of two major issues: the source of meaning and/or the mechanisms of meaning at work (Rosso et al., 2010). Studies of the sources of meaning have focused on determining where employees actually derive meaning associated with their work. Meaning can come from oneself, from others either within or outside the workplace, from the general work context, or from spiritual beliefs. These sources will now be discussed in additional detail.

Meaning derived from oneself as the source can arise from an alignment between work and one's personal values or intrinsic motivation when a job fits an individual's self-concept (Rosso et al., 2010). These sources may be more or less prevalent based on the employee's beliefs about work and how central it is to their lives. For example, as discussed in more detail below, some researchers differentiate job orientations that focus on material benefits of work from a calling where individuals feel genuine self-expression through their work (e.g., Dik & Duffy, 2009; Hall & Chandler, 2005).

Important external sources can be others in the employees' work and non-work environments. Sources within the workplace can be co-workers, where employees find meaning in close interpersonal relationships and shared values (e.g., Kahn, 2007). Leaders can also be a source of meaning by providing a meaningful framework to the employee's work tasks and connecting employees to broader organizational goals (Podolny, Khurana, & Hill-Popper, 2005). Lastly, family members, friends, and community members can invoke meaning when employees can provide for specific needs through their work and can see the impact of their work on the lives of others (Brief & Nord, 1990; Grant, 2007; Grant et al., 2007).

Another source of meaning can be the actual job tasks or the context of work. Meaning can result from the design of the actual tasks, which will be discussed more in the context of the job characteristics model (JCM; Hackman & Oldham) and job-crafting (Wrzesniewski, Berg, & Dutton, 2010), or from identification with the organization's mission (e.g., Pratt, 2000). Lastly, meaning may be derived based on spiritual belief systems, where work is a component of fulfilling a spiritual calling (e.g., Weiss et al., 2000).

In regard to the mechanisms by which work becomes meaningful, researchers have tried to disentangle the processes of meaning to explain how work becomes meaningful. While prior research has generally focused on "who" makes work meaningful, the goal of mechanisms is to elaborate on the "how" and "why" work becomes meaningful (Rosso et al., 2010). Rosso et al., (2010) identified the most common mechanisms discussed in the literature as authenticity, self-efficacy, self-esteem, purpose, belongingness, transcendence, and sense making. Many of these processes were highlighted in the previous section on meaning in life more generally.

The process of authenticity can be an important explanation of finding meaning, where an individual's identity or tasks at work are consistent with their personal attitudes, beliefs, identities, etc. (Shamir, 1991). This concept is also highly related to employee engagement, where employees identify with their work tasks and can experience a sense of immersion while working (e.g., Kahn, 1990). Self-efficacy and self-esteem provide mechanisms whereby engaging in certain work makes an individual feel more confident or efficacious which increases meaning, or individuals gain meaning because they feel better about themselves and their worth as a whole by engaging in work (e.g., Baumeister & Vohs, 2002; Spreitzer et al., 2005).

Similar to some of the discussion of self and spirituality as a source of meaning, another mechanism for meaning can be finding purpose. Researchers have found work can be associated with a sense of purpose, particularly when individuals see significance in the work they are completing (e.g., Pratt & Ashworth, 2003). Similar to purpose, transcendence may also be a mechanism whereby individuals feel connected to something larger than themselves, such as a broader organizational mission or a spiritual entity (Lips-Wiersma, 2002; Weiss et al., 2004).

In terms of social relationships, belongingness can be an important mechanism where individuals feel a social connection to groups through work, either to other individuals in the work context or a group connection to a set of shared experiences, values, or ideals (Hogg & Terry, 2000).

Lastly, finding meaning can occur through the process of sense making. Sense making refers to the process by which individuals better understand their environment through their different interactions, thus interactions at work can help employees to better understand the critical components of their job and how their job fits within the mission of the organization (Wrzesniewski et al., 2003).

Meaningful work has been measured in a variety of ways in research studies. Some sample measures of meaning making and meaningful work are provided in Appendix A.

Models of Meaningful Work in Organizations

Many of the conceptualizations discussed in d efining meaning have focused on how individuals derive or assign meaning to their work themselves; however, Pratt et al., (2013) notes that meaning is also socially constructed in many ways. Thus, organizations can help employees to cultivate meaningful work through a variety of strategies, such as assigning work that is significant and helping individuals see the significance or their personal connection to work. The following models will discuss several frameworks for understanding how task characteristics and job environments may be structured to promote meaningful work. After presenting the basic components of each model, we discuss the research support for the model and briefly address applications of the model to astronauts on LDSEM.

Job Characteristics Model (JCM). First, the Job Characteristics Model (JCM) is a prominent organizational theory that focuses on how different task characteristics of a job can promote psychological states that result in positive outcomes (Hackman & Oldham, 1980). Hackman and Oldham (1980) specified five characteristics that may make tasks more motivating: skill variety, task identity, task significance, autonomy, and feedback. Skill variety refers to the number of different skills or activities that an employee can use or do on the job. Task identity refers to being able to create a complete piece of work, rather than just sub-components of a given product. Task significance is how significant the work completed is to the employee, or to other people within or outside of the organization. Autonomy is how much freedom or control an individual has over the tasks they complete or the ways the tasks are completed. Lastly, feedback is whether or not employees receive information about how they are performing.

Hackman and Oldham (1980) proposed that these different characteristics are associated with three psychological states: how much meaning an employee experiences in his or her job, how much responsibility an employee feels for the outcomes of his or her work, and whether or not an employee has knowledge of the results of the work outcomes. The model proposes that experienced meaningfulness is most affected by skill variety, task identity, and task significance. Employees are expected to experience more meaning from their work if: they are able to use a variety of skills; they could take pride in their work with high task identity, such as through seeing a project through from start to finish; and, they felt their work was important with high task significance. These different psychological responses are then said to relate to positive organizational outcomes, such as higher motivation, satisfaction, retention, and performance (Hackman & Oldham, 1976; 1980).

A final component of the JCM is that there may be individual differences that affect the extent to which task characteristics evoke the key psychological states and result in positive outcomes. Hackman and Oldham (1976) noted that these relationships may be strongest for employees who have a high desire for personal development and pursuing growth through work tasks. They termed this individual difference variable as Growth Need Strength (GNS; Hackman & Oldham, 1976).

Overall this model has received a good deal of empirical support. The initial studies by Hackman and Oldham (1975, 1976) did test the full model and found support for it. Champoux (1991) also found support for this entire theoretical model. Additional experimental studies and correlational research in applied settings have provided support that the different task characteristics can be associated with positive performance outcomes (e.g., De Varo & Brookshire, 2007; Donovan, 2015; Fried & Ferris, 1987); however, support for the key psychological states as pure mediators has been less clear. Some researchers have refined the understanding of psychological states by highlighting the potential for direct and indirect relationships between task characteristics and outcomes, as well as alternative mediators to the ones originally proposed, such as psychological ownership (e.g., Pierce, Jussila, Cummings, 2009; Renn & Vandenberg, 1995).

In general, most recent studies have used components of the JCM model, but few have tested the model in its entirety. Furthermore, support for the moderating effect of GNS has been mixed. An early meta-analysis by Spector (1985) found support for the hypothesis that those high in GNS did exhibit superior performance in the context of better task characteristics; however, low GNS did not necessarily seem to be harmful to the relationship. Further, other studies have failed to find any support for GNS as a moderator (e.g., Evans & Ondrack, 1991; Tiegs, Tetrick, & Fried, 1992).

In addition to testing the JCM model, some researchers have added to the model to highlight other important aspects of job tasks that may impact psychological states and organizational outcomes. As a primary example, Morgeson and Humphrey (2006) expanded upon the JCM to create the Work Design Questionnaire (WDQ). The WDQ included a total of 21 work characteristics, specifically differentiating task characteristics from knowledge characteristics, social characteristics, and the work context, with the overall goal to create a more comprehensive work questionnaire to assess the nature of a job. They retained many of the original task characteristics from Hackman and Oldham's (1980) model, with some refinements, such as breaking autonomy into specific components of control over work schedules, decision making, and work methods.

Morgeson and Humphrey (2006) specifically distinguished task characteristics from several knowledge characteristics, or the kinds of knowledge, skill, or ability that an individual must use to perform job tasks. Specific components of knowledge characteristics included: job complexity (how difficult tasks are to perform); information processing (the degree to which a job requires processing some type of data or information); problem solving (how much active cognitive

processing a job requires); skill variety, (the use of a variety of skills); and, specialization (the extent to which the tasks performed or knowledge needed are specialized).

Social characteristics were also included as part of the more comprehensive job design questionnaire (Morgeson & Humphrey, 2006).

Four major social aspects were discussed, including: the degree of social support available, how interdependent employees are on one another, how much an individual interacts with people outside the organization, and how much feedback employees receive from other individuals within the organization. This latter social characteristic was differentiated from Hackman and Oldham's (1980) conceptualization of feedback as being from the task itself (e.g., knowing the results of your work). Lastly, contextual factors of a job may include the ergonomic design, physical demands, work conditions (e.g., physical hazards, noise, cleanliness), and the use of equipment required in a job.

Overall, Morgeson and Humphrey (2006) found support for their more comprehensive measure of work design, with strong reliability and convergent and discriminant validity. Further, they found some incremental and unique predictive relationships between the novel work design characteristics and organizational outcomes (e.g., social support related to satisfaction; knowledge characteristics related to training and compensation requirements on the job). Other researchers have further validated this measure in other samples and cultural contexts (e.g., Stegmann et al., 2010). Using these frameworks as a foundation for understanding the job tasks that astronauts face may be a vital tool in emphasizing those tasks that would promote meaningfulness, while trying to reduce the number of less significant or menial tasks that may detract from meaningfulness.

Person-Environment Fit Models. While research using the JCM focuses on how specific tasks encourage experienced meaningfulness, other models focus on the fit between an individual and the job environment in understanding meaningful work. Person-Environment (P-E) Fit models are those which highlight the importance of a fit between characteristics of the employee and characteristics of his or her work environment (e.g., Edwards et al., 1998). Some researchers differentiate between perceived fit (from the perspective of the employee) and objective fit (based on measurable features of the person and environment). For the purposes of this review, we will focus on perceived P-E fit as contributing to meaningful work. Most research involving P-E fit theories is focused around the outcomes of employee stress, job satisfaction, or vocational choices; however, many of the concepts discussed in meaningful work (e.g., connection to work, felt authenticity at work) bear a resemblance to these constructs of fit (Hansen, 2013).

Further distinctions have been made where P-E Fit can be discussed in terms of a fit with employees' overall vocation, the organization they are a part of, their immediate work group, or their specific job (e.g., Kristof-Brown et al., 2002). These four types of fit have been found to be positively correlated with one another, and have been associated with important outcomes such as task and contextual performance (Vogel & Feldman, 2009). Fit with one's environment has

also been associated with more positive job attitudes, such as job satisfaction, organizational identification, and organizational commitment (Kristoff-Brown, Zimmerman, & Johnson, 2005). Researchers have also discussed P-E fit in the context of vocational choices made by employees. For example, Kristof-Brown et al., (2005) found person-organization fit to be related to attraction to organizations and intentions to accept job offers from that organization. Thus, individuals may to some extent self-select into careers or jobs that fit their personal characteristics (Schneider, 1987).

Another major area of research on P-E fit is in the domain of work stress, where stress is proposed to result when there is misfit between a person and the environment (Edwards et al., 1998). Stress can specifically be understood by examining relationships between organizational demands and individual abilities to meet those demands, as well as the match between the different needs individuals have to complete tasks and organizational supplies or resources that are provided to support these needs (Edwards et al., 1998). Again, an inadequate fit between the demands and abilities or the needs and supplies can then be experienced as stressful.

While misfit may result in feelings of stress, perceiving a high fit with one's environment may contribute to meaning in work. Britt and Jex (2015) specifically noted the potential for feelings of authenticity when one's job, organization, or vocation matches personal characteristics or values. Specifically, employees may feel more like their true selves when P-E fit is high. Rosso et al. (2010) also discussed authenticity in a similar manner as a mechanism to meaning, where those feeling authentic to their truest self in their job role are hypothesized to experience more meaning from work. Therefore, work tasks or work environments that allow one feel to authentic, fitting well with the environment, may be an important component of promoting meaningful work.

Feeling a connection between oneself and the environment may be particularly important for long-duration missions, where astronauts may experience more sustained meaning if they feel a sense of authenticity or fit with their role. Fit may be enhanced through job tasks related to an astronaut's interests or values. Further, it may be important to discuss the broad organizational and mission values and how each individual contributes in order to enhance his or her sense of authenticity or connection.

Relational Job Design. Many approaches to job design highlight altering tasks to improve employee attitudes or performance. In addition, we discussed individual perceptions of fit as contributors to feelings of authenticity and more meaningful work. Models have also focused on more social aspects of the workplace and connections with other people as important in designing work tasks. Grant's (2007) Model of Relational Job Design highlights some of the social aspects of designing a job. Relational Job Design increases social connections between employees and those who are benefited by their work (Grant, 2007).

Grant (2007) proposed that jobs will be more motivating when employees see that their work impacts others in a positive way and when employees can have actual contact with those who

benefit from the work they do. Experienced meaningfulness of the work is a proposed mechanism by which this relational contact influences motivation. For example, employees may feel more motivated or that their work is more significant if they interact with customers who use the product or service they directly or indirectly provide.

Studies using this model to design or re-design work have shown some success. Some specific strategies from Grant's work include establishing more relationships with clients so that employees can see the impact of their work on others. Grant et al., (2008) found this to be a beneficial approach in an intervention with call center employees, where those who had received contact from beneficiaries performed better than those who received no contact. This theory may be particularly applicable to long-duration space missions, where contact with individuals benefited (or simply inspired) by the space mission may be highly motivating and meaningful to astronauts. Such techniques may be important throughout the space mission to create a foundation for why the astronaut's work is significant prior to their departure, and continuing contact with beneficiaries throughout to maintain perceptions of meaning.

Spreitzer et al.'s (2005) Model of Thriving at Work. Thriving at work represents a distinct construct involving both vitality and learning that facilitates psychological development and health. Vitality describes positive feelings of energy and aliveness. Learning is the process of gathering new knowledge and skills for application. The combination of vitality and learning contributes to the eudaimonic perspective of employees seeking to maximize their potential at work.

The model by Spreitzer, Sutcliffe, Dutton, Sonenshein, and Grant (2005) assumes that reducing stressors in the environment does not enable thriving. Rather, thriving stems from specific psychological states and behaviors, available resources, and unit influences. Furthermore, employees' may thrive even when encountering stressors. Thriving may also be influenced by individual differences in that some employees may have a predisposition leading them to be more likely to thrive. These individuals may possess higher levels of motivation and a strong need for growth and development, and may seek out situations that contribute to thriving, such as challenging assignments and learning new skills. Spreitzer et al., (2005) emphasize that everyone has the capacity to thrive and grow, and it is environmental factors that determine who is successful in this journey. Environmental features include the social structure and context of one's immediate work unit, along with output of resources from work tasks.

Spreitzer et al., (2005) argue that the contributors to thriving take place within a social context, as vitality and learning do not happen independently from others. Social observation, interactions with others, and interpersonal connections all influence the process of employees thriving at work. Thriving is also directly influenced by agentic work behaviors. These behaviors refer to acts that are purposeful and proactive. More specifically, agentic behaviors include task focus, exploration, and heedful relating. Task focus refers to individuals directing their behaviors to successfully complete job responsibilities. Exploration describes a display of experimentation and innovation that leads to a broader focus and growth in new areas. Lastly, heedfully relating

employees pay close attention to those around them, understanding how their job fits into the bigger picture, and act in a way that promotes the success of overarching goals.

Furthermore, Spreitzer et al. (2005) suggest that contextual features of the work unit influence agentic behaviors. Autonomy in decision-making increases the agentic behaviors of task focus, exploration, and heedful relating, and thus, thriving. When employees feel in control and can decide how to perform their job tasks, they will be more determined and persistent in their work, explore more, and connect with others as they work together to make decisions. Moreover, information sharing and a climate of trust and respect in which employees feel safe and valued are crucial in facilitating thriving (Spreitzer et al., 2005).

Agentic behaviors are also influenced through resources from work outputs and experience. Such resources include knowledge, knowing how to do certain tasks or who to look to for additional information, as well as positive affect, or feelings of happiness and gratitude from performing job tasks. Relational resources stem from beneficial connections, such as a mentor or valuable colleague. Resources also include positive meaning, or finding the work to be purposeful, valuable, and significant. An increased task focus may contribute to positive meaning from the high intrinsic motivation that is associated with such performance, and result in a state of flow, which Csikszentmihalyi (1990) described as an experience of being pleasantly immersed in a task. According to Csikszentmihalyi (1990), flow is most likely when individuals are immersed in an activity as a function of activity having a clear goal, being challenging to the individual, and providing the individual with immediate feedback regarding success. Exploration may produce positive meaning as employees' find additional, novel interpretations and value in their work (Wrzesniewski & Dutton 2001). Spreitzer et al. (2005) suggest the resource of positive meaning then facilitates additional agentic behaviors.

Employees who see positive meaning in their work will likely exhibit a strong task focus and prioritize their job duties (Hackman & Oldham, 1980). Even when challenges arise, those with a sense of positive meaning will be more able to see such situations as a chance for growth, and realign priorities to focus on what is important (Davis, Nolen-Hoeksma, & Larsen, 1998). Furthermore, employees' with positive meaning will recognize any challenges as important problems and look for creative solutions, increasing exploration. Lastly, meaning is often shared across work groups, and those who hold similar views of positive meaning will be more likely to perform agentic behaviors, as well as provide support and heedfully relate to fellow employees (Hackman, 2002).

Overall, Spreitzer et al. (2005) argue agentic behaviors increase vitality through task absorption and feelings of accomplishment, satisfying curiosity through exploration, and increased energy from offering social support. In addition, these actions increase learning through practice in efficiency, new knowledge gained through exploration, and learning from colleagues. An increase in vitality and learning is then thought to increase outcomes of thriving, including positive effects on employee development and health. When considering practical applications, supervisors should focus on increasing agentic behaviors through emphasizing significant,

meaningful tasks, increasing opportunities for learning, providing autonomy for exploration and decision- making, and developing a supportive work environment that facilitates heedful relating.

Past research demonstrates support for the hypothesized model, documenting construct and discriminant validity for the concept of thriving, as well as evidence for the contextual influences on reports of thriving (Porath, Spreitzer, Gibson, & Garnett, 2012). Studies that have examined the proposed relationships found psychological capital and a supportive supervisor climate to predict agentic work behaviors, which then predicted increased self-development (Paterson, Luthans, & Jeung, 2014). Furthermore, a recent diary study showed that as employees reported more positive meaning in their job tasks in the morning, they reported higher vitality and learning at the end of the day. This relationship was also mediated by the agentic behavior of task focus (Niessen, Nurnberg, Sonnentag, & Sach, 2012).

In application research on thriving to the astronaut community, astronauts represent a model population for opportunities of thriving at work. The model of thriving described above demonstrates how astronauts on long-duration missions can benefit from thriving at work through focusing on meaningful tasks, understanding how each person's work fits into the overall mission, supporting others, and exploring new pathways to learning and performance. Thus, astronauts should be provided with the context that supports thriving, with resources such as significant job tasks, a supportive climate, and job autonomy.

Job Crafting at Work. Wrzesniewski and Dutton (2001) developed the concept of job crafting to refer to employees being able to change how they perform or perceive their job in ways that allow them to better appreciate the significance of what they are doing, and to create a job that is more consistent with their skills, abilities, and interests. These authors argued that job crafting can occur by employees changing the frequency or types of tasks they perform at work, the frequency and quality of the interpersonal relationships they experience at work, and/or the way they think about their primary work tasks. The authors argue that even when employees are in jobs that are highly controlled, they still have opportunities to make small changes to their work environment, and the way they perceive their work environment. The authors provide an example of a janitor at a hospital who was able to change the meaning of his work by organizing the rooms of patients in a way that created a more positive atmosphere for the patients.

Wrzesniewski, Berg, and Dutton (2010) created an exercise where employees diagram their job in order to think about how they are currently spending their time at work, and how they might better arrange their tasks so their time is spent on tasks that are consistent with their primary interests and abilities. The exercise first encourages employees to describe their current tasks at work with a series of boxes, drawing larger boxes for the tasks where more time is spent. After diagramming the way time is spent on different tasks, employees are encouraged to identify their primary motives, strengths, and passions, and to consider whether the way they currently spend their time is allowing the employee to develop and use those attributes. Employees then think about how they might be able to redistribute their effort, change how they are perceiving aspects

of their work, and consider modifying the frequency of interactions with people at work in order to better spend time engaging in tasks consistent with their abilities, motives, and passions.

Timms, Bakker, and Derks (2013) extended research on job crafting by developing a measure to assess the extent to which employees report crafting their jobs by increasing their exposure to challenges, decreasing their exposure to stressors in the work environment that hinder their performance, and attempting to increase their exposure to resources in the work environment. These authors found that employees who reported trying to create more challenges at work reported higher levels of engagement in their work one month later. Therefore, creating challenging work demands can result in increased engagement at work, which has been linked to performance, well-being, and job satisfaction.

In addition to being related to increased job engagement, van Hooff and van Hooft (2014) recently examined the relationship between the job crafting dimensions, the experience of workplace boredom, and boredom behaviors characterized by withdrawal of effort (e.g. taking long breaks, working slowly). The authors found that the job crafting dimensions of increasing challenges at work and enhancing structural resources (e.g. learning a new task) were negatively related to the experience of boredom at work. In addition, both of these job crafting dimensions interacted with the experience of boredom at work to predict boredom-related behavior. The form of both interactions reflected that the experience of boredom was less related to boredom-related behaviors for employees reporting higher amounts of job crafting. These results suggest that job crafting may not only enhance positive workplace outcomes, but may also prevent negative workplace outcomes.

The opportunity for astronauts to craft their jobs may be particularly present on the transit phases of LDSEM. Recent studies illustrate the importance of related concepts, such as astronauts having some autonomy over their work schedule (Roma et al., 2013). The concept of job crafting includes not only the autonomy to determine how a job gets done, but also how astronauts interact with others on the mission and think about the significance of the work they are doing. Therefore, job crafting has the potential to facilitate astronaut adjustment to the demands of LDSEM.

Organizational Practices to Cultivate Meaning. Pratt et al. (2013) developed a model to address how organizations can enhance the meaning experienced by employees at work by tailoring interventions to the employee's primary work orientation. As discussed above, organizational interventions to enhance the meaningfulness include making changes to the tasks and roles to which employees are assigned (referred to as "meaningfulness in work" practices), and by making changes to the context in which employees do their work (referred to as "meaningfulness at work" practices). However, in order to insure that these interventions have their desired effects, the authors argue employers need to understand the orientation employees have towards their work. Pratt et al. (2013) defined work orientations as "internalized evaluations about what makes work worth doing (p. 175)." Work orientations represent standards individual employees have internalized that are used to evaluate their work at any point in time.

These authors started with the popular model of Wrzesniewski, McCauley, Rozin, and Schwartz (1997), who distinguished between the work orientations of job, career, and calling. A *job orientation* characterizes individuals who approach work as a means of achieving some desired end, such as providing financially for one's family, or some other extrinsic goal. A *career orientation* characterizes individuals who work so they can demonstrate their success and achievement, often by progressing up the "company ladder" and attaining status and recognition by others.

In order to thoroughly describe the *calling orientation* to work, Pratt et al. (2013) use Bellah et al.'s (1985) original description of the orientation. This description included individuals subjugating themselves to a higher-order meaning or purpose associated with work, feeling a sense of community and connection with co-workers, and believing that their work helps other people and contributes to a broader good. These three aspects of a calling orientation highlight that the employee finds meaning in the work itself, the ability for the work to bring fellow employees together, and the impact work on has on others. Wrzesniewski et al. (1997) used the term "calling orientation" to collectively refer to workers characterized by these viewpoints.

In contrast, Pratt et al. (2013) argued that what was previously studied as a single "calling orientation" could actually be divided into three different orientations based upon the original discussion of Bellah et al. (1985). The authors labelled these three orientations craftsmanship, serving, and kinship. A *craftsmanship orientation* describes individuals who experience satisfaction in the work itself, as indicated by the fulfillment achieved in the details of a given job or task, and pride in the quality products that result from work. Employees characterized by a craftsmanship orientation experience satisfaction from demonstrating their competence to produce high quality work. The goal is to produce quality work as an end in itself, and not to compare favorably to others or for higher profit.

Employees characterized by a *serving orientation* enjoy knowing their work helps others, and derive meaning through the benefits their work has for other people. Individuals with a serving orientation may not experience joy in the execution of work itself, as found in the craftsmanship orientation, but rather from the effects that work has on others.

Finally, employees characterized by a *kinship orientation* focus on the establishment, maintenance, and growth of connections between employees working together to achieve a common goal. Employees with a kinship orientation typically view their co-workers as part of their family, and this orientation likely characterizes many individuals who work as part of tight-knit units, including in the military or first responder community (i.e. police, firefighters, emergency medical personnel; see Haski-Leventhal & McLeigh, 2009).

In discussing how organizations can intervene to increase the meaning employees assign to their work, Pratt et al. (2013) emphasized that the practices used should be tailored to the employee's work orientation, and address both meaningfulness as employees perform their work (meaningfulness in practice) and meaningfulness of the organizational context in which work

takes place (meaningful at practice). In terms of enhancing the meaningfulness of the work performed, Pratt et al. (2013) drew on Hackman and Oldham's (1975) JDM model discussed earlier, and argued that employees with a craftsmanship orientation to work will be especially influenced by task identity (completing a single product from start to finish), task feedback, and task autonomy (having the freedom to perform without control by others). We would also add that many of Morgeson and Humphrey's knowledge characteristics are also relevant to employees with a craftsmanship orientation, including job complexity, information processing, problem solving, and specialization. Leaders can enhance the meaning experienced at work by employees with a craftsmanship orientation by insuring these work attributes are present.

In terms of those employees with a serving orientation, it will be especially important to highlight the impact of the employee's work, as well as the work of the organization, on beneficiaries. As discussed earlier, Grant (2007, 2008) has argued that understanding the impact one's job has on beneficiaries can improve motivation and performance among employees, and therefore organizations should highlight this impact whenever possible. He discusses numerous ways to show employees the impact their work has on others, including hearing about other people benefitting from an employee's work, actual contact with the beneficiaries of the employee's work, and being provided information about characteristics of the people who have benefited from the employee's work. Seeing the impact one's work has on others should be especially impactful for those employees with a serving orientation.

For those employees with a kinship orientation, Pratt et al. (2013) emphasize highlighting the connections of the employee's work with the people around them. Employees with a kinship orientation should benefit from being part of a highly interdependent team, where each team member plays a critical role in the success of the group or organization. These types of employees will also look for opportunities to get together with fellow team members outside of the workplace, as cohesion between team members is especially important to employees with a kinship orientation. Morgeson and Humphrey's (2006) social characteristics of work are likely to be especially relevant to employees with this orientation, including the social support that is available, the interdependence of the organization, and the feedback employees receive from other employees.

In addition to structuring work in a way to promote meaningfulness, Pratt et al. (2013) also describe how organizations may change the culture in which employees work in order to enhance meaningfulness. The authors argue that employees with a craftsmanship orientation should benefit from an organizational culture that emphasizes quality in products and procedures. Furthermore, it is important for the organization to not only espouse a concern with quality and high standards, but also to follow through with the enactment of this concern through the provision of resources and exacting standards for performance. As discussed above, organizations seeking to create a culture of meaningfulness for employees with a service orientation can emphasize the importance of what employees do for different beneficiaries of their work, including not only individuals who benefit from the employee's work, but also how the community and even broader humanity benefit from the performance of the organization.

Finally, employees with a kinship orientation will benefit from an organizational culture characterized by an emphasis on the interconnections among the employees, and encouraging employees to look out for each other and provide help when needed.

Although the recent separation of a calling work orientation into craftsmanship, serving, and kinship orientations has not received empirical testing, we would argue that these different orientations to work likely have important implications for the health and performance of employees, and represent an important area for future research. It is likely that employees have varying degrees of all three orientations, and an interesting area for future research is to examine the interaction among the different dimensions in the prediction of performance and well-being within different employee samples. In addition, we are not aware of empirical research that has evaluated the authors' specific recommendations for organizational interventions based on these different orientations. However, as indicated above, empirical research does support re-designing work so that it is more likely to create meaning, and to highlight the impact an employee's work has on the beneficiaries.

Pratt et al.'s (2013) model has special relevance for astronauts on LDSEM as a function of the work orientations that different astronauts are likely to possess. As we will see in the description of our interviews with astronauts and support personnel, astronauts likely possess key attributes of craftsmanship, serving, and kinship orientations, with differences among astronauts in the intensity of the three orientations. Knowing the presence and degree of these orientations within each astronaut will help trainers and mission planners to create individualized strategies for enhancing the experienced meaning for each astronaut.

Theory and Research on Boredom and Monotony. Boredom can be described as "the aversive state of wanting, but being unable, to engage in satisfying activity" (Eastwood et al., 2013, p. 482). Eastwood and colleagues (2013) argue that boredom happens when three conditions are present: when an employee does not have the necessary internal and external resources to focus their attention on an activity, recognizes they are unable to direct their attention, and determines the environment to be the cause. The authors note that the experience of boredom can be characterized not only by low arousal emotions such as dejection or sadness, but also by high arousal emotions of anxiety and nervousness.

As discussed above, van Hooff and van Hooft (2014) provided evidence for bored behavior and work-related boredom as separate constructs. While bored behavior refers to behaviors focused on decreasing the negativity of boredom, work-related boredom describes a preceding negative affective state in which employees' do not see any meaning in their job tasks and do not feel challenged (van Tilburg & Igou, 2012), and thus have a hard time concentrating or finding interest in their work (Fisher, 1993). Mael and Jex (2015) further distinguished between episodic and chronic boredom, in which episodic boredom describes situations that may be boring at times and engaging at others. Chronic boredom, however, reflects consistently boring aspects of work that are necessary to performance in a particular role. Chronic boredom may lead to employees perceiving a lack of meaning or purpose in their role. Boredom may also be

situational or global, where situational reflects boredom in a single aspect of one's overall life, and global reflects personality characteristics that influence boredom in a multitude of situations (i.e. boredom proneness, Mael & Jex, 2015). However, while personality dispositions, such as a proneness to boredom and high levels of extraversion may influence the experience of boredom, researchers have argued that boredom is largely dependent on the work situation. Situations with monotonous, repetitive tasks, which lack a suitable workload and opportunity to utilize skills, may lead to work-related boredom (van Hoof & van Hooft, 2014; Fisher, 1993; Loukidou, Loan-Clarke, & Daniels, 2009).

Workplace boredom is very common, with reports ranging from 25%-87% of all employees reporting boredom at some point (Eastwood et al., 2013), and according to Mael and Jex (2015), reports have been recently rising. Empirical evidence demonstrates the negative effects of boredom. Past research shows boredom is associated with increased job dissatisfaction and counterproductive work behaviors, along with decreased effort and performance (van Hooff & van Hooft, 2014). Boredom has been specifically related to performance errors in pilots (Bhana, 2010) and nuclear military employees (Dumas, 2001), as well as a perception of slower time passage (Martin, Sadlo, & Stew, 2006), depression and anxiety (Goldberg, Eastwood, LaGuardia, & Danckert, 2011), drug and alcohol abuse (LePera, 2011), and even mortality (Britton & Shipley, 2010). Moreover, boredom is related to feelings of a lack of purpose or meaning in life (van Tilburg & Igou, 2012). Results from van Hooff and van Hooft (2014) further showed that work-related boredom is related to the negative work outcomes of counterproductive work behavior, distress, and depressive complaints through bored behavior. However, as noted above these effects decreased as employees reported more job crafting.

Eastwood and colleagues (2013) demonstrated that boredom may stem from mental processes and experiential components, which are influenced by chronic psychological components of weak attention systems, an inability to communicate a desired target, and stimulation sensitivity. Mental processes include a misallocation of attention, such as if there is a subtle distraction present that leads one to find the task at hand less interesting, particularly if the task is not engaging in itself. Mental processes also include when the employee attributes the difficulty of attention to environmental factors. Furthermore, a failure to sustain attention, particularly if the task is reliant on self-sustained attention without any resources in the environment to help focus attention, may influence boredom. Lastly, a failure to regulate arousal and focus attention may result in boredom, as situations of both low and high arousal have been linked to increased boredom (Martin et al., 2006).

Experiential influences on the experience of boredom include negative affect, often from the distaste for tasks outside of a main focus of attention, or from the disruption of attention. Additionally, a perception of time as passing slowly, recognition of difficulty concentrating and mind wandering, and an inadequate amount of arousal for the task (i.e., too low or too high) affect boredom. Experiential components also include constraints and disordered agency, which refers to employees feeling constrained in their choices and having to perform tasks that they do not want to, or are unable to perform tasks that they would choose to. Chronically bored

employees may not be able to be agentic in their behavior and communicate what they would like to focus on, feeling more passive and less determined (Martin et al., 2006).

Mael and Jex (2015) presented an integrative model in which workplace boredom leads to negative organizational outcomes of lowered satisfaction and commitment, along with increased turnover intentions and counterproductive workplace behaviors. Here, workplace boredom is shown to be directly influenced by the work environment, information technology use, and personal characteristics. Information technology use and personal characteristics also influence the strength of the relationship between the work environment and workplace boredom. While there is empirical support for the direct link of characteristics of the work environment, including job tasks, and social and physical environmental features to workplace boredom, there is much less research on the personal characteristics, and very little evidence towards the effect of information technology use on workplace boredom. However, personal characteristics are expected to influence boredom through boredom proneness, which describes employees that require higher levels of stimulation to avoid boredom, and unmet work expectations. Information technology is hypothesized to influence workplace boredom through its association with negative affect and technological limitations acting as barriers.

Overall, the models of boredom presented show support for both mental processes and environmental factors influencing perceptions of tasks and reports of boredom. Because astronauts are likely to experience boredom over the course of a long-duration mission, it is important to reduce monotonous and repetitive tasks wherever possible. In order to help diminish boredom and its negative effects, resources that may help to sustain attention should be incorporated into the environment (Eastwood et al., 2013). Distractions should be limited for those working (Mael & Jex, 2015), highlighting the importance of separate quarters for workspace and living space. Additionally, astronauts should have opportunities for job crafting wherever possible (van Hooff & Hooft, 2014) so they can focus on tasks they find meaningful and engaging.

In addition, astronauts should be encouraged to engage in task-related imagination, which may help to retain focus and avoid distractions from mind wandering (Eastwood et al., 2013). Astronauts should also be encouraged to help others and learn from one another (Mael & Jex, 2015). Such actions may work to combat boredom, as well as increase engagement and employee perceptions of meaningful work (Grant, 2007). In terms of measurement, Eastwood and colleagues (2013) recommend a recent, valid self-report measure of state-boredom, the Multidimensional State Boredom Scale. Objective measures may include observations of slouching or posture change, fidgeting, and physiological changes such as heart rate.

Organizational Constraints. Organizational constraints represent factors that prevent employees from performing at their maximum level. Constraints include a lack of resources, time, equipment, authority, or direction (Peters, O'Connor, & Rudolph, 1980). Organizational constraints are associated with a multitude of negative outcomes, including physical symptoms, such as gastrointestinal problems (Nixon et al., 2011), negative affect (Sonnentag & Starzyk,

2015), and work outcomes such as lower task performance (Gilboa et al., 2008) and extra-role performance (Jex, Adams, Bacharach & Sorenson, 2003).

Organizational constraints may lead employees to feel frustrated, dissatisfied, less motivated, and less efficacious. Employees under such conditions are likely to be more withdrawn and, according to social exchange theory, will not be motivated to provide for the organization when they are not receiving the necessary tools to complete their job tasks (Podsakoff et al., 1997). Additionally, employees who feel they do not have the appropriate resources to perform might form the perception that the tasks are not important or valued, and thus have less meaning. Therefore, it would be advantageous for supervisors to investigate if employees feel they are lacking resources, so they can work to find a solution and seek to remove any organizational constraints present whenever possible.

Astronauts on long-duration missions will conduct a wide array of job tasks in order to function as a self-sustaining vessel, and undoubtedly will experience constraints as a function of faulty equipment, unclear instructions, or unclear guidelines regarding what constitutes successful performance. Astronauts should also feel open to communicate any feelings of constraints, and these voids should be filled as necessary.

An Overall Model of Meaningful Work in Organizations. Many of the theories discussed thus far have drawn inferences about meaning through other areas of research, such as motivational theories on how one's job can be constructed in a way that increases meaning. Fewer theories have highlighted the specific processes by which work is perceived as meaningful and how such processes result in positive organizational outcomes. Rosso et al., (2010) summarized much of the extant literature specific to meaningful work. Their review of this literature contributes to a better understanding of the key sources and processes of meaningful work, as well as proposing simplified pathways of meaning.

In summary, Rosso et al., (2010) described multiple sources of meaning, which can include oneself, others within or outside the organization, the work itself, and one's spiritual life. These sources integrate many of the other models of employee motivation and meaning. Specifically, the work itself as a source of meaning can be understood through the models of job design, such as the JCM and the relational model of job design. Further, concepts from P-E fit emphasize perceived match between the sources from the work environment along with one's personal values and attitudes.

The model further discusses major mechanisms by which work is perceived as meaningful. These include authenticity, self-efficacy, self-esteem, purpose, belongingness, transcendence, and sense-making (Rosso et al., 2010). Again, these can be seen as components of many of the models, such as P-E fit where one may feel a sense of authenticity when their personal characteristics match that of the job or organization. Further, certain task characteristics may be associated with individual perceptions of self-efficacy or self-esteem. Lastly, the relational

model may help to explain a sense of purpose when individuals can see a connection between their work and those that they benefit.

Beyond these sources and mechanisms, Rosso et al., (2010) offered a simplified theoretical model of four main pathways by which work is experienced as meaningful. These pathways are based on two major dimensions. The first is a desire for agency versus a desire for communion or connection with others. They discussed these two factors as fundamental human desires, to experience mastery of some domain, but also to connect with others.

The second dimension was that actions could be direct toward oneself or others. Both experiences that help one to grow personally or feel accomplished and those that benefit others can be experienced as meaningful, but through different tasks or processes. Rosso et al., (2010) further combined these two dimensions into four major pathways by which work can be experienced as meaningful. The first is individualism, where one is focused on agency and the self. Individualism may be promoted more by the mechanisms of self-efficacy and self-esteem when completing work tasks. The second pathway is contribution, where individuals still desire agency but the impact is more targeted toward others. Thus, these employees may thrive on seeing purpose or significance in their work and a connection to others. The third pathway was self-connection, where the self and communion are emphasized. Meaning through this pathway may be derived from feeling authentically connected to others. The final pathway described was unification, which focuses on others and communion. This type of meaning may be more impacted by the mechanisms of purpose and belongingness, identifying with a social entity and feeling strong connectedness.

These four types of pathways were discussed as having different implications for the workplace, but may not necessarily be mutually exclusive. The same work experiences could activate multiple types of meaning. Further, activating more pathways could contribute additively to increased experiences of meaning (Rosso et al., 2010). However, this has not yet been empirically tested.

Based upon Rosso et al.'s (2010) analysis and our own review of the literature, Figure 1 describes an overall model of meaningful work. This model will serve as a framework for understanding the results of studies conducted with astronaut and analog samples described in the next section, and will also facilitate recommended interventions to enhance meaningful work during LDSEM. As seen in Figure 1, different sources of meaning include attributes of the individual employee, others connected to the employee, and the broader organizational culture in which the employee operates. These sources of meaning ultimately influence the perception of meaningful work through one or more of the mechanisms identified above: authenticity, self-efficacy, purpose, belongingness, transcendence, and sense-making. The Figure also highlights boredom, monotony, illegitimate tasks, and organizational constraints as factors that can thwart the processes that provide employees with meaning. Finally, the model highlights that individual and organizational interventions can be employed to both enhance the mechanisms that result in meaning and to mitigate those factors that are in opposition to meaning.

Section 2: Meaningful Work and Boredom/Monotony Among Astronauts and Analog Populations

At different points in Section 1 we provided a brief description of how the components in Figure 1 could apply to the sustainment of meaning for astronauts involved in LDSEM. In this section we review prior research with astronauts and employees in analog settings that has highlighted the importance of meaningful work and boredom/monotony in the adjustment and performance of these personnel. In most of the research reviewed below, meaningful work was not a primary or singular focus of the particular study, but was rather highlighted as one factor of many related to the adjustment and performance of astronaut and analog personnel.

The Role of Meaningful Work in Astronaut and Analog Samples

Meaningful Work among Astronauts. A number of research articles and NASA reports have highlighted the importance of meaningful work among astronauts. One of the richest sources of information regarding the importance of meaningful work in the adjustment and performance of astronauts comes from Stuster (2010), who analyzed the journals of 10 astronauts during their mission to the International Space Station (ISS). The author found that characteristics of the astronaut's work were mentioned more than any other category in the journals, and these entries covered how astronauts viewed the tasks that made up their day, how their work was scheduled, how they recovered from work, and the impact of monotonous versus meaningful work tasks.

Many reports in the journals regarding work were positive in nature, especially the meaningful work associated with extra-vehicular activities (EVAs) and being able to maintain key mission systems. Two representative quotes were "The EVA was a 'home run!' We did all of our tasks and then some" and "Busy day today! Lots of work on the ____ system. It was really fun getting in there and working on taking things apart and putting them back together again. Seems like that is the best work we have going on! It is fun. (p. 12)." Astronauts made many other positive comments about successfully accomplishing their work tasks, which clearly reflects the craftsmanship work orientation described in Section 1. Astronauts clearly find meaning in being able to thoroughly and successfully execute key tasks related to the mission.

Another important feature of the craftsmanship orientation to work on the ISS included the perception of whether the astronauts were ahead versus behind on a schedule. Successful performance is critical to employees who are highly engaged in their work (Britt et al., 2007), and the perception that work tasks are not being completed at a rate desired by mission control would be expected to negatively affect the morale of astronauts. Example quotes highlighting the importance of completing tasks in the expected time include "We were an efficient crew today. I was well ahead of the timeline all day, which feels really great. The contrast between being ahead and falling behind is huge in terms of how I feel during the day. (p. 12)" and "we are by nature and training, performance and goal-oriented. We tend to feel bad about ourselves if we do not complete the plan…. (p.12)." These types of responses clearly reflect the concern of astronauts with not only doing a good job on the key aspects of work tasks, but also completing

the tasks during the expected time allotment. Understanding the importance of pace of task completion for astronaut morale should result in careful consideration of task scheduling on future LDSEM.

Many of the recommendations made by Stuster (2010) based upon his analysis of the astronaut journals deal with strategies for insuring that astronauts remain engaged in what they consider to be meaningful work. These recommendations include: scheduling more tedious tasks across the crew, showing astronauts the results of their hard work, and insuring the timeframe for completion of tasks is appropriate. Additional recommendations for enhancing the meaning astronauts assign to their work were made by Peldszus, Dalke, Pretlove, and Welch (2014). These authors highlighted the importance of astronauts conducting scientific experiments that provided challenge and creativity from the astronauts, as well as taking advantage of the unique environment of the Mars spacecraft (see also Statler & Billings, 1989; Connors et al., 1985). The authors suggest leaving a portion of non-essential training to be completed while on the spaceship, having astronauts develop new skills on-board (e.g. medical skills, manual landing, or telerobotics), and insuring astronauts have time to pursue their own scientific interests in their work and free time given the uniqueness of their position in space. Such activities may include "opportunistic science", and "pleasantly immersive" activities such as growing plants (Horneck et al., 2000; Bishop et al., 2007; Zimmerman, 2003).

These recommendations echo those made by Vanhove et al. (2014), who conducted interviews with current and former NASA astronauts and NASA support personnel regarding their perceptions of what contributes to resilience among astronauts during space flight. One of the factors agreed upon by multiple SMEs was meaningful work, although the respondents did not go into detail regarding what constituted meaningful work. The SMEs also mentioned the importance of mission control in affecting the way work is presented, completed, and viewed. Finally, SMEs noted that giving crewmembers autonomy over executing tasks and taking care of the spacecraft will "provide the crew with meaningful tasks to help fill the transit time, fight off boredom and monotony, and generally keep the crew engaged during the flight." The SMEs also noted that training to address likely stressors in LDSEM cannot account for the meaning that will sustain crewmembers as they accomplish important scientific objectives associated with the mission.

Vessel (2014) also provided a number of strategies for making work more meaningful that have also been recommended by others, including providing crewmembers with greater autonomy in their work during transit and surface missions, insuring astronauts are allowed to contribute to mission goals as well as developing personal scientific interests, providing astronauts with additional educational opportunities, and tailoring resources to the uniqueness of the environment in which astronauts are operating. Vessel (2014) argued that allowing astronauts the freedom to engage in work they find personally meaningful should have a positive effect on their mood and performance.

Meaningful Work in Analog Samples. A number of authors have also addressed the importance of meaningful work in the adjustment of individuals in environments analogous to those encountered by astronauts (e.g. ICE settings such as winter-overs in Antarctica, submariners, military deployments). Much of this research has examined which coping strategies are most effective in the adjustment of individuals in analog environments. In this section we discuss prior research on coping in extreme environments, and highlight how meaningful work can be used as a successful coping strategy.

Researchers argue that apart from the duration of the mission, there are periods about halfway through the mission where individuals experience decreased team functioning, mood, and morale, making coping mechanisms a necessary component of missions in ICE environments (Sandal, Endersen, Vaernes, & Ursin, 2003). Common coping strategies reported in prior studies include focusing on the goal in sight, problem solving, engaging in challenges, showing a strong appreciation for the environment, flexible coping methods, and communication with team members (Sandal et al., 2003). Many of these coping strategies reflect attempts to place the mission of the employees within a more meaningful context. Those individuals who find their work significant, meaningful, and important, will be better able to focus on the main goal of the mission, the accomplishments they are achieving, and other work components, such as the an appreciation for the environment they are discovering.

For example, Kimhi (2011) conducted interviews with 12 members of an Israeli submarine to better understand successful coping, and found that overall, the experience was described as positive, meaningful, and unique. The military personnel displayed high amounts of positive thinking and optimism, as well as a sense of humor. Furthermore, the team embraced the importance of the service, and focused on the positive events and the positive aspects of their work more than the negative (Kimhi, 2011).

In the analog environment of an expedition to the North Pole, Leon, Atlis, Ones, and Mahor (2002) examined the weekly rating forms from a two-member male expedition team free from outside support that traveled to the North Pole across 55 days. The expedition members showed flexibility in their coping methods, reporting the strategies of keeping the goal in sight and maintaining a positive attitude, along with discussion of concerns with other members, relaxation, and meditation. In a semi-structured interview, one member discussed that he coped through working harder, focusing on the task at hand, planning out problem solving methods, and expressing positive feelings to his teammate. Both members noted positive experiences each week in regards to satisfaction with expedition progress, satisfaction in being able to cope with challenges, and enjoyment of the Artic Environment.

Persons on a High Artic Trek also demonstrated a focus on the goal and hard work as coping mechanisms (Leon, List, & Magor, 2004). As they became stressed when their plane for extraction arrived a week late, members were able to press on by keeping the goal in sight, looking at things in a positive way, thinking of something pleasant, and trying harder. Members

also coped through relationships, including talking things through, humor, writing in a diary, and prayer.

Further emphasizing the importance of a focus on problem solving, a study of 107 Japanese polar team members in the Antarctic for 3 years assessed self-report ratings indicating goal orientation, stress resistance, and reports of being aversive to arousal (Weiss, Suedfeld, Steel, & Tanaka, 2000). Over time, members displayed increased scores on planning orientation, showing increased attention to planning for problem solving as a coping strategy, but decreased in hardiness. This pattern of coping represents an increase in a craftsmanship orientation to work (Pratt et al., 2013), as focusing on the details of performance reflects a concern with the quality of the work itself during difficult times. In addition, these results also highlight a greater kinship orientation among the polar team members (Pratt et al., 2013), as the focus on relationships among the team members likely resulted in a greater concern with the functioning of the team itself. In another study, members of an analog crew for a 1-year mission to Mars who completed a High Artic Expedition reported their journey was enhanced by their love for the environment, adventure, exploration, and challenging experiences (Leon et al., 2002).

Supporting the notion of flexible coping, past research suggests that the environment and available resources may influence the participant's coping strategy, and that different coping strategies may influence symptoms of depression (Palinkas & Browner, 1995). For instance, a study of 121 members of the U.S. Antarctic Program over one year examined ratings of life events and occupational stress, personality (i.e., self-confidence and locus of control), coping methods and resources, social resources, and symptoms of depression. For coping methods and resources, participants indicated how often they used a particular method from a list of 32 strategies on a 0 to 3 frequency scale.

Members showed significantly increased symptoms of depression, utilization of avoidance coping, and emotional discharge after the winter in the Antarctic. At baseline, depressive symptoms were related to negative life events, education, job stress, low self-confidence, low social support satisfaction, and active-cognitive and behavioral coping strategies. At Time 1, depressive symptoms were related to negative life events, as well as avoidance, active-cognitive, and active-behavioral coping strategies. Symptoms were also related to information-seeking, affective regulation, and emotional discharge. Self-confidence and social support satisfaction were negatively related to depressive symptoms. Baseline measures of life stressors, personality, coping, and social resources were not associated with Time 1 symptoms of depression. Active coping may have influenced depression when members could not enact the strategies they hoped. The findings emphasize the importance of flexible coping, and could suggest that coping mechanisms reflecting on meaning, without requiring additional action, may be particularly useful.

Research with military personnel has also examined the role of meaningful work in the adjustment of service members serving on missions in isolated locations. Britt, Adler, and Bartone (2001) found that soldiers who were engaged in meaningful work during a peacekeeping

operation reported lower health symptoms during the mission, and in addition reported greater benefits from the mission months after it was over (see also Britt et al., 2007).

Britt and Adler (1999) also examined the role of engagement in meaningful work among military personnel (Army and Air Force) who were deployed on a medical humanitarian assistance mission to a remote city in Kazakhstan. Prior to the deployment, the authors surveyed service members regarding how much they thought they would experience stressors associated with isolation, boredom, and communication difficulties, and how much they thought they would use coping strategies such as actively solving problems and thinking about problems in a different way. The authors then assessed the actual report of stressors and coping strategies during the deployment. The results showed that stressors such as isolation, boredom, and communication difficulties were experienced to a greater extent than anticipated. In addition, service members reported less adaptive coping strategies than anticipated (e.g. lower problem solving, cognitive restructuring). However, despite the greater than expected stressors and lessor than expected use of adaptive coping strategies, symptoms of depression among the personnel remained low during the mission. Soldiers on the mission strongly endorsed statements reflective of the importance and purpose of what they were doing on the mission (which was to deliver medical equipment and training to the local population), and Britt and Adler hypothesized that the meaning soldiers assigned to their work and the mission may have protected them from the greater than expected stressors associated with isolation and boredom.

Salutogenic Growth in Astronaut/Cosmonaut and Analog Samples

A number of authors have recognized that successfully completing difficult missions has the potential to allow astronauts to grow from their experiences, resulting in a greater appreciation for life, recognition of the importance of family and other relationships, and a perception of being able to demonstrate resilience in the face of significant adversity (Ihle et al., 2006; Kanas et al., 1996; Leon et al., 1994, 2011; Ritsher et al., 2005; Suedfeld & Brcic, 2011). We argue this growth results largely from the increased meaning provided by being able to successfully accomplish difficult tasks in the face of unexpected demands, which contributes to the purpose astronauts assign to their work on a given mission.

Examining the positive consequences of space flight, Ritsher et al., (2005) assessed the frequency, intensity, and range of salutogenic experiences among people who had flown in space. The participants included 39 respondents from the Association of Space Explorers (ASE) and NASA who responded to the Positive Effects of Being in Space questionnaire (PEBS). The measure is based off the Post-Traumatic Growth Inventory (PTGI; Tedeschi & Calhoun, 1996), with additional items including representing potential positive experiences of being in space.

All of the participants reported positive experiences relating to being in space. In addition, perceptions of Earth had the greatest change from pre to post flight, including beliefs about the fragility and beauty of Earth. These perceptions were found to change individuals' behaviors, leading to increased environmentalism. The results also revealed two groups of participants that were differentiated based upon how much they changed as a result of their experiences in space.

Ritscher et al. (2005) hypothesized that personality traits might be responsible for who fell in to which group. These findings may provide evidence for selecting crewmembers for space flight who will have more positive experiences to the mission.

Ihle et al., (2006) expanded upon these initial findings and further investigated the differences between the two clusters found by Ritsher et al., (2005). Ihle et al. studied 39 participants who had been to space. All participants reported a positive reaction to being in space, suggesting that traveling to space is a very meaningful experience. The greatest change was for perception of Earth and its beauty and fragility, suggesting that it may be beneficial to have pictures and videos of Earth onboard for when it is out of view. This change was followed by increases in perceptions of space, changes in daily life (e.g., stronger relationship with family and appreciation for mankind), new possibilities (e.g., developed new interests), appreciation of life, personal strength (e.g., greater self-reliance), relating to others (e.g., more compassion), and spiritual change. The results again showed two clusters of participants based on whether they demonstrated high or low change. The more reactive group showed greater change in total scores, on all 8 subscales, and on most individual items.

The authors suggested that those with less of a reaction may benefit more from interpersonal interventions and increased communication with family, while those with a greater reaction may benefit from exposure to the cosmos and inspiring views. Astronauts who perceive positive psychological benefits may be better able to cope with stress knowing they are able to help society, advance technology, enhance knowledge of Earth and our environment, and through experiencing personal inspiration. This type of meaning-based coping may be more useful for long-duration space missions when there is limited social interaction (Ihle, Ritsher, & Kanas, 2006). Ihle et al., (2006) reaffirmed the benefits of examining positive space flight experiences, which may reveal methods of maintaining morale and countermeasures to stressors affiliated with LDSMs.

In addressing salutogenic growth following spaceflights, it is important to note that recently researchers have argued against using measures such as the PTGI, where individuals are asked how much a specific event has changed their perceptions in different domains. Critics of this approach argue individuals are not capable of judging how much a given event has changed them, and therefore responses to the items may be due to a host of factors other than the change caused by the event. In fact, Frazier et al., (2009) assessed the growth-related dimensions independently before and after a stressful event, and found that the perceived change on the growth-related dimensions was not related to the objective changes that occurred in the domains. Furthermore, objective growth was related to lower perceptions of distress, whereas perceived growth was related to higher perceptions of distress. Therefore, future research examining positive growth among astronauts deployed in support of difficult missions should assess growth-related domains before and after stressful events, and to document the actual amount of change and predictors of those changes (see Marshall, Frazier, Frankfurt, & Kuijer, 2015 for an example).

Suedfeld and Brcic (2011) examined how astronauts would respond to Erikson's (1959) critical conflict situations that may occur during one's lifespan, and how their stage of psychosocial development might be different before, during, and following a LDSM. Archival data were collected from 97 astronauts involved with NASA, the Russian Federal Space Agency (RKA), and other during long and short duration missions. The authors hypothesized that the astronauts would respond to the conflict situations in a positive manner, demonstrating high levels of cohesiveness, achievement orientation, and sense of identity.

The results revealed that astronauts reported significantly greater favorable outcomes across flight phases than unfavorable in response to Erikson's (1959) crises, including trust, autonomy, initiative, industry, identity, intimacy, generativity, and integrity. There were differences across space programs in favorable responses, with participants from long flight duration missions having the most consistently high favorable responses. Additionally, Suedfeld and Brcic (2011) found that across mission duration phases, integrity and generativity increase, revealing growth in the astronauts sense of fulfillment, satisfaction, and altruism from pre-flight through post-flight.

The Role of Boredom/Monotony and Organizational Constraints in Astronaut and Analog Samples

In addition to examining the role of meaningful work and salutogenic growth in the adjustment and performance of astronauts and personnel in analogous environments, researchers have also devoted attention to boredom, monotony, and other threats to personnel in ICE environments. In the present section we first discuss the relatively large number of authors who have identified boredom and monotony as concerns that are likely to face astronauts on LDSEM and employees in analog environments. We then turn to the less studied topic of organizational constraints among astronauts.

Boredom and Monotony. A large number of researchers have made the point that boredom and monotonous work are going to be concerns in LDSEM (Kanas, 1998; Kanas & Fedderson, 1971; Kanas et al., 2009; Peldszus et al., 2014; Otto, 2007; Stuster, 1996, 2010; Vanhove et al., 2014; Vessel, 2014). Peldszus et al., (2014) extensively discussed the importance of boredom and monotony in LDSEM, in fact calling the mission to Mars the "perfect boring situation." These authors borrowed the redundancy/variety model by Klapp (1986) to characterize boredom and monotony. According to Klapp's model, situations vary along the dimensions of redundancy-variety and meaning-entropy. Crossing these dimensions provides a four-quadrant model characterized by meaning, variety, entropy, and redundancy. Klapp suggests that boredom arises in the presence of redundancy and the completion of tasks that lack any meaning. He notes that meaningful redundancy and variety can be used to address boredom. Meaningful redundancy includes tasks such as customs, rituals, tradition, and skills. Meaningful variety includes tasks such as discovery, learning, and invention.

Vessel (2014) has discussed the lack of stimulation likely to be encountered on LDSEM as a type of sensory monotony that could have negative consequences for health and performance. He

notes that boredom and monotony may be especially likely after astronauts are in the stage of stagnation after their exposure to the ICE environment. As discussed above, Vessel (2014) cites meaningful work as a potential antidote to extended periods of boredom and monotony, along with other forms of sensory stimulation (e.g. exercise, exposure to nature, virtual reality).

Although numerous authors have cited a concern about boredom and monotony on LDSEM, no account we are aware of has documented the frequency of boredom and monotony on prior space missions. In the study of astronaut diaries referred to earlier, Stuster (2010) did provide sample entries showing that astronauts do experience monotony. Sample quotes included "I think I feel less of a sense of purpose if I don't believe in the tasks that I am doing. Of course, I will continue to do them and to press on. But, it does make the days go longer." and "I started the consumable audit-too tedious for words." Of course, no astronauts have been on space missions lasting three years in duration, or with transit phases of six months duration. Stuster (1996) believes that a mission to Mars will be characterized by periods of boredom and monotony, and provides a number of examples of prior expeditionary missions characterized by low workload conditions. He argues that "the theme that emerges from these and other examples of low workload conditions is that crewmembers must be engaged in meaningful, non-repetitious work to effectively pass the time during isolation and confinement for long durations (p. 88)."

Like other authors, Stuster (1996) recommends astronauts conduct recreational activities and independent study to address boredom, and for mission control to schedule mission-relevant tasks during periods that have the potential to create boredom (i.e. the transit phases to and from Mars). He also makes the important point that despite mission control's best efforts to provide continuous tasks to encourage engagement, it is inevitable that astronauts will find themselves experiencing prolonged periods of boredom. He argues that under such conditions, one skill astronauts need to develop is the ability to waste time and be idle without feeling guilty about not doing anything. Astronauts are achievement-oriented and motivated individuals who want to be engaged in mission-relevant action. Therefore, it may take some practice for astronauts to be comfortable not doing anything for extended periods of time.

Organizational Constraints. In Section 1 we referred to organizational constraints as factors in the work environment that interfere with successful performance. Examples include unclear instructions, faulty equipment, and the lack of critical supplies. Prior research has shown that these types of constraints affect employees who are the highest in job engagement, given that these employees care the most about doing well (Britt et al., 2012). Organizational constraints are inevitable on complex space missions, but an awareness of their influence on the motivation and performance of astronauts should serve to motivate efforts to keep constraints to the minimum level.

The presence of organizational constraints was evident in Stuster's (2010) analysis of astronaut journals, revealing incidences of equipment malfunction, unclear procedures, lack of information, and changing policies. Example quotes include "I still get frustrated by the degree to which we get left out of the loop. This has been a perpetual problem in the ISS crew world (p.

13)," "Several of the procedures, as usual, just took much longer than timelined. We have some tasks, as is too often the case, that were written without our input and which we never actually performed, except on paper," and "I had to laugh to myself at the procedures today. To replace a light bulb, I had to have safety glasses and a vacuum cleaner handy. This was in case the bulb broke. However, the actual bulb is encased in a plastic enclosure, so even if the glass bulb did break, the shards would be completely contained. Also, I had to take a photo of the installed bulb, before turning it on. Why? I have no idea! It's just the way NASA does things." These quotes reflect concerns about constraints in the execution of tasks that appear to have effects on the motivation and enthusiasm of the astronauts.

Summary of Astronaut and Analog Research on Meaningful Work and Boredom/Monotony

Our review of meaningful work and boredom in astronaut and analog samples reveals that a number of authors have mentioned meaningful work as being important in different space missions, and especially during LDSEM. In general, much more has been written on the role of monotony and boredom that is likely to be encountered during LDSEM, and less about the specifics of meaningful work as a mitigation strategy of monotony and boredom. Typically, authors do not go into detail regarding what is likely to make work meaningful for employees in ICE settings, but common recommendations include showing astronauts the results and impact of their hard work, allowing astronauts some autonomy over their work schedules, and encouraging astronauts to conduct their own experiments that are unique to their environment as well as engage in personnel hobbies that can be conducted in space.

The components of Figure 1 identify the different sources of meaning for employees, and the mechanisms that result in the experienced meaningfulness of work tasks. In addition, prior research has recognized that employees differ in which source or sources of meaning are most important to them, and prior research on astronauts and employees in analog settings has typically not recognized these individual differences. The next section of the report describes the results of a series of interviewees with astronauts, astronaut trainers, mission control personnel, and personnel from analog environment that goes into detail about what individuals in these environments find meaningful about their work, as well as their recommendations for encouraging astronauts on LDSEM to remain continuously engaged in what they consider to be meaningful work. We expect our interview responses will reinforce prior research with astronauts and personnel in analog environments, as well as reveal new insights into the role of meaningful work in the adjustment and performance of astronauts on LDSEM.

Section 3: Operational Assessment of Subject Matter Experts Regarding the Role of Meaningful Work in LDSEM

Overview of the Rational for Interview Questions

Our review of the academic literature on meaningful work and related constructs, as well as an examination of studies with astronauts and employees in analog environments, informed the creation of the interview guide used in the present research. We developed questions that discussed specific sources of meaning, mirroring the work of Rossi et al., (2010). Namely, we wanted to identify how different sources such as the work itself, other individuals from within the organization, family and friends, the general public, and personal goals and values influenced perceptions of meaning.

We also asked for specific examples of tasks that were meaningful, which could be understood through job design theories such as the Job Characteristics Theory. In addition to the sources of meaning, we asked about the major barriers to experiencing meaning. Namely, we wanted to identify factors that may induce boredom and factors could prevent astronauts from experiencing continuous meaning. We also asked for any specific indicators that an astronaut was experiencing a low level of meaning or a high level of boredom. Finally, we also asked our SMEs for recommendations they had for enabling astronauts to remain continuously engaged in meaningful work during LDSEM.

Interview Method

Participants

Interviews were conducted with nine Subject Matter Experts (SMEs) who have had direct involvement with space missions through primary or supporting roles or who had experiences with analog environments. These included individuals with a variety of job titles, who offered unique perspectives on the experience of astronauts and what methods could be used to enhance the meaningful nature of work. The job titles of individuals who were interviewed included: two former astronauts, a crew psychologist, an operations planner, a flight director, a crew trainer, an analog environment researcher, a capsule communicator, and an Antarctic explorer.

Procedure

The participants were interviewed using a conference call system. The interview lasted between 30 and 60 minutes. For several participants, the conference call was conducted with two research teams and the participant. Therefore, these hour conference calls were divided into two 30-minute intervals for each team. Full hour interviews were conducted with participants when the research team members were the sole investigators on the conference call. At the start of each call, the research team was introduced to the interviewee. In each interview, the principle investigator and one or two graduate research assistants were present. The interviewee was informed of the content of the study being conducted and their role in the study. They were further informed that while their responses would be used in identifying themes regarding

meaningful work, direct quotations and their names would not be provided in the final report. The interviews were not recorded; however, a graduate research assistant(s) took detailed notes of the responses to be used for further analysis.

Interview questions

The interview guide contained a total of 22 questions. There were three questions directed at the sources of meaning; five questions targeted the determinants of being engaged in meaningful work; two questions on boredom; and eight final questions on recommended interventions to sustain engagement and meaning. The interview was conducted in a semi-structured format, where several primary questions were addressed in every interview, but some were only asked of certain participants if it fit their specific expertise and the time constraints. Further, the interviews were conducted in a fluid manner, such that the interviewer would sometimes move to different questions as the topics came up rather than following a standard pattern of proceeding with each question in order. This allowed the interviewer to probe thoughts or comments that were brought up with additional questions as these topics arose naturally. A full list of the interview questions is included in Appendix B.

Interview processing

A coding scheme was developed to better understand common themes that emerged from the interviews. Our research team, which included the principle investigator, graduate research assistants, and an undergraduate research team, reviewed the interviews in two stages. In the first stage, each member read all of the interviews. The team identified several major themes that paralleled the academic literature on meaningful work, as well as any novel comments or discussions that were mentioned by the SMEs. The major themes that were identified from the initial review of the interviews were discussions of: what interviewees find meaningful about their work, task characteristics that contribute to meaning, factors that detract from meaning, and indicators of disengagement or boredom.

Within each of these major categories, there were between six and 12 sub-codes. In the second stage of processing the interviews, after the codes were identified, each research team member was assigned two interviews to review for more thorough coding. In each interview, the team member indicated whether or not a code appeared in the interview transcript. If the code did appear, examples that exhibited the code were marked. Then all quotes that were marked as exhibiting a particular code were combined into a final document giving the number of SMEs who mentioned the code, and examples of that code being discussed.

Results and Discussion

The role of meaningful work and common sources of meaning

At the start of all interviews, the astronauts and other personnel were asked what they found (or thought astronauts found) most meaningful about their work. A summary of the responses to this question are provided in Table 1. The responses to these questions reflected meaning derived

from broad contributions to humanity, as well as meaning from certain job tasks or feelings of personal fulfillment from the work. However, it is important to note that several of the interviewees commented that there were wide individual differences in what astronauts found meaningful. Many mentioned that the sources would vary from person to person. This was particularly highlighted with certain aspects of work, such as using social media, where some would find it much more meaningful with others.

Overall, many interviewees reported that broad contributions to humanity were highly valued among astronauts. A crew trainer noted the privilege astronauts feel from getting to go on missions that benefit the Earth and how we view the Earth. Several others, including the crew trainer, a crew psychologist, and a capsule communicator, specifically emphasized the benefits of being able to share their work through social media. This provided an opportunity to get feedback from the science community and the general public, and to see appreciation of the work they were doing. Some even noted the specific benefits of being able to share pictures to document what they were doing and share it with the public.

Closely related to benefits for humankind, many also discussed the contribution of educating and inspiring the next generation through their work. The crew psychologist noted that many of the astronauts loved getting to visit schools and talk with children about science. One of the explorers commented that the inspiration was not limited to inspiring students to be astronauts, but in inspiring kids to want to explore and engage in many types of science. These sources of meaning from contributing to humanity and the next generation reflect findings from the academic literature, where individuals experience meaning through seeing how one's work contributes to society. These sources highlighted a connection to the general public or to one's community that is discussed as important in the literature (e.g., Rosso et al., 2010; Grant, 2007; Grant et al., 2008). This also mirrors the task significance component of the JCM, seeing the significance of one's work (Hackman & Oldham, 1980). Grant (2007) also highlights connection with those who benefit from one's work as enhancing meaning. The astronauts were able to see how their work could contribute to the lives of others, both through providing more knowledge about the world to the general public and inspiration to the next generation in their communities to explore and consider engaging in science. Finally, these responses highlight the serving work orientation identified by Pratt et al., (2013).

Astronauts were also discussed as experiencing meaning from contributing to the missions and goals of NASA and that specific space flight. The crew psychologist, capsule communicator, flight director, and Antarctic researcher discussed the importance of contributing to the overall mission as meaningful. The flight director noted that many realize there are no unimportant roles in a mission and that keeping a big picture mindset was especially meaningful for astronauts. Others noted that engaging in tasks or experiments that contributed to the mission or general exploration goals was meaningful to them, particularly when they could contribute through tasks they were personally interested in or knowledgeable about. In addition to science and exploration goals, the Antarctic explorer and researcher, as well as a former astronaut, discussed meaning in the more maintenance duties. These individuals noted that astronauts see the importance in

maintaining the vehicle or station. Particularly when some of those tasks were challenging, they found it meaningful to problem-solve and make sure the station was operating smoothly in order to fulfill the larger mission. Many of these comments from the interviews reflect a fit and acceptance of the organization's mission and goals. Person-Environment Fit models would predict that astronauts should experience meaning when they share values and believe in the overall mission of the organization, and can see how their work contributes to those goals (e.g., Britt & Jex 2015; Kristof-Brown et al., 2002; Rosso et al., 2010).

Lastly, many interviewees reported feeling personally fulfilled or accomplished through their work. This theme of fulfillment was discussed in a variety of forms. First, to many individuals interviewed, it seemed important that astronauts knew they were doing work that was both important and difficult to "stroke their ego". The Antarctic researcher noted that it is very important that others acknowledge the value of what they are doing, even if they already see value themselves. The capsule communicator discussed that feedback on their overall value could involve comparing the astronaut's performance to others (e.g., breaking records for performing certain tasks), as well as receiving personal acknowledgement from support staff at NASA.

Family members who express pride in the astronauts' work were also an important source of meaning. As one example, the capsule communicator noted that astronauts feel a sense of pride when family members could see a story about their work on the news. In addition, the capsule communicator noted feedback from the public was very meaningful, particularly when astronauts get real time feedback or know their work will be discussed, such as through news reports. Such feedback through work and non-work sources could help contribute to task significance and feedback characteristics as highlighted in the JCM (Hackman & Oldham, 1980). Particularly in the case of comparing performance to others, astronauts could see where they were excelling and feel a sense of accomplishment from that feedback.

While specific task characteristics are further discussed in the next section, there were general comments that a match between an astronaut's skills and an assigned task was highly meaningful. The crew trainer and capsule communicator gave specific examples of individuals getting to use their personal experience and interests in different experiments. Delegating work in a way where crews are able to use their interests was discussed as a very effective strategy for enhancing perceptions of meaningfulness. Further, several interviewees mentioned that astronauts found meaning in conducting experiments that could only be done in space. The crew psychologist said that crewmembers are highly interested in conducting science in such an unusual environment. The capsule communicator also said that some astronauts would even use their free time to do additional experiments in the unique environment that aligned with their personal interests. These themes are reflected in the mechanisms that contribute to meaning discussed by Rosso et al., (2010). A high sense of authenticity and self-worth are likely to result when astronauts can use their specific skills to work on a task and feel like they are able to contribute uniquely to the mission.

Many times the crew also had to learn new skills or engage in tasks that they were not familiar with for maintaining the vehicle. The capsule communicator noted that many found it exciting when they had to do an unexpected maintenance task. The former astronauts found that maintenance tasks were important in connecting with the team, where they had to create partnerships and work together in problem solving when unexpected challenges arose. This was especially important for one astronaut on a mission where communication was limited. The astronaut noted that the crew had to be more flexible and creative in both working on experiments and other maintenance tasks.

When challenges or unforeseen situations came up, some noted that astronauts even enjoyed the element of danger. They were able to combine intellectual work with hands-on problem solving in such situations. The capsule communicator specifically noted that some maintenance activities, with or without inherent danger, could be a novel challenge if it was a procedure that had never been done before in space. Astronauts enjoyed these types of challenges. These characteristics reflect several features of the meaningful work literature. Specifically, crewmembers were able to experience skill variety when completing novel tasks (Hackman & Oldham, 1980). Further, in many of these maintenance tasks, crewmembers may have experienced task identity where they could see a procedure to completion, solving a whole problem rather than working on smaller task elements (Hackman & Oldham, 1980). Further, much of this may have worked through the mechanisms of enhancing individual self-esteem or self-efficacy (Baumeister & Vohs, 2002; Rosso et al., 2010; Spreitzer et al., 2005). Astronauts were able to overcome challenges in these situations and became more confident in their abilities.

Perceptions of work and task characteristics that are meaningful for astronauts and analog populations.

When discussing what makes work meaningful, common themes of task and skill variety, job control and autonomy, and understanding the importance of experiments emerged. An Antarctic explorer discussed how doing things in slightly different ways and being able to use a variety of skills can help to maintain focus, while a former astronaut and flight director further emphasized the importance of variety in set routines and activities. Moreover, a thermal control instructor reflected on a time when a crewmember was very satisfied with having skills to perform tasks that they hadn’t been formally trained on. In terms of job control, many noted it is advantageous when astronauts have the flexibility to own and organize their schedule; a tactic that a capsule communicator noted has received much positive feedback and helped to increase morale. Additionally, tasks which are known to be critical to the success of the mission, even if they are repetitive and boring, are perceived as meaningful when the importance is explained. An astronaut psychologist explained that while it is not often done, it is crucial to reference the big picture, and explain how particular tasks contribute to the overall goal.

Furthermore, interviewees discussed meaning stemming from an understanding of how individual contributions facilitate the success of the mission, the opportunity to help shape the

goals of the mission, and the importance of giving specific feedback to astronauts on their performance. More specifically, discussions revealed that astronauts want to be acknowledged with specific comments, receive both positive and negative feedback, and be recognized when they perform creative tasks. These specific task characteristics that were discussed as meaningful are summarized in Table 2.

The responses are congruent with components of the previously described Job Characteristics Model, which cites skill variety, task identity, task significance, autonomy, and feedback as motivating factors (Hackman & Oldham, 1980). The responses are also consistent with the model of thriving at work, which highlights the importance of opportunities for exploration and experimentation, an understanding of how one's contribution affects the overall goals, and understanding the meaning of specific tasks (Spreitzer et al., 2005). Past research also supports providing opportunities for job control and shaping goals through demonstrating relationships between job crafting and positive work outcomes (van Hooff & van Hooft, 2014).

Interviewees also discussed factors that decrease perceptions of meaningful work, many of which oppositely mirror the themes described above (see Table 3). Most commonly cited was having to do tasks with no explanation of why, thus not seeing how the task contributes to the overall goal, and not having the chance to provide input. For example, telling an astronaut to turn on a particular switch, without explaining the meaning or contribution of the task will likely be seen as meaningless. Furthermore, an Antarctic explorer explained how requests made without consideration of the environment or current situation could be frustrating. Similarly, an Antarctic explorer and flight director described situations where tasks seemed as if they were an afterthought that had not been planned out or prioritized appropriately decreased views of meaningful work. Moreover, a decrease in novelty and repeated maintenance tasks, such as changing air filters, which do not require advanced skills, may also contribute to decreased meaning. Such notions are congruent with past research regarding illegitimate tasks, which describes how unexplained tasks that are perceived as unnecessary or misaligned with one's expertise may lead to lowered engagement (Ogly & Kleespies, 2015) and lessened job satisfaction (Stocker et al., 2010).

Other reports mostly referred to communication issues, such as a lack of communication, misperceptions between the ground control and crew, and false or non-specific praise. A flight director described the importance of treating all crewmembers as part of the team, keeping them informed, as well as explaining the situation and why certain things need to happen. A capsule communicator also explained how the same conversations with the same people each day may come to seem boring and meaningless, particularly if one person is unfriendly or saying only the same thing repeatedly. Furthermore, giving the same positive feedback each day, or seeing positive feedback given that is unwarranted, may lead to team members to be cautious of praise. However, interviewees noted that it is still important to recognize performance, even for basic or maintenance tasks, and to treat all team members as important to the mission. Lastly, an astronaut psychologist noted that having to change roles during a crew changeover, such as from leader to follower, might decrease meaning.

In terms of living space, the separation from family, lack of separation of work and life in the capsule were indicated as factors that decrease meaningful work and engagement. A flight director described how the work can easily become tedious, especially when crewmembers cannot leave work at the end of the day as the members on the ground can, and the importance of recognizing that the crew still has a family back on Earth that they are involved with. Many noted how the novelty of exciting tasks wears off, and even meaningful tasks can become ordinary and boring over time, and members are left missing their family as time goes on. A thermal control instructor noted that technology might be a useful tool in offering ways for the crew to disconnect, relax, and connect with their family.

Furthermore, non-motivated team members may affect the mood of others and decrease perceptions of meaningful work in the team as a whole. Non-motivated team members were described as those who were not excited about the mission, and who may work less and wake up late. Multiple interviewees described how a disengaged team member could be infectious and decrease the motivation of others, and even lead members to question why they are working hard when others are not.

Indicators of boredom on LDSEM.

A summary of the main indicators of boredom for astronauts are summarized in Table 4. Astronauts who are bored may be unmotivated and display lowered performance. It was often described that members displaying signs of boredom and disengagement may not perform to the best of their ability, make simple mistakes, and fail to communicate effectively. They may not answer their radio or relay certain information to the control center, only engage in limited communication and short messages, or even fall asleep on the job. Additionally, they may show decreased motivation, and only do the bare minimum. These comments coincide with past research, which supports the relationship between boredom and errors (Bhana, 2010; Dumas, 2001) and lowered performance (van Hooff & van Hooft, 2014).

Many cited issues with sleep problems, including changes in sleep patterns, insomnia, and waking up late. It was also commonly noted that boredom might lead to voice changes and decreased involvement in social events. Indicators include a change in one's tone of voice, enthusiasm conveyed, and content of what is said. An astronaut psychologist suggested that if the technology to accurately analyze voice stress is available, it might be a useful tool. Moreover, decreased enjoyment in pleasurable activities, and pulling away from social activities, such as not attending scheduled dinners and mood changes, were cited as actions of bored or disengaged team members. Other behaviors discussed included reference to a disengaged, long stare. An astronaut psychologist described this phenomenon as when a member simply stares off into nothing, does not display any motivation, and is detached from their duties. In more extreme cases of boredom, persons may even show frustration or start arguments. A former astronaut explains how in such situations, members may start to badger one another and invoke conflict.

Recommendations for enhancing perceptions of meaningful work in LDSEM.

A summary of the recommendations provided by astronauts is provided in Table 5. When discussing strategies to increase engagement and minimize boredom for astronauts in LDSEM, many referenced opportunities for astronauts to utilize real time social media. However, the interviewees also noted that the use of social media should not be required, as it was noted social media may lead to unnecessary stress for those who do not wish to participate. Astronauts could access social media and release blog posts, photographs, and more in order to share with the public and get feedback. A former astronaut describes that for some, these interactions have served as the highlight of their mission. A capsule communicator reminisced about an astronaut who posted a picture from space each night. He recalled there were thousands of comments and responses from the public indicating how much those posts meant to them. It was described that having a large amount of interested followers to post towards is both satisfying and motivating for the crew, and receiving positive comments solidifies the meaningful work that the crew is involved in.

When organizing the mission, it was noted that astronauts would like to see that the crew was compiled so that each person fulfills a specific, specialized role. A flight director described how the ideal team is one where everyone has a specific job and are all seen as equals. Additionally, interviewees noted the importance of ensuring that the more specific goals in transit are related to the overall mission, and that this connection is conveyed.

Many interviews discussed the importance of providing astronauts with autonomy, and allowing them to organize their own schedule to complete the required tasks within a certain time frame. A former astronaut described how once tasks are divided, if there is no certain order they need to be performed in, it would be beneficial to allow astronauts to decide how and when to complete their duties for the day. A capsule communicator explained that there has been much positive feedback regarding increased control, and that flexibility can increase morale and efficiency. There could be also longer time periods set for tasks when appropriate, so that astronauts can set their own schedule to master completion. Such flexibility should be worked into the organization of the mission ahead of time. Furthermore, as astronauts have more autonomy and have the opportunity to make mistakes, it was described that it would be beneficial to track such mistakes and provide feedback, to discuss why they may be occurring and how they can be prevented. This was seen as particularly important since it could be an opportunity to address astronauts who may not be as engaged, and open discussion for ways to get them back on track.

There were also multiple references to providing astronauts with ample options to fill their free time with, so that they can do what interests and excites them. Examples included learning a new skill, starting new experiments on their own, growing plants or food, and making educational videos. Such recommendations are supported by the Job Characteristics Model, which states that tasks with more autonomy are associated with increased positive psychological states and positive outcomes, and that these positive outcomes may be highest for those focused on growth and development at work (Hackman & Oldham, 1980; Hackman & Oldham, 1976).

There were also suggestions on how to provide astronauts with fulfillment during transit. When considering scheduling, many suggestions referred to keeping the astronauts busy and spreading out important tasks across the mission so there is more of a steady flow of work. A flight director explained how waiting for six months or more to arrive at your destination is not meaningful. However, there could be various tasks to achieve along the way that astronauts can look forward to. An astronaut psychologist discussed how transit should be reshaped from being viewed as a waiting period, to a period of meaningful work, completing crucial tasks and prepping for arrival. For example, he recommended providing opportunities for astronauts to begin the initial processing of the materials collected and begin the experiments in order to practice a variety of skills and keep busy while traveling home. Interviewees also discussed ensuring the crew is sticking to a basic schedule that provides structure, including set times for meals, sleep, and free time. Having discipline during the day was seen as a good way to break up the time, and make the tasks seem more meaningful. In addition, it was seen as advantageous to have social rituals, such as shared meals, and celebrations for birthdays and holidays, and specific cultural events.

Furthermore, to help add some variety when in transit, it may be beneficial to vary communications between the crew and ground control. A capsule communicator described how he would make an effort to use different phrases so he was not always saying the same exact thing, as well as that a new person or voice could be a way to keep astronauts engaged. Ground control could also build humor and jokes into certain tasks, such as putting funny duties on a checklist. A flight director also shared their morning ritual of making a comic that reflected parts of the mission. They could also leave surprises embedded within the equipment, such as Easter eggs in the air filters, to help make things less predictable.

In regards to training, interviewees suggested performing training in transit so that there is more to do while traveling, and there is less of a waiting period between training and performance. Of course, all training should be relevant to the mission. Furthermore, astronauts should be encouraged to learn new skills and learn from one another. This includes cross-training each other and preparing for uncommon situations that may arise, which can be both fulfilling and useful. In order to prepare for combating boredom, astronauts could work to learn the best ways for them to deal with boredom beforehand, and work to set a plan on how to deal with boredom when it arises to be better prepared for the mission. For one former astronaut, it was having an array of books readily available. The crew could also be trained to identify basic mental health symptoms and indicators of boredom, so as to better help one another as necessary. The recommendations discussed receive support from the model of thriving at work, which stresses the importance of exploring and experimentation at work, along with relating to and learning from others (Spreitzer et al., 2005).

Lastly, the importance of incorporating families was also discussed. For example, there were multiple references to being able to have conversations with family on a private line, rather than over the radio. In addition, the use of virtual reality can allow astronauts to spend time with their family virtually, going through their home, their favorite vacation spots, or even to new places or current events that the family is experiencing while they are away. This could also be done in a

realistic but artificial space, so the astronaut can utilize it at any time. In addition to allowing the astronaut to be included with their family, interviewees also noted the importance of including the family more in the mission. This includes informing the family of what their astronaut is up to, and providing them with some basic knowledge and training to better understand the astronaut's tasks and daily life. This may help make them feel more connected and allow them to better relate to their astronaut.

Section 4: Guidelines for Future Research on Meaningful Work as a Buffer Against Stressors During LDSEM

The reviews of the broader academic literature on meaningful work and prior analyses of meaningful work among astronauts and employees in analog settings, along with the responses to the operational assessment, point to a number of potential interventions and recommendations for future research. In this final section of the report we provide recommendations for future research on the assessment of meaningful work and boredom during long-duration missions, and on interventions that should serve to enhance astronaut perceptions of being engaged in meaningful work during LDSEM.

Assessment of Meaningful Work, Boredom, and Growth on LDSEM

Despite a large number of authors discussing the importance of meaningful work and boredom in the adjustment of astronauts on LDSEM, there is a surprising lack of measurement tools to assess meaning and boredom among astronauts. One direction for future research is to develop multiple measures of engagement in meaningful work and boredom so that astronauts and flight directors can determine whether interventions are needed to enhance meaning when necessary. Although there are measures of meaningful work and boredom in the academic literature, these measures do not appear well-suited for the astronaut community. In addition, the measures that exist are all self-report, and it would be desirable to have some measures that do not require astronauts to report on meaning and boredom.

Therefore, one area for future research is to develop and validate brief self-report measures of engagement in meaningful work or thriving at work, as well as unobtrusive measures of boredom. Porath et al., (2012) recently developed a relatively short measure of thriving at work that assesses both vitality and development at work. Highly loading items from this assessment could be used to assess thriving during LDSEM, as well as select items from the Steger, Dik, and Duffy (2012) measure of meaningful work. In terms of unobtrusive measures of meaningful work and boredom, the results of the operational assessment interviews revealed a number of recommendations for assessing meaning and boredom, including perceived changes in the pitch of voice, extent of participation in social activities, changes in sleep patterns, and slips in performance (e.g. making more errors). NASA is currently supporting research examining novel measures of sleep patterns and social activities, and one or more of these indices could be utilized to track the extent of astronaut engagement in meaningful work. Further research could also identify cut points where interventions to enhance engagement in meaningful work were needed.

Another assessment in need of development is the extent astronauts possess different work orientations. In the section of the literature review describing the model of meaningful work by Platt et al. (2013), the authors highlighted the importance of knowing the work orientation that characterizes employees. Given that most astronaut candidates likely possess a calling orientation to their work, it would be worth developing assessments of the three types of calling

orientations identified by the authors, including craftsmanship, serving, and kinship orientations. Currently no reliable and valid measurement instruments have been developed to assess these work orientations. In addition to developing self-report measures of these orientations, it might also be possible to develop more indirect measures of the orientations, based on open-ended descriptions of what astronauts find most meaningful about being part of different types of missions. These open-ended descriptions could be coded for the presence of the different calling orientations. Knowing the extent to which astronauts possess the different calling orientations to work will inform the types of interventions that will be most effective at sustaining perceptions of meaning during long and difficult meetings.

A final area in need of assessment involves the concept of growth among astronauts as a result of participating in different types of missions. Prior research has used a variant of the post-Traumatic Growth Inventory (PTGI; Tedeschi & Calhoun, 1996) to assess the presence of growth among astronauts, with additional items added highlighted unique areas of growth for astronauts. Much of the research in this area has assessed growth using the inventory after astronauts have returned from a mission, asking astronauts to reflect on how much they have changed in different areas as a result of the mission. Given the limited ability individuals have for judging the amount a particularly event has affected them in different areas, it would be preferable to develop an instrument of strength-related domains, and assess those domains before and after a particular mission. This instrument would facilitate an understanding of not only the potential negative consequences of participating in a LDSEM, but also the positive effects of the mission on the astronaut.

Testing the Effectiveness of Tailored Interventions to Enhance Meaningful Work

In the prior section of the operational assessment, SMEs provided their recommendations for sustaining engagement in meaningful work during LDSEM. The recommendations offered can be understood within the context of the literature reviews on what makes work meaningful for employees. One of the most mentioned strategies for sustaining engagement in meaningful work during LDSEM was the strategic use of social media to reach out to the broader scientific community and broader humanity regarding the mission. SMEs emphasized the importance of impacting broader humanity as a source of meaning for astronauts, and social media represents a valuable tool in allowing such impact to occur. SMEs cautioned that the use of social media should not be required by astronauts, given individual differences in preference for the communication medium and potential stressors associated with responding to comments. Therefore, future research should examine the effectiveness of training designed to encourage the functional use of social media to enhance meaning through outreach to others, while preventing the potential negative outcomes associated with the use of social media.

In the previous sub-section we described the need for measurement instruments designed to assess the presence of different work orientations that characterize astronauts. A primary purpose of knowing the work orientation of astronauts is to be able to tailor interventions that enhance the meaning astronauts associated with their work. Astronauts characterized by a craftsmanship

orientation to their work enjoy work tasks themselves, appreciating their ability to perform the "nuts and bolts" of work tasks, especially under difficult operational conditions. Therefore, genuine feedback on the quality of their work should be the most effective at encouraging meaning. Astronauts characterized by a serving orientation like to know the broader impact their work is having on others, with others being defined as fellow team members, the broader NASA organization, and/or broader humanity. Interventions most likely to enhance the meaningfulness of work astronauts characterized by a serving orientation include knowledge of the beneficial impact the mission is having on others (e.g. a video of a student inspired by the mission; feedback from a PI on how an astronaut's work on an experiment will contribute to a better understanding of a certain area of science). Finally, astronauts characterized by a kinship orientation to work place a high degree of emphasis on the cohesion and comradery of the team, and will find their work more meaningful when the mission of the team itself is highlighted. Research examining the effectiveness of such tailored interventions at enhancing the meaning of work for astronauts is needed.

As indicated in the literature review, most astronauts report that their involvement in space missions has resulted in positive outcomes, including an increased appreciation of the Earth's beauty, a greater sense of universalism, and a greater appreciation for life and family. These benefits are at times mentioned in astronaut journals during space missions, but astronauts also report that they use the journals to "vent" regarding stressors that are encountered (Stuster, 2010). Prior research shows that expressing gratitude for positive features of the work environment results in more positive well-being for employees (Lyubomirsky & Layous, 2013). One area for additional research would be to assess the effects of a more structured journal format where astronauts are asked to specifically comment on aspects of their work and work environment for which they are grateful. Such an intervention could increase well-being and perceptions of meaning on LDSEM.

As noted in the section on meaningful work and boredom among astronaut samples, many authors report that boredom and monotony will be concerns for astronauts on long-duration missions. Given the importance of preparing employees for the demands likely to be encountered in their work environments (Saunders, Driskell, Johnston, & Salas, 1996), future research should examine the benefits of exposing astronaut candidates to work conditions characterized by boredom, and having astronauts develop coping strategies they find effective for addressing the conditions of boredom. Stuster (1996) argued for the benefits of individuals in ICE environments learning to be comfortable with not doing anything when conditions prevent activities. Such training may be helpful when astronauts have exhausted their coping strategies for encountering boredom.

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Table 1. Number of interviewees who reported different sources for what they found meaningful about their work.

Theme	*N* (out of 9)
Contributing to humanity/humankind	6
Contributing to the overall mission	4
Knowing they are doing important and difficult work; knowing how they are performing relevant to other astronauts	4
Exploration, combining physical/hands-on/intellectual challenges	4
Problem solving/fixing something	4
Overcoming challenges, unforeseen situations, or elements of danger (e.g. unexpected EVAs, fixing experiments, creative partnership with principal investigators, fixing equipment)	4
Learning new skills (e.g. technical, professional development)	4
Contributing to next generation (e.g. students)	4
Personal interest in the work-relevant to own skills and abilities; bringing in one's own interests	3
Being involved in important science experiments that can only be done in space	3
Contributing to successful operation of the vehicle/station	3
Mentioned wide variety of individual differences in what astronauts find meaningful about their work	3

Table 2. Number of interviewees who reported characteristics of tasks that contribute to meaningful work.

Theme	*N* (out of 9)
Task variety / variety of skills /not monotonous	6
Feeling personal control over their schedule, greater autonomy in execution of task	5
Understanding importance of the experiments conducted (even if do not understand all parts of the experiment)	5
Understanding the purpose of the experiment, how their involvement contributes to the overall success of the experiment and big picture of the mission	3
Being acknowledged and given feedback by the principal investigator and ground control/ recognition for performance following tasks/ specific feedback on how they did.	3
Personal involvement in shaping mission goals before the mission	1

Table 3. Number of interviewees who reported different factors that decrease meaningful work and engagement.

Theme	*N* (out of 9)
Told to do tasks without having an explanation of why/not understanding purpose/big picture	4
Lack of or no communication regarding experiments	4
Misperceptions between ground control and crew	4
Combination of decrease in novelty and time away from family	4
Repeated maintenance tasks (e.g. Changing air filters)	3
False praise, non-specific praise	3
Non-motivated team member “infecting” other team members	3
When things hadn’t been planned out and they get afterthought jobs	2
No separation of work and life	2
Change in roles during crew changeover (e.g. was leader, now follower)	1

Table 4. Number of interviewees who reported different factors as indicators of boredom.

Theme	*N* (out of 9)
Sleep, any changes in patterns of sleep, sleeping more or less, circadian rhythm misalignment	4
Slipping in performance (*Example:* Falling asleep on the job)	4
Social / pulling away from social activities/ skipping meals meant to be spent with others	3
Decreased motivation	3
Voice changing; you can tell from their voice, enthusiasm out of voice	3
The ‘’long stare”	2
“Just know it”	1
Frustration (“short-fuse”)	1
Decreased enjoyment in things they would normally enjoy	1

Table 5. Number of interviewees who reported different strategies to increase engagement and minimize boredom.

Theme	*N(out of 9)*
Real time social media (but not a requirement for astronauts)	6
Provide autonomy for astronauts: provide them with a list of things to do, and have them do them (more tasks "flexible" that can be done at any time)	5
Conduct training in transit so it occurs closer to actual performance	5
Free time options (e.g. encourage hobbies, personal experiments)	4
Building teams with tasks in mind (not just randomly selected members); insure different team roles/mix of people; picked to specify different roles	4
Encourage astronauts to learn new skills (e.g. basic medical skills), cross-train one another, preparing for contingencies that hopefully do not happen	3
Track mistakes/errors, talk about why they are occurring (assumes freedom to make mistakes)	3
Spread out important tasks across the crew and across the mission	2
Insure crew is on a schedule, at least in terms of eating meals, free time, and sleep; some structure desirable, especially when a lot of down time	2
Private conversations with family	2
Have crewmembers learn how they best deal with boredom before the mission; have individual plan for what to do when boredom sets in	2
Keeping busy (make sure work days are long and astronauts are kept busy)	2
Use of humor (e.g. ground control comes up with funny jokes embedded in tasks)	2
Use virtual reality, so that astronauts can be with their family virtually, even at vacation spots; use of iPad so astronaut could witness family events; makes sure	2

shared events	
Insure training is relevant to the mission	1
Vary communication between ground control and crew (e.g. vary voices doing the communicating, different words to convey same meaning)	1
Insure in transit goals are connected to the success of the overall mission	1
In addition to a daily schedule, have longer term time periods as well (e.g. have fire training done in next two weeks)	1
Make family more integrated with work (family is aware of what astronaut is doing, give family members some of the same training, family-team effort)	1
Have social rituals that increase cohesion (e.g. meals together, celebrate birthdays, celebrate important holidays for each crewmember)	1
Surprises embedded with equipment for tasks (e.g. Easter eggs)	1
Have crew trained in basic psychological knowledge (perhaps mental health first aid; therapeutic training) each crewmember understands key mental health symptoms/indicators of boredom, so he or she can intervene/help if necessary	1
On transit home, encourage initial processing of material/experiments conducted	1

Appendix A

Sample Measures of Meaning and Meaningful Work

Meaning Making (Van den Heuvel et al., 2009)

1. I actively take the time to reflect on events that happen in my life.
2. I have an understanding of what makes my life meaningful.
3. I prefer not to think about the meaning of events that I encounter (r).
4. When difficult things happen, I am usually quick to see the meaning of why they happen to me.
5. Self-reflection helps me to make my life meaningful.
6. I actively focus on activities and events that I personally find valuable.
7. I feel my life is meaningful.

The Comprehensive Meaningful Work Scale (CMWS; Libs-Wiersma & Wright, 2012)

1. I have a sense of belonging.
2. I can talk openly about my values when we are making decisions.
3. We talk about what matters to us.
4. We support each other.
5. We reassure each other.
6. We enjoy working together.
7. I feel I truly help our customers/clients.
8. We contribute to products and services that enhance human well-being and/or the environment.
9. What we do is worthwhile.
10. We spend a lot of time on things that are truly important.
11. I create and apply new ideas or concepts.
12. I make a difference that matters to others.
13. I experience a sense of achievement.
14. I am excited by the available opportunities for me.
15. At work my sense of what is right and wrong gets blurred (reverse scored).
16. I don't like who I am becoming at work (reverse scored).
17. At work I feel divorced from myself (reverse scored).
18. At work we face up to reality.
19. We are tolerant of being human.
20. We recognize that life is messy and that is OK.
21. I feel inspired at work.
22. The work we are doing makes me feel hopeful about the future.
23. The vision we collectively work towards inspires me.
24. I experience a sense of spiritual connection with my work.
25. In this work I have the time and space to think.
26. We have a good balance between focusing on getting things done and noticing how people are feeling.
27. I create enough space for me.
28. I have a good balance between the needs of others and my own needs.

The Work and Meaning Inventory (WAMI; Steger, Dik, & Duffy, 2012)

1. I have found a meaningful career.
2. I understand how my work contributes to my life's meaning.
3. I have a good sense of what makes my job meaningful.
4. I have discovered work that has a satisfying purpose.
5. I view my work as contributing to my personal growth.
6. My work helps me better understand myself.
7. My work helps me make sense of the world around me.
8. My work really makes no difference to the world (reverse scored).
9. I know my work makes a positive difference in the world.
10. The work I do serves a greater purpose.

Appendix B

Interview Schedule: Meaningful Work During Astronaut Missions

Sources of Meaning in the Astronaut's Job

1) What do astronauts find most meaningful or significant about the work they do?

2) Can you give a specific example where an astronaut commented about a particular aspect of work being especially meaningful?

3) What makes a specific task meaningful for an astronaut?

4) How does an astronaut's view of their work as meaningful fluctuate throughout a mission?

Determinants of Astronauts being Engaged in Meaningful Work

1) Prior researchers have discussed the importance of employees being personally engaged in their work, which results in dedication, absorption, and high energy. What are the biggest determinants of engagement among astronauts, both in general, and during LDSEM?

2) What can different NASA personnel do to help the crew view their work as more meaningful?

Flight Director.
Mission Planner.
Crew psychologist.
Capsule communicator.

Follow up: How do leaders influence an astronaut's engagement in meaningful work?

3) How might family, friends, and the broader public be important in influencing astronauts sustaining their belief that they are involved in meaningful work?

Follow up: How might social media be influential in the meaning astronauts assign to their work.

4) What do you see as the main threats to astronauts continuously approaching their work with a high level of engagement and meaning?

5) To what degree can astronauts be involved in the crafting of their jobs? How constrained are tasks and their working relationships and in what aspects do they have freedom to adapt the job to their personal styles/preferences?

Boredom and Monotony During Space Missions

1) The flip side of meaningful work is boredom and monotony, which have been mentioned in prior studies of astronauts and personnel in analog environments. What do you think are the main determinants of boredom for astronauts on space missions?

> Follow up: There is a special concern regarding the lack of meaningful work and boredom during the transit phases of LDSEM. How might this be a problem?

2) What are the negative effects of boredom for the astronaut's well-being or work performance?

Intervening to Increase Sustained Engagement and Meaning

1) What are good indicators that an astronaut is personally engaged in what they view as meaningful work?

2) What are good recommendations for strategies to increase engagement and views of meaningful work?

3) What cues might prompt an astronaut that boredom is setting in and action is necessary?

4) What are good recommendations for strategies to prevent boredom, especially during the transit phase of a LDSEM?

5) How important is sleep in maintaining engagement?

6) How important is detachment from work in maintaining engagement?

7) What are strategies for having astronauts detach from work in order to replenish their resources, especially during a LDSEM where the astronaut's work environment represents a "total institution"?

Additional Questions

1) In the astronaut journals the topic of morale came up. Would it be worth having a brief measure of morale that astronauts complete? Or perhaps have an application on a computer?

2) Are there any mental health symptoms that you think are partially or fully the result of astronauts not being able to find meaning in their work?

3) Is there anything else you would like to communicate regarding how the nature of the astronaut's work influences his or her health, well-being, and performance, especially on LDSEM?

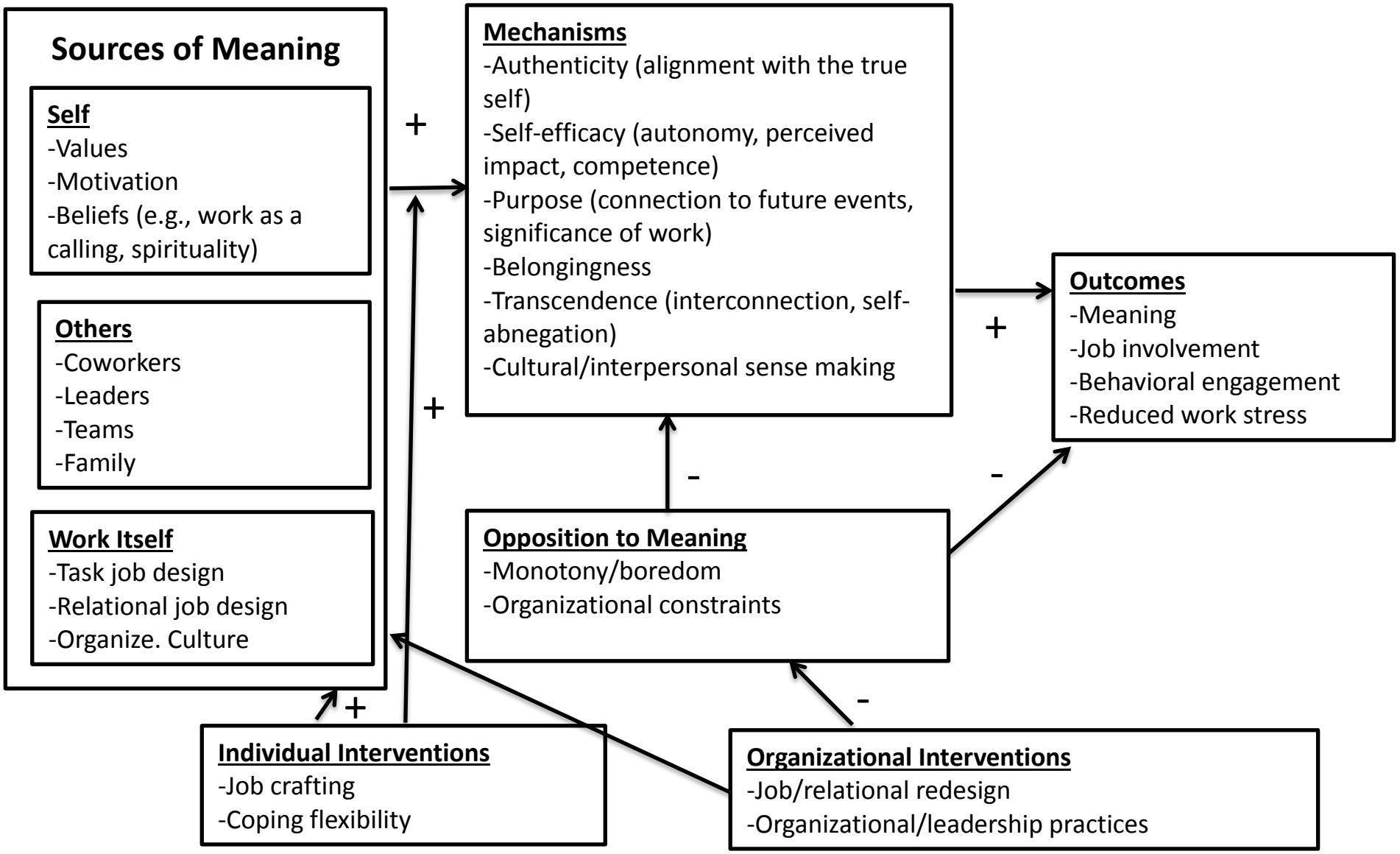

Figure 1: An Overall Model of the Determinants of Meaningful Work

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13. ABSTRACT *(Maximum 200 words)*

This report constitutes the third deliverable for NASA Contract Number NNJ15HK13P titled “Meaningful Work.” This report is presented in four different sections. The first section reviews academic research on meaning in life and meaningful work, as well as research on boredom and monotony. The second section reviews prior research on the role of meaningful work and boredom/monotony in the adjustment and performance of astronauts and personnel in analog environments. The third section presents the results of an operational assessment of interviews with nine subject matter experts (SMEs; astronauts, explorers, astronaut trainers, mission planner, flight director) on the role of meaningful work in the adjustment and performance of individuals in isolated, confined, and extreme (ICE) environments. The final section includes recommendations for interventions designed to enhance the perception of meaningful work on long-duration space exploration mission (LDSEM), and directions for future research on meaningful work as a stress mitigation strategy for astronauts on LDSEM. The key conclusions from the report regarding the role of meaningful work for astronauts on LDSEM are described below according to whether they are based on the literature reviews or the operational assessment of SMEs. Recommendations for future research are then briefly highlighted.

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