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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		
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Space Biology Cross-Element Discipline:	None		
Space Biology Special Category:	None		
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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
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Key Personnel Changes/Previous PI:			
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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).
	"Project FUSION: Facilitating Unified Systems of Interdependent Organizational Networks” is an applied research project rooted in the past decade of theory and research on Multiteam Systems (MTSs) (Mathieu, Marks, & Zaccaro, 2001. International handbook of work and organizational psychology; Luciano, DeChurch, & Mathieu, 2018. Journal of Management, 44(3):1065–1096) that aims to provide an evidence-based countermeasure toolkit to NASA to help facilitate the patterns of psychological relationships (e.g., shared understanding, influence) and behavioral interactions (e.g., coordination, information sharing) across Spaceflight Multiteam Systems (SFMTSs) that are needed to support long-duration/long-distance exploration missions. The Project FUSION research program is focused on establishing an understanding of the key drivers of relational state networks in SFMTSs as well as the patterns of relational state networks that are likely to support Long-duration Exploration Mission (LDEM).success. In turn, the overarching practical goal of Project FUSION is to provide an empirically-derived countermeasure toolkit designed to facilitate the relational state networks needed to support LDEM success. 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). [Ed. note 2/8/2022: Human Research Program gaps have changed since the preceding referenced gaps--see Human Research Roadmap for updated information: https://] To achieve these aims, we are connecting findings from three research foci: Research Foci #1 comprises field research involving analyses of archival documents, interviews, and observations with NASA personnel and personnel in analog environments (e.g., hospital systems). The goal of Research Foci 1 is to provide contextually rich, in-depth information gathered from relevant academic literature and archival resources as well as NASA, analog, and international spaceflight personnel in order to (1) define the key characteristics, potential triggers, and performance outcomes for SFMTSs; (2) better understand existing countermeasures (e.g., training/debriefing); (3) evaluate how best to incorporate FUSION countermeasures into existing protocols; and (4) develop and refine our recommendations for two of our countermeasures (i.e., Countermeasure #1 FUSION SFMTS Task Analysis and Countermeasure #4 FUSION Multiteam Debriefing) Research Foci 2 aims to supplement findings from Research Foci 1 in order to build Agent-Based Models (ABMs) 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. In our FUSION SFMTS ABM, the people or ‘agents’ in the model interact with one another in accordance with rules derived from our theoretical framework of multiteam functioning. The agents’ interactions will generate networks of important psycho-social relationships, like trust, influence, communication, or information sharing, within and between teams. The key goal of our FUSION SFMTS is to better understand the patterns of psycho-social relationships that are likely to arise in SFMTSs under different circumstances. We will compare the patterns of psycho-social relationships that are likely to occur to the patterns that are likely to be effective. We aim to help NASA identify situations in which the patterns of relationships that are likely to occur are unlikely to be effective and, therefore, help determine when certain countermeasures (e.g., training, debriefing) need to be implemented in order to facilitate multiteam coordination and performance. The human-subjects data collected in Research Foci #3 serves as the basis for the models developed in Research Foci #2.

In Research Foci #3, we are conducting laboratory and analog environment experiments with human subjects, which are designed to better understand the drivers and outcomes of relational state networks in SFMTSs. 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. These experiments are intended to: (1) collect data from human subjects needed to refine and validate the model parameters in our SFMTS ABM (Foci 2); (2) test hypotheses about the drivers of psycho-social relationships in SFMTSs; (3) test hypotheses about the antecedents of SFMTS coordination and performance; and (4) evaluate the validity of our third countermeasure (i.e., Countermeasure #3 Project Red FUSION MTS Training). We are leveraging findings from the three research foci to develop, evaluate, and deliver a countermeasure toolkit aimed at steering patterns of relational states within and across SFMTS component teams to support LDEMs. Our toolkit will include four countermeasures:

Countermeasure #1: FUSION SFMTS Task Analysis Procedure: A structured procedure for understanding the characteristics and requirements of SFMTSs.

Countermeasure #2: FUSION ABM: Agent-Based Models (ABMs) of SFMTS dynamics and recommendations based on the results of ‘virtual experiments’ addressing key questions related to MTS coordination throughout LDEMs.

Countermeasure #3: Project RED FUSION MTS Training: A training tool designed to enhance understanding of the communication, leadership, coordination, and risk assessment demands of working in MTS contexts.

Countermeasure #4: FUSION Multiteam Debrief: Recommendations for a multiteam debriefing protocol that expands on existing Space Flight Resource Management (SFRM) systems to reinforce lessons learned related to multiteam collaboration.

We have completed four major activities in Y4. First, as part of Research Foci 1, we completed a detailed study of MTS adaptation in spaceflight contexts using NASA archival documents (Pendergraft et al., 2021, Master’s thesis). Second, as part of Research Foci #1 and Countermeasure #4, we completed a study of the effects of structured prebriefing/debriefing procedures on team performance in an analogous MTS context, specifically within an interconnected system of healthcare teams (Wolf et al., 2021, Master’s thesis). Third, as part of Research Foci #2 and Foci #3, we completed data collection in collaboration with HERA Campaign 6, Mission 1. Fourth, as part of Research Foci #3 and Countermeasure #3, we completed an evaluation study of our Project RED FUSION MTS Training (Gerkin et al., in progress, Master’s thesis).

SFMTS Critical Incident Study (Research Foci #1): Pendergraft, J. G., Carter, D. R., Shuffler, M., Pearman, J., & Lofgren, R. (Master's thesis project defended Fall 2021). Master’s Thesis: NASA Critical Incidents Reveal the Nature of Spaceflight Multiteam System Adaptation. The University of Georgia (Advisor: Carter, D. R.).

Background. High-reliability organizations (HROs), such as the National Aeronautics and Space Administration (NASA), rely on multiteam system work structures to tackle complex goals under uncertain, and often dangerous, circumstances that require members and teams to adapt to dynamically changing task demands. However, little is known currently about the nature of multiteam adaptation, given that most empirical studies of multiteam system functioning have been conducted within controlled laboratory contexts with relatively short-term and stable task demands and most research on adaptation in organizations has focused on either individuals, small stand-alone teams, or entire organizations. This study broadened the understanding of multiteam adaptation by leveraging archival documents from NASA’s Johnson Space Center Oral History Project (OHP) to identify key elements of multiteam adaptation in HRO contexts. We conducted a three-phase historiometric study where Phase I involved the identification of 159 critical incidents pertaining to adaptation within a NASA spaceflight MTS. Phase II involved coding these incidents on an array of attributes pertaining to the central challenges, the circumstances and the attributes of the MTS involved. Phase III involved coding the specific adaptation behaviors engaged in by the MTS. Findings clarify the nature of the critical challenges NASA’s MTSs have faced in previous eras of spaceflight and the ways in which the systems have overcome those challenges.

Major Findings and Implications. In particular, this study revealed three key insights into the challenges facing spaceflight MTSs. (1) Unsuccessful adaptive performance appears to be more associated with social challenges than technical challenges, (2) effective adaptive performance was less likely when spaceflight MTSs had high levels of norm/policy diversity between their component teams, and took longer to resolve challenges even when they were successful in doing so, and (3) the great majority of challenging incidents (CIs) with successful outcomes involved a dedicated integration team leading decision making. These insights are further likely to interact with the context of future Long-Duration Exploration Missions (LDEMs) in ways which heighten the inherent challenges of those missions.

Although NASA has continued to develop an increasing body of experience-backed competencies in these areas, these social challenges nevertheless continue to constitute a substantial challenge to ongoing NASA operations. This trend is likely to continue, given the planned international scope of future LDEMs. Inherent in cross-organizational and cross-cultural operations are increased communication and coordination challenges, which may be further exacerbated by challenging political or operational contexts. Similarly, such operational difficulties are likely to be inherent in LDEMs, given the protracted mission timeframe, isolation of the crew, and technical barriers to communication imposed by the vast distances travelled.

Our second insight, that effective adaptive performance was less likely when SFMTSs had high levels of norm/policy diversity between teams, and took longer when it did occur, reveals further important information about SFMTS operations, particularly as they pertain to factors likely to be present in LDEMs. Norm diversity, a dimension of differentiation within the system, captures the degree to which component teams have differing implicit or explicit expectations about how to respond to situations, tasks, or events. These norms may be outright stated as rules (i.e., prescriptive norms) or may simply be a fact of the way the team tends to operate (i.e., descriptive norms). Regardless of their nature, the consequences of differing norms between the component teams comprising a system appears to be an increased risk of performance decrements. In addition to the increased risk of an overall unsuccessful outcome, high levels of norm diversity also appeared to lead the system to take much longer to resolve challenges as they were encountered. Although the distinction between resolution timeframe and outcome is important, they are more intimately tied in high reliability organization (HRO) operations than in other contexts. As NASA’s experience has shown, rapid resolution of problems as they arise itself represents a critical dimension of spaceflight MTS performance.

The impacts of heightened social challenges present in LDEMs and the likely high norm diversity within the system may be mitigated through the use of targeted countermeasures focusing specifically on improving multiteam processes.

Task Progress:

While NASA currently employs evidence-based practices for training and debriefing, these countermeasures are currently structured to address team-level factors. Multiteam focused countermeasures of the type being developed by this project specifically address the challenge of operating across team (and often organizational) boundaries, and can reinforce likely points of communication and coordination breakdown within the system.

Finally, our third insight revealed that integration teams play a critical role in facilitating SFMTS adaptation. Most often, this integration team took the form of the Mission Control Center (MCC) front room -- particularly in CIs involving a team actively engaging in spaceflight. However, these integration teams could also include specialized coordination teams developed for the sole purpose of coordinating activities around a single task or mission element (e.g., the EVA-Extravehicular Activity Project Office). Where these teams lead the decision making process within the system, the efforts of the other component teams were better coordinated, more efficient, and more effective -- directly contributing to a higher rate of successful outcomes. However, the vast distances travelled in LDEMs will impose the novel challenge of extended communication delays between the crew and Earth-bound teams at some points of the mission timeline.

This lack of instantaneous communication will mean that the crew must operate with a greater degree of autonomy compared to previous missions, without the immediate access to a dedicated integrative team which has proven so useful to NASA SFMTSs in the past. Lanaj and colleagues (2013) demonstrated that decentralized planning and related autonomous activities among component teams of an MTS can sometimes result in lower efficiency and performance, particularly due to the strong negative effects of excessive risk seeking and coordination failures. Both of these factors (i.e., greater risk seeking and lower coordination) have the potential to result in devastating consequences for SFMTSs. Organizations must be cautious when implementing training to equip MTS component teams to act independently of the larger organizational unit -- while such independent action is one of the inherent benefits of the MTS structure, permitting or incentivizing too much independent action may have severe consequences. In the context of LDEMs, targeted preparatory training for more autonomous operations will be necessary, but must be accompanied by training which mitigates its anticipated negative consequences.

Evaluation of Structured Prebriefing/Debriefing Procedures within Healthcare Multiteam Systems. Citation: Wolf, V. Annamaria, Shuffler, M. & Carter, D. R. (V.A. Wolf, defended October 2021). Master's Thesis: Coordination In Healthcare Multiteam Systems: A Qualitative Study Of Healthcare Meetings. Clemson University (Advisor: Shuffler, M.).

This study aimed to identify how MTS coordination performance may be supported by pre-brief processes during joint-rounding in an interdisciplinary healthcare setting, and how countermeasures related to these activities may inform pre-brief procedures in MTSs within hospitals and other contexts (e.g., SFMTSs). Within healthcare contexts, specialized professionals work as members of MTSs to deliver care to their mutual patients. Communication and coordination breakdowns in these environments impact the lives of patients and the overall effectiveness and performance of the healthcare institutions. Joint patient rounding, particularly when interdisciplinary and representative of multiple teams, can counter MTS coordination breakdowns. Joint patient rounding involves the coming-together of healthcare professionals to discuss their patients and identify the course of action for their care, and provide the opportunity for inter-team collaboration. Research on interdisciplinary rounding suggests the implementation of rounds garners benefits for healthcare MTS coordination, for example, improved safety climate (O'Leary et al., 2011. Archives of Internal Medicine, 171(7):678-684), faster patient discharge (Southwick et al., 2014. Academic Medicine, 89(7):1018-1023), more efficient cross-provider communication (Riegel, 2018. Medsurge Nursing, 27(3)), and stronger cohesion and trust among providers (e.g., nurses and physicians) (Henkin, et al., 2016. Journal of Multidisciplinary Healthcare, 9:201-205; O'Leary et al., 2010. Journal of general internal medicine, 25(8):826-832).

Our research team conducted a series of interviews (Study 1) and observations (Study 2) to better understand joint patient rounding (pre-brief/debrief) procedures within the context of a healthcare MTS. We collaborated with healthcare leaders of an inpatient nursing unit for adult oncology within a hospital located in the southeastern United States. The MTS included a physician team, a nursing team; members of these teams strive to engage in joint-rounding on a daily basis to discuss their mutual patients. The rounding practices contain elements of pre-brief, MTS planning for patient care, and de-brief of previous MTS action phases. Study 1 aimed to clarify the barrier and facilitators of these joint-rounds. Based on Study 1, we gained insight into the focus of composition of joint-rounds, and became aware of a second healthcare meeting ongoing in this environment. Firstly, Joint-rounds include an attending and resident physicians, and a nurse navigator (and ideally a registered nurse), and are focused on patients' clinical and medical needs with a secondary focus on education for the physicians in training. The second healthcare meeting is composed of members of the nursing and case management team, and focused on what patients would need for a safe and timely hospital discharge. Study 2 was conducted to gain a deeper understanding of the procedures and processes within both of these healthcare meetings, and how they impact the MTS.

Study 1 Analyses/Results: Interviews with subject matter experts (SMEs). Using a qualitative research approach, transcripts were initially coded for behaviours, procedures, and activities that were either beneficial or detrimental to joint-rounding and MTS outcomes. Additional iterations of analysis revealed common sentiments across interviewees, and codes were condensed into descriptive themes and sub-themes related to facilitators of, and barriers to, effective joint-rounding. We identified procedures that were important to consider before, during, and after joint-round episodes. This suggests that pre- and de-brief episodes are impacted by preparatory and follow-up work, as well as activities occurring during the episodes themselves. Our results suggest countermeasures aiming to facilitate effective pre-brief and debrief during join-rounding. Based on the themes we identified, countermeasures may insure that: pre-round preparation & coordination occurs; that nurses and physicians engage in information sharing & planning during rounds and hold attitudes that indicate readiness to collaborate; that joint-rounding members involve & closing information loops with relevant others who did not attend the round, post-rounding.

Study 2 Analyses/Results: Observations of Hospital System MTSs. Our qualitative analysis revealed four key processes and sub-processes that capture how meetings within this researched environment facilitates patient care within the MTS. Namely, members used these meetings for the purposes of informing and gaining clarity about the patients, other teams, and upcoming plans. This illustrates how the central purpose of the MTS (patient care) is addressed, but also inter-team interdependencies (other teams). Within these themes, we see elements of de-briefing procedures that allow members to discuss previous events and establish shared awareness of the current situation prior to taking, or planning, further action. We found that the latter activities fell under strategizing processes wherein care plans were developed and adjusted, at times with the understanding that they would be enacted contingent upon other factors. Within the strategizing process, we also see the intention to coordinate with other teams in pursuit of shared goals. Elements of

pre-briefing are evident within this process, where members establish and orient themselves to upcoming objectives. The final process identified, i.e., pedagogy, was only present within the meeting among physicians and nurse navigators, while the former processes occurred across meetings. This process captures activities related to learning, teaching, lecturing, and quizzing for the benefit of resident physician's medical education.

This research begins to identify and deconstruct the processes that occur during joint rounds and healthcare meetings, and how these facilitate inter-team coordination. Understanding how such meetings facilitate coordination at the system-level can inform NASA. In consideration of countermeasure #4, NASA may draw from these findings to structure meetings and develop protocols to support integration across multiple meetings occurring within SFMTSs. In particular, our findings support pre-briefing and debriefing as useful strategies for orienting meeting members to previous and upcoming events, which, in combination with cross-team considerations, can enhance the multiteam focus and thereby support cross-team coordination. Future research is needed to understand how the focus of multi-team, interdisciplinary meetings ought to be prioritized depending on the needs of the MTS. In the case of our research, we beg the question of under what circumstances rounding meetings should emphasize pedagogy that supports resident learning over patient-care focused strategizing for patient care planning. This question is relevant for SFMTSs, which are also dynamic environments where priorities shift, and where focusing one's attention on the most pertinent objectives can be the difference between life or death.

HERA Campaign 6 Mission 1 Data Collection, Fall 2021

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. Research Foci 2 is focused on building ABMs based on the data collected in Research Foci 2. In Y2-Y3 we completed a first round of data collection in the HERA analog environment, successfully completing Project RED (Red planet Exploration & Development) experimental sessions during the four missions of HERA Campaign 5. During Y4, we completed data collection during HERA Campaign 6 Mission 1, following the resumption of HERA operations after COVID-related delays during 2020. Continuing into HERA C6, data collection will be used for the testing of specific hypotheses regarding MTS composition, development, communication and coordination. Additionally, HERA C6 data will be used to bolster and further validate our ABMs.

Methods. The HERA/laboratory studies in Y2-Y4 leveraged the Project RED (Red planet Exploration & Development) computerized SFMTS simulation. In a Project RED simulation, four interdisciplinary teams work interdependently as a 12-person SFMTS to solve a complex task: designing a well to support a human colony on Mars. The Project RED simulation has been implemented in other NASA-funded projects and has demonstrated utility in examining the teamwork risks present in LDEMs. The simulation provides metrics of individual, team, and system performance. The Project RED software provides metrics of individual, team, and system performance. System performance is indexed in terms of both efficiency and ingenuity, both important aspects of space mission team success. Participants complete a series of self-report surveys which provide information about individual differences, and affective, cognitive, and instrumental states and relationships within and across teams throughout the simulation. The software interface provides digital traces to index information sharing and utilization, team attention allocation, and problem solving unobtrusively. Chat, video, and audio data can also be used to examine intra- and inter-team interaction as it unfolds over time and in response to dynamic environments and triggers during subsequent analyses.

Evaluation of Countermeasure #3 (Project RED FUSION MTS Training). Citation: Gerkin, E., Carter, D., & DeChurch, L.A. (Expected Defense Date: Spring 2022). Thesis: Project RED: A multiteam system training simulation. University of Georgia (Advisor: Carter, D.).

Background. Our research team conducted an additional validation effort of the Project RED 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. Project RED Training is designed to develop trainees' declarative knowledge of multiteam definitional features, challenges – particularly those associated with component team differentiation (Luciano et al., 2018) – and strategies associated with working within a MTS context. The purpose of this study was to evaluate the degree to which Project RED training enhanced trainees' understanding of such MTS concepts, unique collaboration challenges, and cross-team interaction strategies in comparison to a similar single team-training activity called "Interstellar." Project RED emphasizes team and multiteam collaboration; as such, we hypothesized that trainees' scores on a declarative knowledge measure assessing understanding of multiteam system issues would be higher after completing Project RED than after Interstellar.

Within Project RED, we also explored the use of a team-priority manipulation that is a customizable aspect of the Project RED multiteam training simulation. Each team within a MTS was assigned to one of three different priorities – Team-, Compromise-, or Collaboration-focus. The Team-Focus asked participants to focus only on their team goals and not make any compromises. Under the Compromise-Focus, participants were told they would have to make concessions to achieve the overall goal of the MTS. Lastly, the Collaboration-Focus had participants work collaboratively while still maintaining their team goals. Different combinations of team priorities were used to create 4 manipulation conditions.

Results/Implications. Results of preliminary analyses support the notion that trainees' knowledge of multiteam system concepts is greater after completing Project RED than after completing Interstellar. Specifically, knowledge of multiteam system definitional features was higher after Project RED than after Interstellar. Lastly, knowledge of multiteam system working strategies was higher after trainees' completed Project RED than after completing Interstellar. Further, the comparison of different priority conditions within Project RED suggest that trainees did, in fact, pursue their assigned priorities and that the systems might be less likely to succeed overall when one or more teams behaved competitively. Overall, these results provide preliminary evidence supporting the benefits of Project RED for training multiteam system lessons.

Bibliography Type:	Description: (Last Updated: 01/24/2024)
Dissertations and Theses	Pendergraft JG, Carter DR, Shuffler M, Pearman J, Lofgren R. "NASA Critical Incidents Reveal the Nature of Spaceflight Multiteam System Adaptation." J.G. Pendergraft. Master's thesis project defended Fall 2021, The University of Georgia, Fall 2021. , Sep-2021
Dissertations and Theses	Wolf VA, Shuffler M, Carter D. "Coordination In Healthcare Multiteam Systems: A Qualitative Study Of Healthcare Meetings." V.A. Wolf, Master's Thesis, Clemson University, defended October 2021. , Oct-2021

Dissertations and Theses	Gerkin E, Carter D, DeChurch LA. "Project RED: A multiteam system training simulation." E. Gerkin, Master's Thesis, The University of Georgia. Expected Defense Date: Spring 2022. , Apr-2022