Fiscal Year:	FY 2016	**Task Last Updated:**	FY 07/20/2016
PI Name:	DeChurch, Leslie Ph.D.		
Project Title:	SCALE: Shared Cognitive Architectures for Long-term Exploration		
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) **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:	dechurch@northwestern.edu	**Fax:**	FY
PI Organization Type:	UNIVERSITY	**Phone:**	954-646-5083
Organization Name:	Northwestern University		
PI Address 1:	Northwestern University		
PI Address 2:	School of Communication		
PI Web Page:			
City:	Evanston	**State:**	IL
Zip Code:	60208	**Congressional District:**	9
Comments:	NOTE: Previously at Georgia Institute of Technology until July 2016.		
Project Type:	Ground	**Solicitation / Funding Source:**	2014-15 HERO NNJ14ZSA001N-Crew Health (FLAGSHIP & NSBRI)
Start Date:	07/01/2015	**End Date:**	10/05/2016
No. of Post Docs:	0	**No. of PhD Degrees:**	0
No. of PhD Candidates:	1	**No. of Master' Degrees:**	0
No. of Master's Candidates:	3	**No. of Bachelor's Degrees:**	0
No. of Bachelor's Candidates:	3	**Monitoring Center:**	NASA JSC
Contact Monitor:	Williams, Thomas	**Contact Phone:**	281-483-8773
Contact Email:	thomas.j.will1@nasa.gov		
Flight Program:			
Flight Assignment:	NOTE: End date changed to 10/5/2016 (original due date was 6/30/2018) due to PI move to Northwestern University and new award granted (Ed., 2/12/18) NOTE: Element change to Human Factors & Behavioral Performance; previously Behavioral Health & Performance (Ed., 1/17/17)		
Key Personnel Changes/Previous PI:	July 2016: none		
COI Name (Institution):	Contractor, Noshir Ph.D. (Northwestern University) Johnson, Jeffrey Ph.D. (University of Florida, Gainesville)		
Grant/Contract No.:	NNX15AM26G		
Performance Goal No.:			
Performance Goal Text:			

Task Description:	Among the remarkable team challenges NASA faces in long distance space exploration (LDSE) missions is the need to maintain team shared mental models (SMMs). Maintaining team SMMs requires the ability to detect shifts in cognition that will likely occur during the mission that could lead to ineffective crew functioning and performance. Maintaining team SMMs also requires validated countermeasures for bringing team members' cognitive understanding back into alignment. Leaving low Earth orbit is extreme teamwork - team SMMs need to be maintained within teams operating close up (the crew), and between teams operating at an unprecedented distance (i.e., the crew & ground; 33 million miles in the case of a Mars Mission). A multidisciplinary research team will leverage expertise in Psychology, Industrial Engineering, & Anthropology to understand the emergence and outcomes of critical shifts in team cognition over LDSE missions. What are the triggering events of SMM divergence, how can we detect them, and which countermeasures most effectively bring them back into alignment? This project leverages a novel conceptual framework of shared cognitive architecture (SCA) to understand the patterns of SMMs that dynamically link members of teams, and teams to other teams, as they go beyond low Earth orbit. We use semantic analysis to identify cognitive shifts, and relational event network analysis to understand the antecedents and consequences of these shifts. We use these alongside an agent-based model fit on LDSE analogue data, so that we can explore an exhaustive set of potential triggering conditions that must be unpacked to conduct efficient ground analogue research. We then conduct this research in HERA (Human Exploration Research Analog), Moonwalk, and Antarctica. The project culminates in the evaluation of a dashboard fed with the results of computational modeling, human validation, and lexical markers to detect and suggest countermeasures to maintain SMMs through time and space.
Rationale for HRP Directed Research:	
Research Impact/Earth Benefits:	Many of the environmental conditions faced by crews during LDSE missions are not unique to space travel. With our research program, we hope to reveal how conditions seen in organizations across the world impact shared cognitive architecture, and what we can do to mitigate these risks. Our meta-analysis has begun to investigate the impact of shared cognitive architecture on team outcomes across a variety of environmental conditions seen in LDSE missions that can also be applied to work in all organizations.
Task Progress:	Among the significant teamwork challenges NASA will face on a future mission to Mars, or any future mission out of the Earth's lower orbit, is the need to maintain shared mental models. Shared mental models need to be maintained within teams who operate at a short distance (i.e., the crew), and also between teams who operate at a great distance (i.e., the crew and ground). Our investigation of shared mental models incorporates two features that bolster our contribution. First, we model the role of critical contextual forces, resulting from the crew's interdependence and embeddedness within a system of teams, that ultimately shapes and constrains the maintenance of shared team mental models over long distance space exploration (LDSE). To reflect this focus of our research, we adopt the term shared cognitive architectures, in lieu of shared mental models. The difference in terms reflects the fact that shared cognition needs to be differentiated in terms of that within teams and that between teams; the patterns of within and between team shared mental models are defined as shared cognitive architecture: Shared cognitive architecture (SCA) characterizes the dynamic patterns of structured knowledge about critical elements of teamwork and taskwork, and how these mental representations are shared both within teams (e.g., the crew), and also between teams (e.g., mission control). The second feature of this research program that bolsters its contribution is the investigation of cognitive shifts. Dynamism is an important and under-researched aspect of team cognition relevant to spaceflight. Extant research measures team cognition as a stable property of a team. Given the complexity of astronaut crews working within multiteam systems, we conceptualize cognition as dynamic, shifting in response to a variety of triggering events. Astronaut mental models will have some elements that will need to shift as s/he engages in memberships in multiple groups, interacts with multiple teams, and encounters changes in tasks and goals. However, despite these dynamics, crew cognitive architectures need to remain in, or return to, synchrony with the other members of the crew. DATA COLLECTION A. HERA Campaign Participation and Data Collection: We participated in HERA Campaign 3 Mission 1, in partial fulfillment of our objective to collect team task switching data in an analog environment. To capture the full representative structure of a NASA mission to Mars, the HERA crew served as an isolated/confined crew in an environment similar to one that may travel beyond low-Earth orbit, and eight undergraduate participants at Georgia Tech served as Mission Control teams supporting the HERA crew on their mission. We ran three 2-hour sessions (3-hour sessions for participants at Georgia Tech who received 1 hour of training) in which we collected unobtrusive team task-switching data, as well as performance data on the overall task. We also collected team process data through pop-up surveys administered throughout sessions. Additionally, we implemented a time delay within our own software platform to align with the time delay manipulation implemented in HERA during our second session. We are pleased to report that all data collection efforts across all three 2-hour HERA sessions were successful. B. Project RED Platform, and Additional Multiteam System Experimental Sessions - Control Sessions: The platform used to collect this data was the computer-based multi-team task platform that we developed at Georgia Tech, called Project Red planet Exploration and Development (Project RED). In Project RED, four teams of 3 members each (i.e., a Multiteam System; MTS) work on solving the complex problem of designing and implementing a well infrastructure on Mars that will support future inhabitants of the planet. We are pleased to report that all data collection efforts across all three 2-hour HERA sessions were successful. We have also designed four additional control experiment sessions (one completed, three to be run by the end of the annual review period) to obtain baseline measures against which we can compare our analog data of crew members in an isolated/confined environment. One manipulation will be the distribution of the MTS. In the distributed condition, 4 participants will serve as the "crew" located in the SONIC lab at Northwestern University, and the remaining 8 "Mission Control" participants will be located in the DELTA lab at Georgia Tech. For the non-distributed MTS condition, all participants will be located at the DELTA lab at Georgia Tech. The second manipulation will be the presence or absence of a time delay in communication. C. Project RED Relay - Mapping Shared Cognitive Architecture: To understand the knowledge that individuals have about who knows whom, we implemented a knowledge task called "Project RED Relay," to assess how well people recall information about their group's network structure, and how well they understand other people's knowledge of the group's network. This task provides insight into how accurate or convergent knowledge of networks relates to team performance and outcomes during an LDSE mission where individuals work with a variety of others. Project Red Relay is administered to participants following the Project RED Design task as a network game that people access via laptops. This task asks people to direct messages containing files that need to be sent to a specified target in as few steps as

	possible by routing the message to other people who may be connected to the intended final target. Participants can only choose a small number of contacts to use to direct messages, and to route the messages efficiently, they must be able to know whom other participants selected as their contacts. During this network game, we collected measures of cognitive awareness and perceived individual, team, and MTS efficacy at routing the messages. Therefore, this knowledge task allows us to measure the accuracy, efficiency, and perceptions of people's cognitive structures.
Bibliography Type:	Description: (Last Updated: 04/29/2025)
Abstracts for Journals and Proceedings	DeChurch LA, Contractor NS, Johnson J, Mesmer-Magnus J, Plummer G, Twyman M, Niler A, Larson, Hernandez I. "SCALE: Shared Cognitive Architecture for Long - Distance Exploration." Poster 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	Plummer G, Jeon G, DeChurch LA, Contractor NS. "Harmful effects of team external activity on team cognition." Contractor, N. S. (chair), & Plummer, G. (co-chair), Novel ways to understand and assess teamwork. Symposium conducted at the 31st Annual Conference of the Society of Industrial and Organizational Psychology, Anaheim, CA, April 14-16, 2016. 31st Annual Conference of the Society of Industrial and Organizational Psychology, Anaheim, CA, April 14-16, 2016. , Apr-2016
Abstracts for Journals and Proceedings	Bedwell WL, Bell ST, Contractor NS, Fiore SM, Kozlowski SWJ, Salas E, Tannenbaum SI. "Organizing that's out of this world!" Larson, L. E., Jones, B.R., & DeChurch, L.A. (co-chairs), Ignite and Panel Discussion. Panel convened at the 31st Annual Conference of the Society of Industrial and Organizational Psychology, Anaheim, CA, April 14-16, 2016. 31st Annual Conference of the Society of Industrial and Organizational Psychology, Anaheim, CA, April 14-16, 2016. , Apr-2016