The Rocket Science of Teams

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Performing technologically advanced work in an environment hostile to human existence on a limited budget necessitates good teamwork, a phenomenon that spaceflight agencies (and countless other organizations) around the world recognize. We suggest that the National Aeronautics and Space Administration (NASA) serves as an exemplar of an organization that has recognized and attempted to respond to many of the challenges articulated by Tannenbaum, Mathieu, Salas, and Cohen (2012). In addition, we suggest that spaceflight operations of the future can serve as an information resource and operational laboratory for future research on teams and teamwork.

Historically, NASA has been comprising teams that needed to work together in high criticality situations, which often involved the coordination and cooperation of many teams at multiple time points and across great distances. Indeed, this extensive spaceflight history has produced a substantial number of best practices in terms of teamwork, especially when considering the themes of dynamic composition, technology, and distance (cf., www.ntrs.nasa.gov). Our following comments outline some historical and current practices within spaceflight operations that exemplify issues related to dynamic composition and technology and distance, in hopes that other industrial–organizational (I–O) practitioners may derive some qualitative value from seeing how some of the challenges and changes mentioned by Tannenbaum et al. are addressed in one real ''out of this world'' context. We also discuss new research and research questions that are emerging for NASA and spaceflight operations in general that augment Tannenbaum et al.'s suggested directions. Perhaps these questions might be useful to other I–O psychologists outside of NASA, as our field helps shape the future of teamwork practices and research on Earth.

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Dynamic Composition

To begin, we note that NASA has been at the forefront in structuring and facilitating multiteam teams to provide dynamic flight control since the first NASA spaceflight. For the past 11 years, multiple flight control teams in three different global sites have continuously supported the International Space Station (ISS) on a rotational basis for 24 hours every day; thus, these teams are largely plug and play as changes in members and handovers to other teams are highly orchestrated. This coordinated planning helps limit the chaos associated with constantly changing membership and coordinating across international sites. In addition, NASA, like other space agencies, has a strong culture that allows for team members to have at least one shared overarching goal and an overarching space-faring culture that subsumes professional, organizational, and regional cultural memberships. These best practices have already been shared with other industries (i.e., crew resource management as relevant to the airline industry and, more recently, the medical industry), but from our perspective, these methods could be adapted and applied wherever teams would benefit from a more coordinated effort when managing projects and tasks.

Dynamic composition has long been relevant when considering the diverse population of astronauts who comprise space teams. With a substantial increase in NASA's pool of possible crewmembers with the introduction of the ISS (early 1990s), we have moved from the adversarial stance of the early space race to a more cooperative one. Indeed, the ISS was built and is maintained by five space agencies representing 23 countries. Each space agency has its own mission control that necessitates extensive coordination between each agency's teams. To ensure successful cooperation and effective performance among team members, these space agencies have developed extensive psychosocial training (including cultural training) for astronauts and cosmonauts and have integrated these psychosocial competencies into technical training for both crews and ground controllers. Based on these experiences, we suggest that merely identifying cross-cultural understanding will not be sufficient to ensure successful team performance. Many organizations may need to take a more proactive approach in providing the necessary training and increased interaction among multicultural team members in situations that require both technical coordination and crisis management, like these international space agencies have, as organizations in the emerging global economy become engaged in more operations that depend on multiteam coordination and cooperation.

As a last example, team members of the future might include those that are not human. For NASA, a robot has already joined the ISS within this last year. With this most recent addition, team members on the ISS and future missions will include humanoid robots in space. As such, crews will now have to learn how to interact and work with this humanoid robot and integrate it into already dynamic crews. This trend toward artificial intelligence as members of teams within organizations beyond space is likely to increase as well. As such, we suggest that it will be important for organizations to consider how to address technological advances that dynamically affect team membership, composition, and interaction.

Technology and Distance

Spaceflight operations also offer some lessons learned regarding technology and distance issues encountered with teams. Early space programs such as Gemini and Apollo experienced long periods without communication between two subsets of the larger mission team: the space crew and the mission control center (i.e., the ground crew). Indeed, astronauts and cosmonauts can be viewed as the original telecommuters; thus, lessons learned from these historical perspectives are not only pertinent to the current body of knowledge

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of teams across organizations but also relevant for new questions that need to be addressed as organizations adapt to the increasing numbers of virtual and globally distributed teams. For example, before the shuttle program, the practice wherein one central person (called the CAPCOM) from the mission control center would be the only person who would communicate with the space crew was established. This practice increased efficiency and centralized communications between both groups. Blackout periods of communication were and are a frequent occurrence—even aboard the ISS—thus, coordination among multiple and dynamic teams across the world must be efficient and highly orchestrated. The physical distance between mission control and the space crew is enough to create a tendency toward an ''us versus them'' perspective. Changes in technology, however, have been able to compensate and decrease some feelings of distance between teams. The increased privacy provided by the Internet Protocol (IP) phone allows the space crew and ground crew to communicate more candidly off the public communication loop. Improved video capability and increased bandwidth allow ground support to work alongside the crew and troubleshoot as necessary, which has increased the cohesion between mission control and space crews and decreased their felt distance. We see these approaches aimed at reducing the virtual distance as highly relevant to other organizations as teams are increasingly comprising individuals from different locations as discussed by Tannenbaum et al.

In addition, stressors are very much present within the spaceflight environment. Space crewmembers live in very tight quarters for long periods of time (an average of 6 months on ISS), and these environmental conditions can be very stressful for the team. To combat these issues, NASA has implemented countermeasures to ameliorate some of the detrimental effects of these stressors. For example, increased communication frequencies available between the space vehicle and Earth have augmented the ability of spaceflight organizations to provide social support to team members. The IP phones on ISS allow crewmembers to contact friends and family relatively often. Furthermore, the recently created local network allows crews to browse the Web in real time and decreases feelings of isolation from the world and society at large. Crewmember support measures also include public-relation events that serve as a healthy outlet and often improve the morale of both the individuals and the crew as a whole.[1] However, as individual team members are becoming more continuously accessible due to an increase in modalities of communication (e.g., smart phones, video conferencing, and social media), teams in many organizations are starting to see the lines between time off and time working blur in ways similar to the way work and time off has always been blurred among flight controllers and astronauts. NASA has learned the importance of strictly defining and limiting work schedules to protect team performance and health as an organizational asset. It is imperative that the occupational health needs of individual employees within organizations are addressed as technological advances increase, and many of these countermeasures could be adapted to support teams and team members in any organization.

Lastly, Tannenbaum et al. discuss monitoring technologies and how these may be needed now more than ever, but that their use might lead to feelings of violation (i.e., related to privacy) among team members. The major space agencies of the world are developing many different monitoring technologies to support crew health and performance in preparation for longer duration missions. These technologies are seen as a way to maintain communication and connection between the space

1. Examples include Astronaut Bill McArthur talking from ISS to Paul McCartney during a live concert, Astronaut Peggy Whitson throwing from space the ceremonial first pitch for the World Series, and ISS Commander and Navy Captain Mike Lopez-Alegria reenlisting sailors aboard the USS Dwight D. Eisenhower in a special ceremony.

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crew and ground crew, as environmental constraints will inhibit the current level of contact between crews and Earth (e.g., mission crews venturing to Mars will experience up to 20-minute delays each way when trying to communicate with ground control on Earth). Examples of these technologies include tools to monitor sleep and circadian rhythm, behavioral health of the crew, and team dynamics, including team performance and team cohesion. At NASA, we have learned that these monitoring technologies are useful only when they place the feedback mechanism directly into the hands of the team itself so that the team can track its progress and monitor its risk and then access various countermeasures as desired. Similarly, as monitoring employees across organizations increases, it would behoove researchers and operational implementers alike to consider how to engage the employees through this process and ensure that informative feedback is provided to benefit both the organization and the individuals.

Future Directions

Advancing from the Gemini and Apollo mission eras has driven teamwork practices and research to change to better meet the needs of the current space programs (e.g., the ISS). These changes within the team context will continue as NASA prepares for its next transition, one of longer duration missions (e.g., Mars and beyond) and the commercialization of spaceflight (in terms of transport vehicles). These adaptations and changes to the way we implement our practices are imperative for NASA to remain a powerhouse in spaceflight.

As we begin this transition, NASA must address some critical research questions to remain competitive and effective. As we rely more heavily on teamwork, how can NASA stay at the cutting edge of human spaceflight? What are the organizational levers that NASA can implement to increase team member health and team performance? From our perspective, research would benefit from a better understanding of the orchestration necessary in swapping team members and offsetting the challenges associated with dynamic compositions. Yet another concern is the role of selection and team composition in the success of long-duration missions. Those astronauts who go to near-Earth asteroids and Mars will be from a generation more comfortable with remote communication and using technology to enhance teamwork. The transition to longer duration spaceflight necessitates ground crew and space crew members from many cultures to communicate and coordinate more than ever before, requiring us to select employees with an aptitude and sensitivity for increased intercultural cooperation in dynamic team environments. Lastly, regarding technology and distance, in what ways will the increased distance of longer duration missions influence teamwork and team performance within NASA and other space agencies?

In many ways, these questions will influence future team practices for NASA and, in turn, will be relevant for teams on Earth as we see similar changes in composition, interaction, and performance occur in other organizations. We believe that specialty operational contexts (including spaceflight) will provide opportunities to inspire and fund research more immediately relevant to working teams in all organizations, but it is our responsibility to look for these opportunities rather than wait for invitations to explore the future frontiers of teamwork.

Reference

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