Teams in Space: It Isn't Just Rocket Science

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All it may take for a team of the most highly trained, courageous astronauts to fall apart in the vacuum of space is a squabble over Nutella.

During a situational experiment designed to model the conditions necessary to support long-duration space exploration (LDSE), participants were given a finite amount of the popular hazelnut spread to last them the entire “trip,” said APS Fellow Steve Kozlowski, a Michigan State University scientist who studies teams working in extreme environments and who heard about the incident. One member of the group, however, ate more than their share — and refused to “fess up.”

The seemingly minor incident caused an almost irreparable rift in the group, seriously impeding collaboration and teamwork throughout the project, he explained.

Kozlowski is among a growing cadre of behavioral, industrial/organizational, and human-factors psychological scientists studying human behavior, specifically how we function in teams, in space. He has partnered with NASA to track 32 LDSE experiments since 2009.

“It’s a totally immersive experience,” he said of LDSE simulations. “Once you’re there, you’re there. Your connections with the rest of the world are very limited or nonexistent, and your social world is much smaller, [down] to the people who are in the same environment confined with you.”

Ever-Evolving Entities

Although Kozlowski’s team can only study a few people at a time — LDSE environments such as habitats with limited space, food, and contact with the outside world are designed for small groups —they can glean a wealth of information from those individuals, he says. The participants submit daily journal entries for study, offering the researchers hundreds of data points that paint a picture of a team as an ever-evolving entity.

“We have data from three missions that were longer than 6 months,” he explained. “In every single one of them, there’s no ‘Boom’ [moment], but somewhere between 4 and 7 months, one or more members start to desynchronize. We see these teams of six people break into two or three subclusters,” and the group begins to fracture.

These three missions, which Kozlowski said represent “rough replications” due to their similar natures (size of group, duration, environment), are helping psychological scientists predict — and potentially prevent — stressful phenomena.

The US administration’s new “Moon to Mars” initiative includes several goals, such as conducting a “crewed flight sending Americans around the Moon in 2023,” that could have a major impact on psychological scientists’ LDSE research because those journeys will require teamwork across even longer stretches of time and distance.

According to NASA, a trip to Mars would take approximately 9 months — and an even longer duration for the return trip due to travel restrictions such as having to wait for the appropriate launch time — and involve more than one organization’s oversight.

For example, Kozlowski said, “there is this myth in the community of a ‘third-quarter effect,’ in which astronauts report getting most down in the third quarter [of their missions]. We really want to understand what the experience is like and what kinds of cycles might be present in the data … that’s an obvious thing where you’d want to have countermeasures in place.”

Wearing Your Heart on Your Sleeve

One such countermeasure might take the form of wearable technology. Psychological scientists studying industrial/organizational behavior are experimenting with sensors that measure peer interactions, both physical (triggered by the sensors) and virtual. In this case, bioinformatics helped alert researchers to participants’ bodily reactions to communication — both positive and negative — from other teammates.

In a 2009 study, a team of psychological scientists gave 22 employees at a German bank “sociometric badges” designed to measure face-to-face interactions, proximity to others, physical activity levels, and speech. The employees wore the badges for 20 days and each day answered questionnaires about their levels of productivity, job satisfaction, and group interactions; their email communications also were monitored.

By comparing the information from the badges, self-reports, and emails, the researchers were able to identify factors affecting workplace positivity, peer interactions, and organizational management. They found, for example, that the more total communication (email and face-to-face) a person engaged in, the lower they rated their level of job happiness. In addition, they discovered that individuals with the most central roles in the organization (i.e., those with less autonomy and creative opportunities) had decreased job satisfaction compared with their less centralized peers.

The psychological scientists say this experiment could have implications for team building, company structure, efficient methods of workplace communication, and performance.

“These tools can begin to fuse the information together to help us figure out which teams are more effective and why they are more effective,” said Kozlowski, who has been incorporating wearable badges into his LDSE missions to measure team members’ stress levels in their interactions. “This could then be a way in which to train people and create protocol. The badge just opens up new tools along with these other digital traces. To me, that’s one of the neat things.”

The Isolation Factor

Teams working in remote environments (or simulations thereof) are not so different from more routine collaborations, said Jay C. Buckey, a former astronaut who participated in the 16-day NASA Final Spacelab Mission and studies space physiology and medicine. But the solitude creates particularly difficult conditions such as increased physical and mental stress.

“In our daily lives, we face a lot of the same psychological challenges that long-duration astronauts do,” such as differences in “outlook, expectations, and past experiences,” Buckey said. “The isolated and confined environment magnifies their importance tremendously.”

The International Biomedical Expedition to the Antarctic (IBEA), an investigation of environmental stress conducted in 1981, offers one such example. Twelve biomedical scientists and technicians underwent a mission consisting of 142 days of physiological, psychological, psychophysiological, microbiological, immunological, and sleep experimentation in Sydney and the Antarctic to see how they would react to such testing in extreme conditions. Although these professionals were prepared to undergo an invasive series of studies by an outside team that accompanied them, the scientists suffered from several stressors, including lack of contact with the outside world, fatigue, and resentment due to unequal work load.

One of the main reasons the IBEA team suffered difficulties was their lack of understanding of team cohesion, psychological scientists Anthony J. W. Taylor and Iain A. McCormick concluded in a 1985 paper evaluating the success of the mission.

“[D]espite their previous experience, few of the scientists had any real understanding of group dynamics or of procedures by which subjects could be humanely and carefully treated,” Taylor and McCormick wrote. “In fact, it was the intervention of the senior author that enabled the group to ventilate and solve some of its problems, build group cohesion, and ensure the continuation of the project.”

A variety of outlooks, expectations, and past experiences can be a source of strength for a group, but these differences can also be points of conflict and ongoing friction.

“Each person in the group has to know how to manage that tension,” Buckey added.

Asking the Right Questions

Dorothy Carter, an industrial/organizational psychologist working at the University of Georgia, is partnering with NASA to ensure that their missions don’t suffer similar breakdowns in group cohesion.

“To achieve their mission objectives, the members and component teams comprising spaceflight

multiteam systems will need to develop and maintain effective patterns of psychological relationships (e.g., shared understanding, trust/influence) and behavioral interactions (e.g., information sharing, coordination) within teams (i.e., teamwork) and across teams (i.e., multiteamwork)," Carter explained. She noted, however, that effective patterns of communication and interaction often do not emerge seamlessly. Teams — and the combinations that comprise them — are ever-changing and complex, so breakdowns that negatively affect performance can occur often.

Carter is at work on Project FUSION (Facilitating Unified Systems of Interdependent Organizational Networks), an applied research project that began in February 2018. A team of psychological scientists is conducting field studies, agent-based modeling, virtual experimentation, and lab testing to discover what elements of LDSE missions most strain team dynamics. Their research will include interviews, focus groups, and observations with NASA personnel as well as experiments with the newest crew living in NASA's Human Exploration Research Analog, a confined environment designed to "mimic the hazards of life in space," according to Carter.

NASA asks, "How can we help ensure that a single-, four-, or six-person team can function seamlessly throughout the duration of a mission with unprecedented challenges?" Carter said of her work with the organization. "The team will be multicultural and interdisciplinary, working in uncomfortable and dangerous conditions while at an extreme distance — up to 128 million miles — from ground control teams back on Earth (roughly the equivalent of 142 trips to the moon!)."

No One Size Fits All

Marissa Shuffler (Clemson University) is an industrial/organizational psychologist who works with Carter to study NASA's extreme teams. She says one of the most important aspects of team building can be counterintuitive — there is no one right way to build a team.

"There are many different types of what we more broadly refer to as 'team development interventions,' each of which can affect certain aspects of teams," Shuffler explained. "When we think about developing extreme teams, it is important to match the specific types of interventions to specific team attitudes, behaviors, and cognitions that may need to be improved or developed. For example, a team debrief after an intensive training preparation exercise for a crew of astronauts can really help the crew to hone in on what they did well as a team, as well as areas for improvement."

Indeed, a 2013 meta-analysis indicated that a 15-minute debrief can lead to robust improvements in performance for teams of professionals ranging from astronauts to accountants. APS Fellow Scott Tannenbaum and his colleague Christopher Cerasoli at the Group for Organizational Effectiveness, a global consulting firm, conducted a meta-analysis of 31 studies on debriefs comprising a total of 2,136 participants. Their results indicate that on average, debriefs improved effectiveness over a control group by around 25%.

Their extensive review on the literature identified four essential elements to an effective debriefing:

- Active self-learning — Participants engage in some form of active involvement rather than being merely passive recipients;
- Developmental intent — A clear, primary intent for improvement or learning that is nonpunitive

rather than judgmental;
- Specific events — Involves reflection on specific events or performance episodes rather than general performance or competencies; and
- Multiple information sources — Includes input from multiple team members or from a focal participant and at least one external source, such as an observer or objective data source.

“By pairing active learning with multiple information sources to improve situational understanding and by identifying lessons learned and establishing specific future plans and goals, debriefs are designed to give individuals and teams a systematic, credible method for improving their performance,” the researchers write in the journal *Human Factors*.

Overall, they found that teams that used debriefs were consistently more effective than teams that did not, showing an average performance improvement of 20% to 25%. Debriefs tended to be more effective when they were structured and when an outside facilitator led them. Although the results were robust, the researchers urge caution before making any causal inferences.

These kinds of debrief techniques are already being incorporated into plans for a future trip to Mars, as Tannenbaum, Kozlowski, APS Fellow Eduardo Salas (Rice University), and colleagues report in a 2015 article in *Current Directions in Psychological Science*.

Communications between Earth and Mars will have a lag of at least 20 minutes each way, so psychological scientists are working with NASA to develop automated debrief protocols that don’t rely on outside facilitators. One tool is already being tested with teams living and working together in isolated confined environments that simulate life in space.

“The tool gathers and analyzes crew input to produce a customized debrief guide for each team, with a focus not only on team and task work but also on factors that might affect team resilience,” lead author Salas and his colleagues wrote.

The Premium Blend

Another factor that concerns NASA officials, and that psychological scientists are helping them understand, is team composition. LDSE mission success depends on selecting crew members who can work well together. But research shows that traditional personnel-selection models, which focus on individual qualifications for designated roles, don’t necessarily mesh with missions where collaboration and teamwork are at a premium, Salas and his coauthors say. The space agency is funding research by psychological and other organizational scientists to identify the optimum crew composition, with examinations of role preferences, collective orientation, living-style preferences, and other attributes of team members.

Shuffler also works with the US military, which has given her a novel perspective on how each team varies. While she noted that, as with extreme-environment teams, military personnel face unique challenges, she also lays out some real-world interventions and solutions.

“We know from research with military units, aviation crews, and similar extreme teams, if we can provide the tools and resources that can help teams create and sustain necessary conditions — such as

clear roles and responsibilities, shared knowledge of the team's goals and how they are going to coordinate, appropriate conflict management strategies, and a psychologically safe climate for admitting errors and rewarding team successes, to name a few — they can be successful," she said.

Kozlowski, who also has worked with the military, agreed.

"No two teams do things exactly the same way … and the army can't tell you what is the best way to do this," he concluded. "It's all about asking questions. We're on the cusp of a potential revolution by badges, digital traces, and other things like that to augment questionnaires. It gives us new insights to open up and unpack these process dynamics, like movies instead of snapshots." And LDSEs missions focused on space, said Kozlowski, are one of the most engaging, interesting, and valuable ways to do that.

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