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| **Fiscal Year:** | FY 2016 | **Task Last Updated:** | FY 07/20/2016 |
| **PI Name:** | DeChurch, Leslie Ph.D. | | |
| **Project Title:** | Team Task Switching in Astronaut Crews on the International Space Station: Integrating Multiteam Membership, Multiteam Systems, Multitasking,& Multidimensional Networks to Monitor & Enable Functional Work Shifts in Astronaut Crews | | |
| **Division Name:** | Human Research | | |
| **Program/Discipline:** | | | |
| **Program/Discipline--Element/Subdiscipline:** | | | |
| **Joint Agency Name:** | | **TechPort:** | No |
| **Human Research Program Elements:** | (1) **HFBP**:Human Factors & Behavioral Performance (IRP Rev H) | | |
| **Human Research Program Risks:** | (1) **HSIA**:Risk of Adverse Outcomes Due to Inadequate Human Systems Integration Architecture<br>(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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| **City:** | Evanston | **State:** | IL |
| **Zip Code:** | 60208 | **Congressional District:** | 9 |
| **Comments:** | NOTE: Previously at Georgia Institute of Technology until July 2016. | | |
| **Project Type:** | Flight | **Solicitation / Funding Source:** | 2013-14 HERO NNJ13ZSA002N-ILSRA. International Life Sciences Research Announcement |
| **Start Date:** | 05/12/2015 | **End Date:** | 10/05/2016 |
| **No. of Post Docs:** | 1 | **No. of PhD Degrees:** | |
| **No. of PhD Candidates:** | 1 | **No. of Master' Degrees:** | |
| **No. of Master's Candidates:** | 1 | **No. of Bachelor's Degrees:** | |
| **No. of Bachelor's Candidates:** | 5 | **Monitoring Center:** | NASA JSC |
| **Contact Monitor:** | | **Contact Phone:** | |
| **Contact Email:** | | | |
| **Flight Program:** | ISS | | |
| **Flight Assignment:** | NOTE: End date changed to 10/5/2016 (original due date was 5/11/2018) due to PI move to Northwestern University and new award granted (Ed., 2/12/18)<br>NOTE: Element change to Human Factors & Behavioral Performance; previously Behavioral Health & Performance (Ed., 1/17/17) | | |
| **Key Personnel Changes/Previous PI:** | | | |
| **COI Name (Institution):** | Contractor, Noshir Ph.D. ( Northwestern University ) | | |
| **Grant/Contract No.:** | NNX15AK73G | | |
| **Performance Goal No.:** | | | |
| **Performance Goal Text:** | | | |

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| **Task Description:** | We are at the dawn of a new era of human space exploration. Moving beyond low Earth orbit and the relative safety of the International Space Station (ISS) toward near-Earth asteroids and Mars presents previously unimaginable opportunities as well as organizational challenges. One significant challenge is the complexity of the operating environment within which astronauts will work. This complexity will place enormous demands on astronauts, and research is needed that develops concrete countermeasures to mitigate the risks stemming from performance decrements due to inadequate cooperation, coordination, communication, and psychosocial adaptation within a team. Astronauts will push the bounds of human cognitive and social functioning as they multitask across tasks, teams, and tools working toward personal, team, and system goals. This multidisciplinary research project is designed to help them do just that. This three-year programmatic investigation into team task switching leverages: (1) agent-based models to understand how task switching behavior and performance-related switching costs occur based on dynamic interplay between independent and interdependent tasks, (2) laboratory experiments conducted in two multiteam systems laboratories (one at Georgia Tech, the other at Northwestern) to test the theoretical model derived from agent-based models, (3) unobtrusive data collection strategies to capture information on the tasks and complex social network structures of ISS crew members, (4) design of interventions to enable adaptive team task switches using virtual experiments, (5) validation of intervention strategies using one of NASA's space analogs, and (6) development of a dashboard decision aid to anticipate and pre-empt dysfunctional task switching. An innovative feature of our investigation is the use of a multidimensional network approach to characterize and model the switches between tasks, tools, teams, and multi-team systems. The combined outputs of this proposed multi-disciplinary project speak directly to NASA Human Research Program's (HRP's) identified team gaps for autonomous, long duration, and/or long distance exploration missions associated with the need to identify (1) key threats to the team (Team Gap 1), (2) countermeasures to support team function (Team Gap 3), (3) validated methods that can be used to maintain team function (Team Gap 5), and (4) psychological and psychosocial factors, measures, and combinations thereof that can be used to compose highly effective crews (Team Gap 8). |
| **Rationale for HRP Directed Research:** | |
| **Research Impact/Earth Benefits:** | Previous models of task switching revolve around task and individual factors that affect work efficiency as individuals move from task to task throughout their workday. However, individuals not only accomplish tasks individually using one technological tool, they do so as members of multiple teams using a variety of technologies.<br>Our research on team task switching examines factors that affect the decision and ability of individuals to switch between tasks with varying levels of interdependence, as well as discuss the mediators and moderators that determine adaptive switching in today's complicated work environments. This model affords a comprehensive understanding of how individuals adapt to dynamic, environmentally-triggered performance demands requiring them to change tasks, teams, and technologies, and shift back and forth between personal, team, and system goals.<br><br>Our research will be useful for investigating task switching in any modern-day organization facing complex collaborative challenges, such as NASA space exploration, large scientific consortia (e.g., CERN-the European Organization for Nuclear Research), cybersecurity teams, healthcare systems, and the military. Furthermore, findings could then be leveraged to develop system-wide interventions that increase overall work efficiency and resilience in safety-critical systems. |
| | NASA's future mission to Mars will require challenging taskwork and complex teamwork -- astronauts, Mission Control, and other entities working on the Mars mission will be required to attend to many tasks, team members or other teams, and tools at once, often switching between them. Acknowledging these complex processes, we have created a conceptual framework to specify the specific relationship between task, team, and tool factor variables and task switching outcomes. Our conceptual model delineates two types of task switching: lateral and vertical. Lateral shifts include shifts between tasks, teams, or tools. Vertical shifts involve a shift in the level of interdependence (e.g., individual, single team, multiple teams) needed to complete a task. These can be either upward (e.g., working independently to working with a team) or downward (e.g., working with a team to working independently). To demonstrate this framework, we are designing an agent-based model (ABM). ABMs are a tool that allow us to both map and trace potential behaviors and interactions. In particular, our ABM models the dynamics of multiple autonomous individuals switching between multiple tasks, working within multiple groups with different compositions.<br>In order to understand the important characteristics of teams that individuals use when making decisions on when to switch team tasks, and on which team they would prefer to work, we utilized a novel approach to uncovering individuals' "policies" for making decisions that describe how some team characteristics may be more heavily weighted in those decisions than others. The impetus for this research was to better understand how astronauts on extended long-distance space exploration missions, who may be completely isolated from Mission Control, and, therefore, have the agency to freely switch between multiple team tasks, make team task switching decisions. To this end, we leveraged the policy capturing approach to identify social factors that individuals use when choosing to work with a team. Aspects of teams that individuals find "attractive" will be determined by analyzing the team task switching choices participants make while reading a number of team task scenarios. Specifically, a within-subjects crossed design will be used with social factors as the independent variable (i.e., team cohesion, team processes, and shared mental models) and task switching decision (i.e., likelihood of remaining on the current team task) as the dependent variable. The study will be the first to isolate social factors related to an individual's task management choices in complex work systems.<br><br>DATA COLLECTION<br><br>A. HERA (Human Exploration Research Analog) 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. |

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| **Task Progress:** | 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.<br><br>C. Policy Capturing - Judgment and Decision Making Approach to Understanding Team Task Switching: In order to understand the important characteristics of teams that individuals use when making decisions on when to switch team tasks, and on which team they would prefer to work, we utilized a novel approach to uncovering individuals’ “policies” for making decisions that describe how some team characteristics may be more heavily weighted in those decisions than others. The impetus for this research was to better understand how astronauts on extended LDSE missions, who may be completely isolated from Mission Control, and, therefore, have the agency to freely switch between multiple team tasks, make team task switching decisions. To this end, we leveraged the policy capturing approach to identify social factors that individuals use when choosing to work with a team. Aspects of teams that individuals find “attractive” will be determined by analyzing the team task switching choices participants make while reading a number of team task scenarios. Specifically, a within-subjects crossed design will be used with social factors as the independent variable (i.e., team cohesion, team processes, and shared mental models) and task switching decision (i.e., likelihood of remaining on the current team task) as the dependent variable. The study will be the first to isolate social factors related to an individual’s task management choices in complex work systems.<br><br>D. ISS Protocol Submission: We have also submitted a proposal for studying team task switching on the ISS in addition to the Project RED data. We received feedback from International Space Station Medical Projects, and our response to their feedback is currently under review. Sampling actual flight crews would enable us to provide the most accurate and useful assessment of the effects of task entrainment in real space environments, and to develop an intervention to mitigate these effects. The proposed in-flight research would be carried out using a sample of two members of three flight crews (six total participants) over a 1.5-year period (Planned for Expeditions 49 - 52), and would examine when member switch tasks, as well as available measures of performance on these tasks, and end-of-day (EOD) survey data being collected on these days in order to map key team characteristics involved in lateral team task switches to switch costs and key interdependence coordination costs and motivation involved in vertical shifts to switch costs. Astronauts will be wearing activity trackers and sociometric badges that provide further information about the task performance and preferences. Additionally, we requested the documentation of start and stop times of tasks, an assessment of the degree to which each task is complete or requires rework, and proposed distributing surveys to further assess how lateral switches across teams and vertical switches to different levels of interdependence impact team and task perceptions. |
| **Bibliography Type:** | Description: (Last Updated: 04/29/2025) |
| **Abstracts for Journals and Proceedings** | DeChurch LA, Contractor NS, Mesmer-Magnus J, McDonald J, Hernandez I. "Team Task Switching in Astronaut Crews on the International Space Station: Integrating Multiteam Membership, Multiteam Systems, Multitasking & Multidimensional Networks to Monitor & Enable Functional Work Shifts in Astronaut Crews." Poster presented at the 2016 NASA Human Research Program Investigators’ Workshop, Galveston, TX, February 8-11, 2016.<br>2016 NASA Human Research Program Investigators’ Workshop, Galveston, TX, February 8-11, 2016. , Feb-2016 |
| **Significant Media Coverage** | Forbush E. "News coverage of agent-based model, 'Students Use NetLogo to Plan Mars Mission, Model New Societies.' " Northwestern University McCormick School of Engineering News, 17, June 2015., Jun-2015 |