Fiscal Year:	FY 2021	**Task Last Updated:**	FY 04/21/2021
PI Name:	Fischer, Ute Ph.D.		
Project Title:	Understanding Key Components of Successful Autonomous Space Missions		
Division Name:	Human Research		
Program/Discipline:			
Program/Discipline--Element/Subdiscipline:	HUMAN RESEARCH--Behavior and performance		
Joint Agency Name:		**TechPort:**	No
Human Research Program Elements:	(1) **HFBP**:Human Factors & Behavioral Performance (IRP Rev H)		
Human Research Program Risks:	(1) **BMed**:Risk of Adverse Cognitive or Behavioral Conditions and Psychiatric Disorders (2) **Team**:Risk of Performance and Behavioral Health Decrements Due to Inadequate Cooperation, Coordination, Communication, and Psychosocial Adaptation within a Team		
Space Biology Element:	None		
Space Biology Cross-Element Discipline:	None		
Space Biology Special Category:	None		
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Zip Code:	30332-0165	**Congressional District:**	5
Comments:	NOTE: The NSSC also lists the PI as Ute Fischer-Loss (Ed., March 2025).		
Project Type:	Ground	**Solicitation / Funding Source:**	2015-16 HERO NNJ15ZSA001N-Crew Health (FLAGSHIP, NSBRI, OMNIBUS). Appendix A-Crew Health, Appendix B-NSBRI, Appendix C-Omnibus
Start Date:	06/29/2016	**End Date:**	03/31/2024
No. of Post Docs:	0	**No. of PhD Degrees:**	0
No. of PhD Candidates:	0	**No. of Master' Degrees:**	0
No. of Master's Candidates:	0	**No. of Bachelor's Degrees:**	0
No. of Bachelor's Candidates:	0	**Monitoring Center:**	NASA JSC
Contact Monitor:	Whitmire, Alexandra	**Contact Phone:**	
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Flight Program:			
Flight Assignment:	NOTE: End date changed to 3/31/2024 per NSSC information (Ed., 7/12/21) NOTE: End date changed to 6/28/2021 per NSSC information (Ed., 5/21/2020) 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)		
Key Personnel Changes/Previous PI:	May 2020 report: Dr. Tofighi withdrew as Co-Investigator from the project effective July 1, 2019.		
COI Name (Institution):	Mosier, Kathleen Ph.D. (Teamscape LLC)		
Grant/Contract No.:	NNX16AM16G		
Performance Goal No.:			

Performance Goal Text:	
Task Description:	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.
Rationale for HRP Directed Research:	
Research Impact/Earth Benefits:	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.
Task Progress:	Planned missions to be conducted in Human Exploration Research Analog (HERA) Campaign 6 and in the NEK (Nezemnyy Eksperimental'nyy Kompleks) facility SIRIUS (Scientific International Research In a Unique terrestrial Station)-- SIRIUS 20/21-- were delayed by a year due to Covid-19. Both simulations were expected to start in November 2020. HERA C6 is currently scheduled to begin no earlier than mid-September 2021 and SIRIUS 21 (formerly SIRIUS 20) is scheduled for November 2021. As a result of these delays, our efforts during the past year pertained to the planning of HERA C6 and SIRIUS 21. Furthermore, since no new data were collected, analyses during the past year focused on data that were obtained during HERA C5 and SIRIUS 19 and that were not covered in last year's report. Data pertain to participants' responses to surveys that tap individual traits (i.e., Need for Autonomy; Resilience) and knowledge (i.e., Teamwork Model) critical to successful autonomous space exploration missions. We also examined the communications between crew and crew/mission control (MCC) that occurred during experimental tasks. Descriptive analyses only were conducted since meaningful inferential and modeling approaches will require the larger N that data collection in HERA C6 and SIRIUS 21 will supply. Need for Autonomy (Yun et al., 2006) is a 3-item measure to assess an "individual trait or predisposition that refers to a personal need or eagerness to take or display one's initiative in doing one's own job." A participant's score can range from 1 (indicating little need for autonomy) to 5 (indicating high need for autonomy). The analysis of HERA and SIRIUS crewmembers' responses revealed that their scores ranged from 3 (i.e., a neutral attitude towards autonomy) to 5 (i.e., a strong predisposition towards autonomy). The analysis also revealed that some crews showed less variability in members' self-reported need for autonomy than others. Future analyses involving data collected in HERA C6 and SIRIUS 21 will examine whether individual differences regarding this trait relate to the cohesion and group dynamics within a crew. The Brief Resilience Scale (Smith et al., 2008) includes 6 items that assess an individual's "ability to bounce back or recover from stress." A participant's score can range from 1 (indicating low resilience) to 5 (indicating high resilience). The analysis of HERA and SIRIUS crewmembers' ratings showed that resilience scores fell between 3 and 5; i.e., scores ranged from moderately to highly resilient. Moreover, crews were found to differ concerning the average resilience score of their members and the variability in scores between members of a crew. Future analyses on a larger data set will need to explore whether and how these differences relate to team process (cohesion, group dynamics) and task performance variables. Teamwork Model. Crewmembers' and MCC personnel's model of teamwork was assessed early in their mission-related training to determine whether members of the crew/MCC multiteam system had a shared understanding of teamwork. The survey included eight teamwork concepts and their definitions—Leadership; Mutual Performance Monitoring; Backup Behavior; Adaptability; Team Orientation; Shared Mental Models; Mutual Trust; and Team Communication. Participants were presented with pairs of concepts (e.g., Leadership and Team Communication; Leadership and Trust; etc.) and asked to rate how closely related the concepts within a given pair were. Participants' ratings were analyzed using Pathfinder (Schvaneveldt, 1990), a software that generates a network representation to capture the underlying relationships between proximity data. Average representations were created for each crew and for the MCC personnel interacting with a given crew. The models generated revealed considerable agreement between members of the crew/MCC multiteam system concerning central teamwork concepts. Central concepts for HERA crews and MCC were team communication and leadership. SIRIUS crew and MCC also considered team communication to be a central concept of teamwork. Interestingly, leadership was not a central concept in the teamwork model generated for SIRIUS MCC personnel. This may reflect differences in the operational role MCC played in the HERA missions compared to SIRIUS 19. Since SIRIUS 19 involved high crew autonomy, MCC in this mission was cast in a more supportive role than MCC in HERA. HERA C5 missions followed current operations with MCC largely in control of a mission. Data from HERA C6 and SIRIUS 21are needed to explore this issue further. Crew/MCC Communication during Experimental Tasks. Communication coding focused on task-related exchanges between crew and MCC. An exchange was defined as communication sequence consisting of two parts: the presentation of information by a speaker, and the addressee's answer in which he/she provides evidence of attention, understanding and uptake (Clark, 1996). Coding identified the MTS member (crew or MCC) who initiated the exchange and classified the type of contribution—that is, whether the speaker pushed information (i.e., informed, gave directions or assistance to

the addressee) or whether he/she pulled information (i.e., requested information or assistance from the addressee).

The analysis of crew/MCC communications in HERA showed that regardless of task event, most exchanges were initiated by the crew. Moreover, these contacts predominantly involved information sharing. Since crewmembers volunteered task-related information, there apparently was little need for MCC to request (i.e., pull) information from crewmembers. Accordingly, in most exchanges that were initiated by MCC, they provided information or directed crewmembers' actions. Results from this analysis will serve as baseline for the analysis of crew/MCC communication in HERA C6 missions that will involve comparable tasks but varying levels of crew autonomy.

In SIRIUS, most task-related communications were found to be initiated by MCC who predominantly asked the crew for information, most frequently to submit some report; that is, information requests tended to concern updates on crew performance.

References

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Schvaneveldt, R. W. (1990). Pathfinder associative networks: Studies in knowledge organization. Ablex Publishing.

Smith, B. W., Dalen, J., Wiggins, K., Tooley, E., et al. (2008). The Brief Resilience Scale: Assessing the ability to bounce back. International Journal of Behavioral Medicine, 15, 194-200.

Yun, S., Cox, J., & Sims Jr., H. P. (2006). The forgotten follower: a contingency model of leadership and follower self-leadership. Journal of Managerial Psychology, 21(4), 374-388.

Bibliography Type:	Description: (Last Updated: 03/22/2024)
Articles in Peer-reviewed Journals	Fischer U, Mosier K. "Examining teamwork of space crewmembers and mission control personnel under crew autonomy: A multi-team system perspective." Proceedings of the Human Factors and Ergonomics Society Annual Meeting. 2020 Dec;64(1):164-8. (64th Annual Conference of the Human Factors and Ergonomics Society, Virtual Meeting, October 4-9, 2020.) https://doi.org/10.1177/1071181320641041 , Dec-2020
Books/Book Chapters	Fischer U, Mosier K. "Mitigating the impact of communication delay." in "Psychology and Human Performance in Space Programs: Extreme Application." Ed. L.B. Landon, K.J. Slack, E. Salas. Boca Raton, FL: CRC Press, 2020. p. 101-114. Book doi: https://doi.org/10.1201/9780429440854 , Oct-2020