Fiscal Year:	FY 2021	**Task Last Updated:**	FY 12/14/2020
PI Name:	Carter, Dorothy Ph.D.		
Project Title:	Project FUSION: Facilitating Unified Systems of Interdependent Organizational Networks		
Division Name:	Human Research		
Program/Discipline:			
Program/Discipline--Element/Subdiscipline:			
Joint Agency Name:		**TechPort:**	Yes
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 (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		
PI Email:	dorothyrpc@gmail.com	**Fax:**	FY
PI Organization Type:	UNIVERSITY	**Phone:**	281-701-7090
Organization Name:	Michigan State University		
PI Address 1:	Department of Psychology		
PI Address 2:	16 Physics Rd #262		
PI Web Page:			
City:	East Lansing	**State:**	MI
Zip Code:	48824	**Congressional District:**	7
Comments:	The Principal Investigator (PI) was previously at the University of Georgia.		
Project Type:	Ground	**Solicitation / Funding Source:**	2016-2017 HERO NNJ16ZSA001N-Crew Health (FLAGSHIP, OMNIBUS). Appendix A-Omnibus, Appendix B-Flagship
Start Date:	02/12/2018	**End Date:**	03/31/2022
No. of Post Docs:	0	**No. of PhD Degrees:**	0
No. of PhD Candidates:	1	**No. of Master' Degrees:**	1
No. of Master's Candidates:	5	**No. of Bachelor's Degrees:**	0
No. of Bachelor's Candidates:	12	**Monitoring Center:**	NASA JSC
Contact Monitor:	Whitmire, Alexandra	**Contact Phone:**	
Contact Email:	alexandra.m.whitmire@nasa.gov		
Flight Program:			
Flight Assignment:	NOTE: End date changed to 3/31/2022 per NSSC information and A. Beitman/HFBP (Ed., 10/20/21) NOTE: End date changed to 2/11/2022 per NSSC information via L. Barnes-Moten/JSC (Ed., 4/7/21)		
Key Personnel Changes/Previous PI:			
COI Name (Institution):	Contractor, Noshir Ph.D. (Northwestern University) Schecter, Aaron Ph.D. (University of Georgia) DeChurch, Leslie Ph.D. (Northwestern University) Shuffler, Marissa Ph.D. (Clemson University)		
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Performance Goal No.:			
Performance Goal Text:			

Task Description:	As we set our sights on Mars, and other destinations beyond lower Earth orbit, we must enable extreme forms of teamwork across Spaceflight Multiteam Systems (SFMTSs) composed of teams that are separated by unprecedented degrees of space and time. In “Project FUSION: Facilitating Unified Systems of Interdependent Organizational Networks,” we are engaging in a transformative research program rooted in the past decade of theory and research on MTSs, but breaking new ground in how MTSs are conceptualized and studied. Our programmatic research aims to illuminate the underlying forces that give rise to the psycho-social relational states (e.g., influence, trust, shared cognition) within and between teams that underpin mission success. These crucial relationships, and the drivers of their emergence, will need to be understood, monitored, and at times, circumvented using countermeasures in order to enable coordinated efforts across the SFMTSs involved in Long-duration Exploration Mission (LDEMs). Project FUSION is a multi-pronged, multi-method, interdisciplinary project with three main research foci: (1) field investigations using NASA personnel; (2) development of an agent-based computational model capturing the drivers of relational states; and (3) controlled laboratory experiments and analog studies. Our research design is intended to be iterative. Findings within each foci are continually infusing the refinement and design of research in other foci. Further, Project FUSION is an applied research project with the ultimate goal of translating findings from three research foci in order to provide NASA with a "countermeasure toolkit" comprised of validated interventions that can be used to facilitate effective teamwork in SFMTSs. The countermeasure toolkit under development in this project consists of: (1) a SFMTS task analysis procedure, (2) a decision-making guidebook based on our agent-based computational model of SFMTS dynamics, (3) a multiteam training countermeasure ready for operational implementation with astronauts and mission controllers, and (4) a multiteam debriefing protocol ready for operational implementation with astronauts and mission controllers.
Rationale for HRP Directed Research:	
Research Impact/Earth Benefits:	The findings from this project will have substantial implications for human life on Earth, and in particular, for the effectiveness of teams and larger systems of teams in organizations operating in high-stakes environments. The field studies, laboratory studies, and computer simulation studies aim to better understand the patterns of social relationships (e.g., trust, influence, information sharing) that are likely to form within and across teams in large interdependent organizational systems. By better understanding the patterns of relationships that are likely, we can help determine when and where teamwork interventions or "countermeasures" are necessary. Moreover, the ultimate goal of this applied research project is to develop and validate a toolkit of countermeasures, including training, debriefing procedures, and decision-making protocols that are designed to facilitate team and inter-team collaboration in complex organizational systems. These countermeasures will be able to be utilized widely across many organizational contexts beyond NASA (e.g., healthcare, the military, corporations).
	In Project FUSION, we are conducting a programmatic stream of research that aims to identify: (Aim #1) the key factors affecting the networks of relational states within and between teams that support SFMTS coordination and performance (Team Gap 1); (Aim #2) the key developmental factors that trigger shifts in networks of relational states in SFMTSs over time (Team Gap 1); (Aim #3) the ways in which networks of relational states affect team and system coordination and performance (Team Gap 1); and (Aim #4) validated proactive and/or reactive countermeasures targeting relational states in order to support SFMTS coordination and mission success that are multicultural and able to be implemented into existing systems (Team Gaps 3, 4, 5, 6, 8, MPTASK-01 and -02). To achieve these four research aims, we are connecting findings from: (Research Foci #1) field research involving analyses of archival documents, interviews and observations with NASA personnel; (Research Foci #2) computational ‘agent-based’ models combined with virtual experimentation; and (Research Foci #3) laboratory and analog environment experimental studies with human subjects designed to better understand the drivers and outcomes of relational state networks in SFMTSs. In Y3, we have built on our previous Foci 1 efforts from Y1 and Y2 in three major ways. First, we finalized three publications which synthesized different aspects of the academic literature (i.e., MTSs; leadership in interteam contexts, dynamic team memberships) in order to better understand SFMTS functioning, and we began a fourth review of the academic literature on team debriefing. The first literature review project synthesized the MTS literature as it relates to the context of LDEM. The resulting published book chapter clarifies the key characteristics of SFMTSs, delineates anticipated teamwork challenges during LDEM, and advances an overarching framework for a countermeasure toolkit that allows NASA personnel to systematically understand, anticipate, diagnose, and facilitate SFMTS functioning throughout the mission. The second literature review project within Research Foci 1 was a review and synthesis of relevant literature related to leadership in interteam contexts (such as SFMTS contexts involving multiple interdependent teams). The resulting published annual review revealed that in comparison to leadership targeted within teams in support of team-level goals, defining ‘what’ constitutes functionally effective leadership in interteam contexts requires greater precision with regard to ‘where’ (i.e., within teams, across teams) and ‘why’ (i.e., in support of team goals, system goals, etc.) leadership processes are enacted, as well as greater consideration of ‘when’ (i.e., under what circumstances) and among ‘whom’ (i.e., which people) leadership processes arise. The third literature review project within Research Foci 1 was a review and synthesis of academic research related to changes in team memberships over time. Our published literature review demonstrates the importance of characteristics across the individual-, team-, and organizational-levels for improving teams’ adaptability to membership changes. Our review also demonstrates that changes in team membership can trigger a series of other events and outcomes for individuals, teams, and the embedding organization. For NASA personnel, changes in the mission control team membership may have ramifications for spaceflight team functioning. In Y3, we conducted an extensive literature review to better understand the current state of the literature on team debriefing. Team debriefs are especially necessary within dynamic, high-stakes environments that require team members to continuously adapt to changing circumstances. An SFMTS context presents additional challenges related to communication, cohesion, and situational/risk awareness. Our goal is to leverage the extant literature on team debriefing in order to provide NASA recommendations for expanded debriefing protocols in multiteam contexts. Second, we are conducting three projects leveraging archival sources to better understand SFMTS functioning. Alongside reviews of academic research, interviews, and observations, these studies provide a foundation for the other two research research foci by providing a grounded and inductive examination of NASA SFMTS processes. Archival examinations of these processes are particularly useful for capturing long-term trends which can be difficult to access through alternate forms of data. In our first publication based on an analysis of archival documentation, we documented how the lessons learned during these prior eras of spaceflight will combine to inform decisions in preparation for a forthcoming fourth era of spaceflight focusing on LDEMs. The second of these publications utilized a critical incident (CI) technique to identify specific events that have occurred in prior SFMTSs, the outcomes of which are clearly tied to behaviors demonstrated by the individuals and teams involved. This study serves to begin to break apart the specifics of

Task Progress:	how shifting inter-team autonomy is exhibited within teams (i.e., crew claiming, mission control granting) in space and what team boundary work (i.e., buffering) looks like in SFMTSs. Further, this study may serve as a springboard for further research to continue to investigate the specifics of these processes as well as continue to examine them through other, varied methods. Our final ongoing publication in this area seeks to develop a practical understanding of MTS adaptation within the high-stakes environment of spaceflight by leveraging a historiometric approach. Third, we continued to refine our interview and observational protocols, and we conducted a pilot observational study session. These projects are designed to support a deeper understanding of the SFMTS context, evaluate our first countermeasure (i.e., the FUSION SFMTS Task Analysis Procedure), and provide the basis of our fourth countermeasure (i.e., FUSION Debriefing). In preparation for the larger interview study, we conducted a series of preliminary interviews with NASA personnel focusing on developing our understanding of key aspects of SFMTS functioning, and NASA operations more generally. These initial interviews consisted of a joint field trial of our preliminary interview protocol, and an information gathering focus regarding key linkages within NASA aimed at improving our sampling during future interviews. In preparation for further observations, we are coordinating with the Flight Operations Directorate (FOD) and seeking further approval for subsequent observations of training and other activities of NASA personnel in 2021. Thus far, we have successfully completed one virtual observation of an extravehicular activity (EVA) training activity with FOD personnel via Microsoft Teams in April 2020. During this observation, we piloted our proposed observational data collection format, successfully collecting information on a number of areas of interest. We also conducted interviews and observations of MTSs in analogous circumstances, including healthcare and emergency response settings. Given that SFMTSs are highly complex and dynamic, it is often difficult for personnel involved in mission planning and support to project the combined effects of all possible internal and external factors that may impact SFMTS functioning throughout the duration of a LDEM. To help address these challenges, Research Foci 2 aims to supplement findings from Research Foci 1 in order to build an Agent-Based Model (ABM) of SFMTS dynamics that can be used to make predictions about the functioning of SFMTSs and, in particular, when and among whom mission-critical breakdowns in collaboration and coordination are likely to occur. Currently members of our research team are working to formalize a complete version of our ABM of MTS dynamics. Our research team will refine the model using data collected in the Project RED Laboratory studies during Y1-Y3 (Foci 3). To fit an ABM to an empirical setting, the parameters are trained on empirical data by matching the emergent phenomena of the model with observed outcomes. The data needed for this verification is being collected in the Human Exploration Research Analog (HERA) environment. As stated in the project proposal, all code and documentation associated with the expanded, docked, and refined FUSION SFMTS ABM will be delivered to NASA by the end of the project. Research Foci 3 consists of a series of experiments with human subjects located in university laboratories and/or the Human Exploration Research Analog (HERA) environment. In Y2-Y3 we completed a first round of data collection in the HERA analog environment, successfully completing Project RED experimental sessions during the four missions of HERA Campaign 5. We executed the first of our planned Project RED studies in accordance with the goals articulated in our initial proposal and definitional phase documents. This first round of data collection, upon completion, will form the basis for the generation and estimation of our initial ABM. Our studies in C5 evaluate the antecedents of relational state networks in SFMTSs, and in particular, consider the role of team differentiation factors such as geographic distance and differences in expertise priorities. Data collected as part of HERA C5 is being used to create the SFMTS ABM (Foci 2) and additionally, as primary data used to test specific hypotheses about SFMTS functioning. Our third countermeasure is the Project RED FUSION Training program which leverages a simplified table-top (paper-and-pencil) version of the Project RED computerized simulation being implemented in the laboratory and analog environment experiments. The Project RED FUSION Training is designed to teach trainees about the interteam collaboration and communication demands of working in a MTS. The training builds on the foundation of team skills learned during Spaceflight Resource Management (SFRM) training by emphasizing additional inter-team collaboration demands associated with working in a larger system. In Y3, we conducted two validations of our Project RED FUSION Training program. First our research team conducted an initial validation effort of the Project RED FUSION Training with a sample of 128 professional masters students enrolled in a Collaborative Leadership course at Northwestern University. One of the key lessons that the MTS activity is designed to reinforce is that it is important to consider and integrate multiple goals when working in a larger system and to understand that other individuals from other teams may hold different priorities. In order for a MTS to perform effectively, constituent members and teams may need to value and work toward the superordinate goal of the system, which requires collaborative interaction across multiple teams. This validation effort provided encouraging early indications of the viability of directed multiteam training to improve collaborative processes among teams in a SFMTS. Awareness and commitment to the overarching superordinate goal of the system is often a precursor to effective inter-team collaboration. Our research team is currently in the process of collecting additional validation evidence using a second masters level course on leading teams. Second, our research team conducted an additional validation effort of the Project RED FUSION Training over the course of two weeks (4 class periods) with a sample of n = 120 undergraduate students enrolled in a Social Psychology course at the University of Georgia. The purpose of the present study was to evaluate the degree to which Project RED FUSION training enhanced trainees' understanding of MTS concepts and unique collaboration challenges in comparison to a team-training activity. Compared to a standalone team activity, participants' knowledge of MTSs significantly increased after the Project RED FUSION multiteam activity. Therefore, the present study provides support for Project RED FUSION as an effective training approach to teach MTS concepts and unique collaboration issues.
Bibliography Type:	Description: (Last Updated: 07/09/2025)
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Dissertations and Theses	Alvarado L. "Interteam autonomy shifts and boundary work in spaceflight multiteam systems." Master's Thesis, Clemson University, May 2020. , May-2020
Dissertations and Theses	Pendergraft JG. "Adaptation processes in spaceflight multiteam systems." Master's Thesis, University of Georgia, Athens, Spring 2020. , May-2020