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Leadership for long-duration space missions: A shift toward a collective approach

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ABSTRACT

For many years, leadership operations within the National Aeronautics and Space Administration (NASA) have utilized a primarily hierarchical approach. In the present effort, we investigated the leadership needs and considerations given the increased interest in and potential for long-duration space exploration. Specifically, it is argued that a collective leadership approach in which leadership is shared and distributed based on expertise would be beneficial for these types of missions. Interviews were conducted with eleven subject matter experts with wide-ranging experience in NASA and its missions. A mixed-methods analytic approach applied to these interviews provided support for the viability of a collective leadership framework. Implications for NASA and other similar organizational contexts are discussed.

1. Introduction

As the 21st century bears witness to unparalleled technological advances, the National Aeronautics and Space Administration (NASA) sets its sights on uncharted voyages including a human expedition to Mars. Missions of this nature pose unprecedented challenges, physical and psychological, for both Mission Control and the astronaut crew. Identifying and buffering against these challenges has prompted numerous researchers to investigate the effects of space travel on human performance [1–4]. During interplanetary travel, the crew will be confined in close quarters and have periods of extended communication delays with Mission Control. Adaptations to the current leadership paradigm should be considered due to the uncertain, more complex, and particularly dangerous nature of future space exploration missions [4].

Any long-duration space mission, including the Mars Mission, will present challenges for the crew as well as Mission Control due to the high levels of danger, boredom, and stress involved [2]. For example, a mission to Mars could last 3 years with 6 months of travel time in each direction [4]. These extended travel periods will potentially feature significant periods of downtime and boredom for the crew. In addition, the communication delay between Earth and the space crew will last approximately twenty minutes on average, suggesting that the crew will need to assume greater autonomy during these periods [4]. Given these novel constraints for space travel, a shift in NASA's leadership paradigm should be considered to effectively combat the challenges of such a mission.

In the present effort, the leadership paradigm at NASA, past and present, is reviewed and considered in light of the challenges associated with long-duration space exploration. The challenges associated with long-duration space missions offer implications for leadership operations at NASA, both within Mission Control and the astronaut crew. To assess the potential impact, interviews were conducted via telephone with 11 subject matter experts at NASA regarding perspectives on past leadership operations and considerations for future long-duration space exploration. The purpose of the present effort is to examine these perspectives to determine what must be changed with respect to future leadership operations.

2. Traditional leadership culture at NASA

Throughout much of its history, NASA's leadership operations have relied primarily on the directives of Mission Control, particularly the Flight Director. As a result, for many years, astronauts

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have had little autonomy or discretion in decision making during missions. The nature of these leadership operations are perhaps best illustrated in the 2001 autobiography of former Flight Director, Gene Kranz, *Failure Is Not An Option.* In one passage, Kranz [5] states, "The military has long used the command-and-control principle and now it was formalized in Mission Control… a new deal that gave the crew control of the spacecraft and gave the ground command of the mission" (p. 131). This passage makes two points apparent regarding mission operations during NASA's early days. First, missions were primarily at the discretion of Mission Control, such that the schedule and operations were mostly formulated within Mission Control. Second, as a result of these mission operations, the crew was granted little autonomy in terms of executing missions. In short, the responsibility of planning mission operations resided mainly with Mission Control while the crew implemented and executed the operations schedule outlined by Mission Control. As the agency evolved, it soon became apparent that this leadership approach presented benefits as well as significant costs.

In particular, although leadership operations in the early days of NASA offered little autonomy to the crew, this approach was valuable for short missions (e.g., several days or weeks) for two reasons. First, the high level of discretion possessed by Mission Control reduced any potential ambiguity with respect to the role of Mission Control or the crew in mission operations. This approach ensured the schedule would be developed by Mission Control and, in turn, executed by the crew. Second, if any problems or challenges arose during a mission, the crew could contact Mission Control for assistance with little to no communication delay. Crews cannot be prepared for every contingency and issue arising during missions. Mission Control serves as a crucial source of support in a variety of ways, from facilitating ground to crew communication, providing technical information and problem solving, modeling and testing solutions, and attending to astronaut physical, social, and mental well-being, among many others. These two key features suggest that hierarchical leadership operations during NASA's early days offered benefits for both the crew and Mission Control.

Despite these benefits, the embedded hierarchical structure at NASA has also contributed to suboptimal outcomes [6]. Namely, an inability to consider the perspectives of engineers contributed to two unsuccessful mission outcomes. In the case of *Challenger*, engineers expressed concern the night prior to launch regarding the abnormally cold temperatures at launch and their potential effect on the O-rings. Despite these warnings, upper management proceeded with the mission, and *Challenger* suffered catastrophic loss of structural integrity approximately 1 min after launch. With regard to the *Columbia* mission, upper management once again denied requests from engineers to take images of the damaged left wing, and soon thereafter, the shuttle disintegrated upon re-entry [6]. Although these events were largely the result of technical issues, the role of hierarchical structure also contributed to the inability to correct these mechanical malfunctions. In both scenarios, production pressures limited the influence of engineers requesting a reevaluation or further inspection of technical operations. Rather than postponing missions to assess potential system deficiencies, upper management proceeded with the launches as scheduled. It should be noted that in future long-duration space missions, the crew will likely be composed of astronauts with an engineering or science background [4]. Thus, a hierarchical structure which utilizes the decision making of a select few limits the capacity for successful mission operation.

3. Current leadership culture at NASA

Despite the hierarchical nature of NASA's traditional leadership culture, much time has passed since the *Gemini* and *Apollo* missions when Gene Kranz served as Flight Director. The current leadership culture at NASA appears to be shifting away from this hierarchical approach based on two pieces of evidence. First, NASA has developed a leadership model featuring five competencies: personal effectiveness, leading people, business acumen, managing information and knowledge, and discipline competency [7]. Thus, the leadership model offers a multifaceted approach to leadership in which multiple, varied competencies are being developed and assessed. Second, two leadership development programs, NASA Foundations of Influence, Relationships, Success, and Teamwork and NASA Mid-Level Leader Program, offer training opportunities for lower- and mid-level scientists, engineers, and administrative professionals, respectively [7], both of which emphasize the development of competencies presented in the leadership model. Taken together, this evidence suggests that NASA has begun to shift leadership operations away from a top-down command-and-control model. In addition, the evidence would suggest that NASA is now concerned with developing a broad set of competencies across multiple job types and levels. However, as NASA changes its focus towards long-duration space exploration, an evaluation of the leadership paradigm and potential needs for future space exploration is both timely and necessary before embarking on unprecedented long-duration missions.

4. Impetus for change

Future long-duration space missions will involve months of interplanetary travel and periods of significant communication delay between Mission Control and the crew. For missions of this nature, isolation from Earth as well as confinement within the spacecraft present psychosocial challenges for the crew [8]. These psychosocial challenges should not be underestimated, as they can greatly affect the safety and success of such a mission. In fact, the unprecedented challenges of long-duration space exploration suggest that our base understanding of key psychosocial dynamics is inherently limited [2]. Specifically, current assumptions about effective leadership cannot be blindly applied to long-duration space missions.

To gain a better understanding of effective leadership in the context of long-duration space exploration, we draw from three themes relevant to NASA operations. First, the expertise of a range of NASA personnel should play a significant role in orchestrating leadership. One fundamental advantage to operations within NASA is the high levels of expertise embedded within the agency. Second, the expertise of these individuals can be utilized within the framework of collective leadership [9,10]. Thus, collective leadership offers a practical framework for organizing and drawing on the extensive expertise within the agency (details below). Third, not only must expertise be considered for leadership operations, but unexpected events and sufficient preparation for these events will also significantly impact the success of the mission. Although these events might be infrequent in nature, appropriate leadership preparation is critical. Thus, the organization of expertise within a collective leadership framework offers a viable approach for the leadership of a long-duration space mission. Moreover, the crew and Mission Control should be also prepared to operate in a dynamic, dangerous environment presenting unexpected events. These three themes, and their potential implications for long-duration space exploration, will be discussed next.

5. Leadership considerations for long-duration space exploration

5.1. Expertise of NASA personnel

In considering the unique leadership considerations for long-

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