Fiscal Year:	FY 2016	**Task Last Updated:**	FY 11/05/2016
PI Name:	Palinkas, Lawrence Ph.D.		
Project Title:	Assessing the Impact of Communication Delay on Behavioral Health and Performance: An Examination of Autonomous Operations Utilizing the International Space Station		
Division Name:	Human Research		
Program/Discipline:	HUMAN RESEARCH		
Program/Discipline--Element/Subdiscipline:	HUMAN RESEARCH--Behavior and performance		
Joint Agency Name:		**TechPort:**	No
Human Research Program Elements:	(1) **BHP**:Behavioral Health & Performance (archival in 2017)		
Human Research Program Risks:	(1) **BMed**:Risk of Adverse Cognitive or Behavioral Conditions and Psychiatric Disorders (2) **HSIA**:Risk of Adverse Outcomes Due to Inadequate Human Systems Integration Architecture (3) **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		
PI Email:	palinkas@usc.edu	**Fax:**	FY
PI Organization Type:	UNIVERSITY	**Phone:**	858 922-7265
Organization Name:	University of Southern California		
PI Address 1:	School of Social Work		
PI Address 2:	MRF 339		
PI Web Page:			
City:	Los Angeles	**State:**	CA
Zip Code:	90089-0411	**Congressional District:**	33
Comments:			
Project Type:	Flight	**Solicitation / Funding Source:**	Directed Research
Start Date:	09/05/2012	**End Date:**	09/30/2016
No. of Post Docs:	1	**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:	Leveton, Lauren	**Contact Phone:**	
Contact Email:	lauren.b.leveton@nasa5.gov		
Flight Program:	ISS		
Flight Assignment:	ISS NOTE: End date changed to 9/30/2016 per NSSC information (Ed., 7/18/16) NOTE: End date is now 6/30/2016 per NSSC information (Ed., 6/8/15) NOTE: Period of performance corrected to 9/5/2012-9/4/2015 per NSSC information (Ed., 4/4/2013)		
Key Personnel Changes/Previous PI:			
COI Name (Institution):	Chou, Chih-ping (University of Southern California) Vessey, William Ph.D. (Wyle/NASA Johnson Space Center) Leveton, Lauren (NASA Johnson Space Center) Kintz, Natalie (University of Southern California)		
Grant/Contract No.:	NNX12AR21A		
Performance Goal No.:			

Performance Goal Text:	
Task Description:	Deep space explorations will involve significant delays in communication to and from Earth that will likely impact individual and team outcomes. However, the extent of these impacts and the appropriate countermeasures for their mitigation remain largely unknown. This study utilized the International Space Station (ISS), a high-fidelity analog for deep space, as a research platform to assess the impact of communication delays on individual and team performance, mood, and behavior. Three astronauts on the ISS and 18 mission support personnel performed tasks with and without communication delays (50-second one-way) during a mission lasting 166 days. Self-reported assessments of individual and team performance and mood were obtained after each task. Secondary outcomes included communication quality and task autonomy. Qualitative data from post-mission interviews with astronauts were used to validate and expand on quantitative data, and to elicit recommendations for countermeasures. Crew well-being and communication quality were significantly reduced in communication delay tasks compared to control. Communication delays were also significantly associated with increased individual stress/frustration. Qualitative data suggest communication delays impacted operational outcomes (i.e., task efficiency), teamwork processes (i.e., team/task coordination), and mood (i.e., stress/frustration), particularly when tasks involved high task-related communication demands, either because of poor communication strategies or low crew autonomy. Training, teamwork, and technology-focused countermeasures were identified to mitigate or prevent adverse impacts.
Rationale for HRP Directed Research:	This research is directed because NASA must define complete scientific activities in a short time and there is insufficient time to issue a solicitation.
Research Impact/Earth Benefits:	Overall, these data suggest communication delays impacted operational outcomes (i.e., task efficiency), teamwork processes (i.e., team coordination/cohesion), and individual well-being (i.e., stress/frustration), especially when tasks involved a high level of back-and-forth communications. Training, teamwork, and technology-focused countermeasures that increase crew autonomy and decrease task-related communication demand may help prevent or mitigate adverse impacts. Understanding the impacts of communication delays on the ISS may benefit the characterization of risk of communication delay on performance and well-being, the selection and composition of teams engaging in asynchronous communication, the development of countermeasures to support autonomous operations, and the future of team communication and coordination around the world.
Task Progress:	This study examined how interdependent teams (such as those with members in the field and at home base) interact and perform tasks with and without delays in communications between the team elements. It had three specific aims: 1) determine the feasibility and acceptability of conducting a study of communication delays on the ISS; 2) determine if there is an association between delays in communication, individual and team performance, and well-being; and 3) determine whether these associations are influenced by task complexity (i.e., criticality and novelty), task-related communication demands, communication quality, and task autonomy. The study participants included three astronauts on the ISS (two American crewmembers and one European crewmember) and 18 participating mission support personnel who were asked to perform 10 tasks (6 without a delay in communication and 4 with a 50-second one-way delay) during a mission lasting more than 160 days. The tasks performed by the teams varied along two dimensions: 1) those that are either critical or not critical (“criticality”) and 2) those that are either novel or familiar (“novelty”). Tasks included variations in both dimensions as it was assumed that highly novel and highly critical tasks are similar to those that a team may encounter during a long duration mission in which they have no prior training but must address. After each task, participating ISS crewmembers and mission support personnel were asked to complete post-task questionnaires that included questions about individual and team behavior, performance, and mood. This study provided a preliminary understanding of the impact of communication delays on individual and team performance and well-being, as well as insight into how teams perform and interact under autonomous conditions in the analog environment most comparable to deep space. Post-task assessments were completed by participating astronauts 100% (22/22) of the time, and by participating mission control personnel 83.3% of the time (15/18). Qualitative analysis of post-mission interviews found the study to be important and acceptable to the three astronauts. However, they also reported the study was limited in the number and type of tasks included, limitations in survey questions, and preference for open-ended to scaled items. Crew well-being and communication quality were significantly reduced in communication delay tasks compared to control. Communication delays were also significantly associated with increased stress/frustration. Qualitative data suggest communication delays impacted operational outcomes (i.e., task efficiency), teamwork processes (i.e., team/task coordination), and mood (i.e., stress/frustration), particularly when tasks involved high task-related communication demands, either because of poor communication strategies or low crew autonomy. Training, teamwork, and technology-focused countermeasures were identified to mitigate or prevent adverse impacts. Results from this study suggest task novelty may moderate the relationships between communication delays and individual and crew performance, and communication quality. However, contrary to our expectations, the inverse relationships between communication delays and crew performance and communication quality were stronger in low compared to high novel tasks. Furthermore, there was a trend for individual performance to improve in communication delay compared to control conditions in high novel tasks. In low novel tasks, participants may have assumed a shared situational model was established, and thus, in the absence of any formal communication delay training, may have inappropriately used minimal or ambiguous responses while performing the task. For example, one crewmember described his experience performing a standard weekly cleaning activity (low novel) with a communication delay, “So you call down and you ask them (mission support team) to disable smoke detection, and then you kind of forget that you even called…And then a minute later a call comes up and just says, OK, smoke detection has been disabled. And the crew is like, well I don’t know, is it Node 1, is it Node 3, what did we even call for?” On the other hand, team members may have been more engaged in and complete with their communications while performing highly novel tasks, and this proactive approach may have mitigated potential adverse impacts. Furthermore, qualitative feedback from the ISS crewmembers indicated detailed task procedures were provided for some of the high novel tasks. For example, one crewmember stated, “For each complicated step, we had short videos embedded in the procedures to help us. I think those were critical to our overall execution of the task.” Accordingly, detailed task procedures may mitigate or prevent adverse impacts of communication delays on individual and team outcomes during deep space explorations.

	In contrast, task criticality did not moderate the relationship between communication delays and performance, crew morale, communication quality, or task autonomy in the current study. There was however, a trend towards a main effect of task criticality on task autonomy, suggesting ISS crewmembers felt they had more autonomy when they performed low compared to high critical tasks. Apart from the small sample size, the lack of a statistically significant interaction between communication delays and task criticality may be attributed to a number of factors, including the short communication delay interval, the type and number of tasks studied, and/or the format and number of survey items administered. Since qualitative data suggested high task-related communication demands contributed to adverse impacts of communication delays, exploratory analyses were conducted to explore whether these relationships were also observed in the quantitative data. Results from this study suggest task-related communication demands may moderate the relationships between communication delays and individual and team outcomes. Specifically, the inverse association between communication delays and crew and team performance, and communication quality was stronger when tasks required high compared to low task-related communication demands. Furthermore, task autonomy decreased in communication delay compared to control conditions when tasks involved a high, but not low level of task-related communication demands. Collectively, the qualitative and quantitative data suggest communication delays were more likely to negatively impact individual and team outcomes when tasks involve high levels of task-related communication; accordingly, countermeasures that reduce back-and-forth communications, either by increasing crew autonomy or improving communication strategies, may mitigate or prevent adverse impacts.
Bibliography Type:	Description: (Last Updated: 11/13/2019)
Abstracts for Journals and Proceedings	Palinkas LA, Kintz N. "The impact of experimental delays in communication to and from the International Space Station on subjective assessments of performance and well-being." Presented at the 87th Aerospace Medical Association Annual Meeting, Atlantic City, NJ, April 24-28, 2016. Aerospace Medicine and Human Performance. 2016 Mar;87(3):190. , Mar-2016
Abstracts for Journals and Proceedings	Kintz N, Palinkas LA. "Impact of communications delays on performance and well-being aboard the International Space Station: Lessons learned for long-duration spaceflight." Presented at the 87th Aerospace Medical Association Annual Meeting, Atlantic City, NJ, April 24-28, 2016. Aerospace Medicine and Human Performance. 2016 Mar;87(3):322. , Mar-2016
Abstracts for Journals and Proceedings	Kintz N, Palinkas LA. "Assessing the impact of communication delays on performance and well-being aboard the International Space Station." Presented at the 2016 NASA Human Research Program Investigators' Workshop, Galveston, TX, February 8-11, 2016. 2016 NASA Human Research Program Investigators' Workshop, Galveston, TX, February 8-11, 2016. , Feb-2016
Abstracts for Journals and Proceedings	Palinkas LA, Vessey WB, Chou CP, Leviton LB. "Communication delay and its impacts on performance, well-being and autonomy on the ISS." Presented at the 2015 NASA Human Research Program Investigators' Workshop, Galveston, TX, January 13-15, 2015. 2015 NASA Human Research Program Investigators' Workshop, Galveston, TX, January 13-15, 2015. , Jan-2015
Articles in Peer-reviewed Journals	Kintz NM, Chou CP, Vessey WB, Leveton LB, Palinkas LA. "Impact of simulated ISS communication delays on individual and team behavior and performance: a mixed-methods approach." Acta Astronautica. 2016 Dec;129:193-200. http://dx.doi.org/10.1016/j.actaastro.2016.09.018 , Dec-2016
Articles in Peer-reviewed Journals	Kintz N, Palinkas LA. "Communication delays impact behavior and performance aboard the International Space Station." Aerosp Med Hum Perform. 2016 Nov;87(11):940-6. https://doi.org/10.3357/AMHP.4626.2016 ; PubMed PMID: 27779953 , Nov-2016
NASA Technical Documents	Palinkas LA, Kintz NM, Vessey WB, Chou C-P, Leveton LB. "Assessing the impact of communication delay on behavioral health and performance: An examination of autonomous operations utilizing the International Space Station." Houston, TX: NASA Johnson Space Center, 2017 Jan. 60 p. NASA/TM-2017-219285. , Jan-2017