

<b>Fiscal Year:</b>	FY 2019	<b>Task Last Updated:</b>	FY 04/29/2019
<b>PI Name:</b>	Fischer, Ute Ph.D.		
<b>Project Title:</b>	Understanding Key Components of Successful Autonomous Space Missions		
<b>Division Name:</b>	Human Research		
<b>Program/Discipline:</b>			
<b>Program/Discipline--Element/Subdiscipline:</b>	HUMAN RESEARCH--Behavior and performance		
<b>Joint Agency Name:</b>	<b>TechPort:</b>	No	
<b>Human Research Program Elements:</b>	(1) <b>HFBP</b> :Human Factors & Behavioral Performance (IRP Rev H)		
<b>Human Research Program Risks:</b>	(1) <b>BMed</b> :Risk of Adverse Cognitive or Behavioral Conditions and Psychiatric Disorders (2) <b>Team</b> :Risk of Performance and Behavioral Health Decrements Due to Inadequate Cooperation, Coordination, Communication, and Psychosocial Adaptation within a Team		
<b>Space Biology Element:</b>	None		
<b>Space Biology Cross-Element Discipline:</b>	None		
<b>Space Biology Special Category:</b>	None		
<b>PI Email:</b>	<a href="mailto:ute.fischer@gatech.edu">ute.fischer@gatech.edu</a>	<b>Fax:</b>	FY
<b>PI Organization Type:</b>	UNIVERSITY	<b>Phone:</b>	404-894-7627
<b>Organization Name:</b>	Georgia Institute of Technology		
<b>PI Address 1:</b>	School of Literature, Communication and Culture		
<b>PI Address 2:</b>	686 Cherry Street		
<b>PI Web Page:</b>			
<b>City:</b>	Atlanta	<b>State:</b>	GA
<b>Zip Code:</b>	30332-0165	<b>Congressional District:</b>	5
<b>Comments:</b>			
<b>Project Type:</b>	GROUND	<b>Solicitation / Funding Source:</b>	2015-16 HERO NNJ15ZSA001N-Crew Health (FLAGSHIP, NSBRI, OMNIBUS). Appendix A-Crew Health, Appendix B-NSBRI, Appendix C-Omnibus
<b>Start Date:</b>	06/29/2016	<b>End Date:</b>	06/28/2020
<b>No. of Post Docs:</b>	0	<b>No. of PhD Degrees:</b>	0
<b>No. of PhD Candidates:</b>	1	<b>No. of Master' Degrees:</b>	0
<b>No. of Master's Candidates:</b>	0	<b>No. of Bachelor's Degrees:</b>	0
<b>No. of Bachelor's Candidates:</b>	0	<b>Monitoring Center:</b>	NASA JSC
<b>Contact Monitor:</b>	Williams, Thomas	<b>Contact Phone:</b>	281-483-8773
<b>Contact Email:</b>	<a href="mailto:thomas.j.will1@nasa.gov">thomas.j.will1@nasa.gov</a>		
<b>Flight Program:</b>			
<b>Flight Assignment:</b>	NOTE: End date changed to 6/28/2020 per L. Juliette/HRP (Ed., 2/19/2020) NOTE: Element change to Human Factors & Behavioral Performance; previously Behavioral Health & Performance (Ed., 1/18/17)		
<b>Key Personnel Changes/Previous PI:</b>			
<b>COI Name (Institution):</b>	Mosier, Kathleen Ph.D. ( Teamscape LLC ) Tofighi, Davood Ph.D. ( University of New Mexico, Albuquerque )		
<b>Grant/Contract No.:</b>	NNX16AM16G		
<b>Performance Goal No.:</b>			
<b>Performance Goal Text:</b>			

Task Description:	<p>Exploration space missions will require that space crews manage tasks more autonomously than in current operations, although they will continue to be part of the multi-team system (MTS) comprised of members in space and on the ground. The overall goal of the proposed research is to develop countermeasures that will enhance the ability of MTS members to maintain effective team performance and manage autonomous operations during Long Duration Exploration Missions (LDEMs). We will use NASA Life Sciences Data Archive (LSDA) data collected in space analogs and the International Space Station (ISS) to develop models of the individual- and team-level relationships between crew autonomy, emergent states, and team performance. Additionally, several simulations will be conducted in space analogs to assess the impact of different autonomy implementations on MTS performance in long-duration missions. Data from this study will be used to refine the individual- and team-level models, and to create a MTS-level model of the autonomy-performance relationship. Our approach is comprehensive in that we will examine different implementations and levels of autonomy, experience with interdependent and autonomous operations, individual and team process variables as well as varying task constraints. A set of products to support space and mission control teams during long-duration exploration missions will be delivered. These include: a validated model of factors related to team autonomy and team performance in LDEMs; recommendations for how team autonomy should be managed within a MTS during LDEMs, including countermeasures to mitigate potential negative effects; and recommendations for future research on autonomous team functioning.</p>
Rationale for HRP Directed Research:	
Research Impact/Earth Benefits:	<p>Multiteam collaboration is not a unique feature of spaceflight operations but common to many organizations, as is the question of how best to implement task autonomy within a multiteam system. We therefore expect that our research findings not only generalize to other isolated and confined extreme (ICE) environments, such as Antarctica, but also apply to any organization that require the collaboration by different work units.</p>
Task Progress:	<p>Analysis of LSDA data. Data transfer from LSDA was initiated in spring 2018 and continued throughout the year, and it is ongoing as more data become available.</p> <p>Statistical modeling was conducted on data from Human Exploration Research Analog (HERA) campaigns 1 and 2 that addressed individual- (affect; stress; workload) and team-level (team cohesion; team orientation; task performance) variables. Missions in HERA campaign 1 lasted for 7 days; missions in campaign 2 were 14 days long. Missions in both campaigns involved days with communication delay. In HERA C1, the communication between the crew and ground control was delayed by 10 minutes (one-way) on mission days 5 and 6. In HERA C2, crew/ground communication was delayed by 5 minutes on mission days 5 and 6, and by 10 minutes on mission days 7 and 8. Each campaign consisted of four missions. There were four crew members in each mission, yielding a total of 32 participants.</p> <p>The HERA campaigns followed current mission operations and did not vary the level of crew autonomy during a mission; that is, ground was in charge of the crew's daily schedule, task objectives, and assignments. However, on days with transmission delay, the communication between ground control and the crew was limited and thus provided the crew, at least subjectively, with a sense of autonomy. In the present analyses, we therefore used communication delay as a proxy for crew autonomy, and examined its impact on crew members' affective and cognitive states as well as its influence on team-level variables. Missions were divided into three segments – pre, during, and post communication delay. We hypothesized that the presence of communication delay would affect crew members' perceptions of stress and workload which, in turn, would influence their affective responses. Specifically, we hypothesized that the presence of communication delay would lead to reduced stress, and more positive and less negative affect, analogous to research findings on the impact of team autonomy on members' stress and affect. Changes in perceived stress were also hypothesized to be associated with changes in members' team orientation and team cohesion; in particular, we predicted that crew members' cohesion and team orientation would increase with communication delay and be associated with improved task performance. Unlike their perception of stress, crew members' perception of workload was hypothesized to increase with the presence of communication delay, i.e., when communications with and thus input from mission control was limited.</p> <p>Several multi-level analyses were conducted that included communication delay as independent variable and explored the mediating effect of perceived stress on positive affect, negative affect, members' perception of team cohesion, and members' level of team orientation. A second set of analyses included the same independent and dependent variables and addressed the mediating effect of perceived workload. The final set of analyses examined the direct and indirect effect (as mediated by team cohesion or team orientation) of communication delay on task performance.</p> <p>The present modeling effort did not find that individual and team variables were significantly impacted by the presence of communication delay, with crew members' perceptions of their workload being the only exception. The positive changes we observed –with respect to team cohesion, experienced stress and affect as well as task performance—all occurred over time. This finding suggests that the experience of delayed and thus limited communication with ground support did at least not adversely affect crew members. This finding may also suggest that the experience of communication delay gave crew members a gradual boost in morale and teamwork that carried over to subsequent mission days. Additional analyses are planned to examine this conjecture. Moreover, data collected in Scientific International Research In a Unique terrestrial Station (SIRIUS) and HERA campaigns 5 and 6 will help us to examine the impact of crew autonomy directly and independent of communication delay.</p> <p>Analysis of Crew-Ground Communications. Currently available data sets include few measures on the level of the space crew/mission control multi-team system. The research team is therefore conducting a supplementary analysis of existing recordings and transcripts of crew-mission control communications to examine whether the frequency, nature, and tone of the interactions change over time and in response to communication delay and crew autonomy. The initial data set consists of the voice recordings of the communications that occurred between crew members and HABCOMs on 12 days during the four missions in HERA campaign 3. The selected days counterbalance crew tasks with mission segments and communication delay. Audio files are being uploaded into Audacity, a free audio-editing software. Audacity allows users to mark segments in the audio stream and to assign codes to these segments in a separate track. Tracks can subsequently be exported to a text file for analysis, providing time stamps in addition to codes. Coding of HERA crew-HABCOM communication is ongoing.</p> <p>Long-duration exploration mission simulations – HERA C5 and SIRIUS. The research team is currently participating in two space exploration simulations (HERA C5 and SIRIUS). Campaign 1 of HERA C5 started in mid-February 2019. Mission 1 ended on April 1, 2019. The SIRIUS mission is taking place in the NEK facility (Nezemnyy</p>

	<p>Eksperimental'nyy Kompleks, a closed habitat) in Moscow, Russia, and was launched on March 20, 2019 with an end date of July 22, 2019.</p> <p>HERA C5 missions have a duration of 45 days. Missions involve communication delays (increasing from 30 seconds to 5 minutes, one-way). As they do not include any crew autonomy manipulation, C5 missions will serve as baseline conditions to SIRIUS and HERA C6. During the SIRIUS mission crew members work under 5 min communication delays and have high autonomy. Crew autonomy in HERA-C6 missions is planned to increase with communication delay as a function of distance to Earth and then to remain high during the return to Earth. Our research team has been selected to participate in HERA C6 and we are set to participate in the first planning meeting on May 16, 2019.</p> <p>During HERA C5M1 we collected data from all four crew members and seven mission control personnel (HABCOMs). HERA crew members and HABCOMs completed pre-mission surveys and completed our Asynchronous Communication Training module. During the mission crew members were presented with eight mission-integral tasks that served as our experimental tasks. Four of these tasks were demand tasks—unscheduled tasks or modifications to a scheduled task requested by mission control. The four stretch tasks pertain to events that occur or happen to the crew and necessitate problem solving in the course of which the crew may or may not consult with mission control. After each experimental task, crew and HABCOMs were asked to rate their performance, teamwork, and workload. Surveys administered throughout the mission assessed team efficacy and the team concept held by crew members and HABCOMs. Crew members were also asked to complete a team dynamics survey. HABCOM-specific surveys targeted their perceptions of stress, mental workload, and mood during experimental tasks and on days with communication delay. We also will receive video/audio recordings of crew members' communications while responding to Demand and Stretch tasks to support analysis of their task performance. Likewise, we plan to analyze crew-ground communications during these tasks.</p> <p>The SIRIUS simulation is still ongoing. It involves the same measures as used in HERA C5; however, experimental tasks have been adapted to mission characteristics and objectives. Russian translations of the surveys are available to crew and mission control personnel to provide non-US participants with the option of responding in their native language. Survey completion rates by crew members and flight controllers are being monitored and have been excellent. The Principal Investigator-team also participates in bi-weekly conference calls with the NASA Johnson Space Center SIRIUS 18/19 team and other investigators.</p>
<b>Bibliography Type:</b>	Description: (Last Updated: 03/22/2024)
<b>Abstracts for Journals and Proceedings</b>	<p>Fischer U, Mosier K, Tofighi D, Russell M. "Understanding key components of successful autonomous space missions." Presented at the 2019 NASA Human Research Program Investigators' Workshop, Galveston, TX, January 22-25, 2019.</p> <p>2019 NASA Human Research Program Investigators' Workshop, Galveston, TX, January 22-25, 2019. , Jan-2019</p>
<b>Books/Book Chapters</b>	<p>Fischer U, Mosier K. "Teamwork in Spaceflight Operations." in "The Oxford Handbook of Expertise: Research and Application." Ed. P. Ward, J. M. Schraagen, J. Gore, E. Roth. Oxford: Oxford University Press, 2019 in press. Online Publication Date for article: Feb 2019. <a href="https://doi.org/10.1093/oxfordhb/9780198795872.013.36">https://doi.org/10.1093/oxfordhb/9780198795872.013.36</a> (4/30/19: book is still in publication as of April 2019; individual chapters released online ahead of print.), Feb-2019</p>