Fiscal Year:	FY 2014	**Task Last Updated:**	FY 07/05/2014
PI Name:	Fischer, Ute Ph.D.		
Project Title:	Protocols for Asynchronous Communication in Space Operations: Communication Analysis		
Division Name:	Human Research		
Program/Discipline:	HUMAN RESEARCH		
Program/Discipline--Element/Subdiscipline:	HUMAN RESEARCH--Behavior and performance		
Joint Agency Name:		**TechPort:**	Yes
Human Research Program Elements:	(1) **BHP**:Behavioral Health & Performance (archival in 2017)		
Human Research Program Risks:	(1) **HSIA**:Risk of Adverse Outcomes Due to Inadequate Human Systems Integration Architecture (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:**	2011 Crew Health NNJ11ZSA002NA
Start Date:	09/06/2012	**End Date:**	03/05/2016
No. of Post Docs:		**No. of PhD Degrees:**	
No. of PhD Candidates:		**No. of Master' Degrees:**	1
No. of Master's Candidates:	5	**No. of Bachelor's Degrees:**	
No. of Bachelor's Candidates:	2	**Monitoring Center:**	NASA JSC
Contact Monitor:	Leveton, Lauren	**Contact Phone:**	
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Flight Program:			
Flight Assignment:	NOTE: End date is now 3/5/2016 per NSSC information (Ed., 6/8/15)		
Key Personnel Changes/Previous PI:			
COI Name (Institution):	Mosier, Kathleen (California State University, San Fransisco)		
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Performance Goal Text:			

Task Description:	Effective and efficient communication between Mission Control and space crews is essential for successful task performance and mission safety. The importance of team communication is heightened when unforeseen problems arise, such as system failures that are time-critical and require extensive coordination and collaboration between space and ground crews. During long duration missions and missions beyond Low Earth Orbit, space-ground communications will involve delays up to 20 minutes one way, a reality that poses a formidable challenge to team communication and task performance. This project will determine how transmission delays impact team communication, teamwork, and task performance in relation to varying task demands and media constraints. A series of four studies will be conducted involving laboratory experiments and research in space-analog environments. The overall aim of the proposed research is to develop and validate protocols supporting Mission Control–space crew communication and collaboration during long-duration space missions. Specific project goals are: (1) Determine the impact of communication delays on communication, teamwork, and task performance in relation to varying task demands, i.e., procedural tasks vs. tasks requiring analysis and decision making, and different communication media (voice vs. text). (2) Develop and validate measures to assess and characterize team communication effectiveness and task performance in relation to different operational tasks. (3) Develop and validate communication protocols to support joint problem solving and decision making by mission controllers and space crews during periods of asynchronous communication.
Rationale for HRP Directed Research:	
Research Impact/Earth Benefits:	Our research will result in communication protocols and/or procedures that will support collaborative problem solving and decision making by teams that are distributed across Earth and space and communicating asynchronously. Communication protocols resulting from this research could also be used to support collaborative work within on-ground distributed synchronous teams, for instance, during military operations or in telemedicine.
	Major accomplishments for Year 2 are: (1) Analysis of team performance and communication data collected during Year 1. Data were from a laboratory experiment [San Francisco State University (SFSU) Study 1] that examined the impact of communication delay and media on teamwork in remote teams. (2) Participation in two simulations in the Human Exploration Research Analog (HERA) facility to determine the impact of long intervals of communication delays on teamwork. (3) Development of media-specific communication protocols and conventions to support collaboration in distributed teams communicating asynchronously. (4) Evaluation of these communication protocols in the laboratory (SFSU Study 2) and in two analog environments (HERA and NASA Extreme Environment Mission Operations NEEMO). 1. SFSU Study 1: Impact of Communication Delay on Teamwork and Task Performance. The overall aim of this experiment was to determine the impact of transmission delay on team communication and task performance in relation to varying task demands (procedural vs. ill-defined), and different communication media (voice vs. text). Spatially distributed teams of three collaborated in a computer-based task environment and communicated either by voice-over-internet or via a texting tool. The micro-world for the study was AutoCAMS 2.0 (Manzey et al., 2008) which simulates the life support system of a spacecraft and requires team members to monitor and control different subsystems, and to diagnose and repair system failures. Each team was required to perform procedural and problem solving tasks during one synchronous and one asynchronous (5-min delay in communications transmission) flight segment. The experiment extended through two days: day 1 involved 2-3 hours of position-specific (Flight System Engineer, FSE, or Pioneer Crewmember) task training; day 2 consisted of two 90-minute experimental sessions. 72 (24 teams of 3) undergraduate and graduate students between the ages of 21-55 participated. Task performance was measured in terms of time required to initiate a successful repair (= repair duration) as well as accuracy of the repair procedure. Communication analysis focused on the interactions between the FSE and the Pioneer crew during the failure repair tasks. To date detailed analysis have been completed for communications occurring under time delayed conditions as findings were a precondition for the design of the communication protocols and their validation in SFSU Study 2 and the HERA and NEEMO missions. Analyses revealed that transmission delay impacted repair duration and more importantly, that its effect varied by communication medium. When communication was delayed, teams used a comparable amount of time to repair system failures, irrespective of the communication medium used. However, when communication was synchronous, voice teams outperformed text groups. Likewise, teams' accuracy in performing system repairs was influenced by communication medium. Overall, teams communicating by text undertook more incorrect repairs than teams communicating by voice, although this effect was most pronounced when communication was synchronous as opposed to asynchronous. The analysis of team communication focused on Pioneer Crew/FSE interactions during transmission delay. Medium-specific differences concerned structural aspects of team communication (i.e., communication rate; distance between adjacency pairs, such as question and answer) as well as content variables (i.e., use of ambiguous terms; missing responses). Specifically, text teams made shorter and more frequent communications than voice teams, and in so doing kept adjacency pairs further apart (e.g., questions and answers were separated by more communications when using text). Text teams were more likely to use ambiguous terms; that is, terms whose meaning was underspecified (e.g., "We have a problem") or could not be established within a turn but rested on information in preceding turns. These differences are consistent with medium-specific opportunities and constraints. Text provides participants with a written record of their on-going conversation, and thus may help them to keep track of related contributions and the identity of referents. Voice communication is cognitively more taxing than text-based communication insofar as participants need to remember their ongoing discourse to interpret new information. Voice teams seemingly adapted to this constraint by talking less frequently while packing more information into one turn than text teams; this behavior kept related communications closely aligned and that may have aided comprehension. However, in both text and voice teams instances of miscommunication in which team members failed to account for the communication delay were evident. Team members mistook a remote partner's communication that immediately followed their own transmission as a response to it, or they repeated a message before they could have received a response from their partner. These instances required additional communication in which team members clarified their situation understanding, or they spiraled into misunderstanding from which team members never recovered and thus were unable to repair a system failure. These findings led to the design of media-specific communication protocols that sought to minimize the risk of miscommunication and to help remote team members communicate efficiently under time-delayed conditions. Communication protocols will be described below in section (3). Additional analyses are planned to relate communication behavior by voice and text teams to their task performance. 2. Analog Research to Examine the Impact of Longer (10-min) Communication Delay on Teamwork

Task Progress:	We were invited to participate in two HERA (Human Exploration Research Analog) simulations (Feb/March 2014; April 2014) to examine the impact of a 10 min transmission delay on team communication under different media conditions. These studies were not part of our Year 2 proposed work; rather we were responding to the opportunity to participate in collaborative research within a space analog environment and to collect data from astronaut-like participants. Two days of the 7-day simulations involved a communication delay of 10 min; on one of these days communication between the HERA crew and mission control was voice-only; on the other day participants had voice and text communication available to them. The four HERA crew members and 6 mission control personnel responded to daily surveys asking them to rate the effectiveness of their communication during specific tasks, and on the day with voice and text communication to explain their choice of medium. In addition to the surveys, we plan to analyze crew-mission control interactions using the same coding categories as in SFSU Study 1. Analysis is ongoing. Survey responses indicate that crew members decided to talk less with mission control on days with communication delay but generally judged their interactions to be effective on these days. Choice of communication medium was driven by task constraints—voice was preferred during tasks requiring manual input—and by communication goal; that is, crew members preferred text to communicate task completion and voice to request assistance from mission control. 3. Design of Medium-Specific Communication Protocols The structure of the communication protocols was informed by schema-based approaches to instructional design (Morrow & Rogers, 2008; Morrow et al., 1996; 1998; 2005); their specific content was based on findings in SFSU Study 1 and our analysis of space-ground communication in the Autonomous Mission Operations (AMO) study (Fischer, Mosier & Orasanu 2013), as well as recommendations discussed by Love and Reagan (2013). The overall design objective was to facilitate remote collaboration under time-delayed conditions utilizing medium-specific opportunities. Specific design goals included: to help remote team members keep track of conversational threads and the temporal sequence of contributions, and to establish common ground in an efficient manner. The effectiveness of the communication protocols is being assessed in the laboratory with student participants as well as in analog environments (see section 4 below). 4. Evaluation of Communication Protocols The same task environment (AutoCams) as in SFSU Study 1 was used to assess the effectiveness of the communication protocols. Participants in the experimental group received the communication protocols and instructions on how to apply them as part of their position-specific (FSE or Pioneer crew member) task training. Participants in the control group received only task specific training. After training, participants completed two 90-min sessions, one in which the communication between the Pioneer crew and the FSE was voice-based, and one that provided only text communication. Communication between remote team members in both sessions was delayed by 5 minutes. The study design included 24 teams of three; data collection was completed at the end of June 2014. The communication protocols have also been introduced in two analog environments to evaluate their effectiveness with astronaut-like participants (HERA-C1M3) and astronauts (NEEMO 18 and 19). Participants in all three simulations received communication training in June 2014. The HERA mission was completed in June; NEEMO 18 is scheduled for July 2014, and NEEMO 19 for September 2014. Participants are being asked to follow the communication protocols in crew-mission control interactions on mission days with a transmission delay and to complete surveys concerning their effectiveness and the importance of individual components. These studies are part of research proposed for Year 3. References Love, S. G. & Reagan, M. L. (2013). Delayed voice communication. Acta Astronautica 91, 89-95. Manzey, D., Bleil, M., Bahner-Heyne, J. E., Klostermann, A., Onnasch, L., Reichenbach, J., & Röttger, S. (2008). AutoCAMS 2.0 Manual . Berlin: Technical University of Berlin. Morrow, D. G. & Rogers, W. A. (2008). Environmental support: An integrative framework. Human Factors 50(4), 589-613. Morrow, D. G., Leirer, Von O., Andrassy, J. M., Decker Tanke, E., & Stine-Morrow, E. (1996). Medication instruction design: Younger and older adult schemas for taking medication. Human Factors 38(4), 556-573. Morrow, D. G., Leirer, Von O., Andrassy, J. M., Hier, C. M., & Menard, W. E., (1998). The influence of list format and category headers on age differences in understanding medication instructions. Experimental Aging Research , 24, 231-256. Morrow , D. G., Weiner, M., Young, J., Steinley, D., Deer, M., & Murray, M. D. (2005). Improving medication knowledge among older adults with heart failure: A patient-centered approach to instruction design. The Gerontologist , 45(4), 545-552.
Bibliography Type:	Description: (Last Updated: 03/22/2024)
Articles in Peer-reviewed Journals	Fischer U, Miller C, Morrow D, Mosier K, Orasanu J, Veinott B. "Exploring communication in remote teams: Issues and methods." Proceedings of the Human Factors and Ergonomics Society Annual Meeting. 2013 Sep;57(1):309-13. (57th Annual Meeting of the Human Factors and Ergonomics Society, San Diego, CA, September 30-October 4, 2013.) http://dx.doi.org/10.1177/1541931213571068 , Sep-2013
Articles in Peer-reviewed Journals	Fischer U, Mosier K, Orasanu J. "The impact of transmission delays on Mission Control-Space Crew communication." Proceedings of the Human Factors and Ergonomics Society Annual Meeting. 2013 Sep;57(1):1372-6. (57th Annual Meeting of the Human Factors and Ergonomics Society, San Diego, CA, September 30-October 4, 2013.) http://dx.doi.org/10.1177/1541931213571303 , Sep-2013
Papers from Meeting Proceedings	Fischer U, Mosier K. "The impact of transmission delay and medium on team communication and task performance by distributed teams." 58th Annual Meeting of the Human Factors and Ergonomics Society, Chicago, IL, October 27-31, 2014. Proceedings of the 58th Annual Meeting of the Human Factors and Ergonomics Society, Chicago, IL, October 27-31, 2014. In press as of July 2014. , Jul-2014