Fiscal Year:	FY 2014	**Task Last Updated:**	FY 06/10/2014
PI Name:	Kozlowski, Steve Ph.D.		
Project Title:	Measuring, Monitoring, and Regulating Teamwork for Long Duration Missions		
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) **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		
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Comments:	I moved from Michigan State University to the University of South Florida in August 2020.		
Project Type:	GROUND	**Solicitation / Funding Source:**	2012 Crew Health NNJ12ZSA002N
Start Date:	08/16/2013	**End Date:**	08/15/2016
No. of Post Docs:	0	**No. of PhD Degrees:**	0
No. of PhD Candidates:	4	**No. of Master' Degrees:**	0
No. of Master's Candidates:	3	**No. of Bachelor's Degrees:**	0
No. of Bachelor's Candidates:	0	**Monitoring Center:**	NASA JSC
Contact Monitor:	Leveton, Lauren	**Contact Phone:**	
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Flight Program:			
Flight Assignment:			
Key Personnel Changes/Previous PI:			
COI Name (Institution):	Biswas, Subir (Michigan State University) Chang, Chu-Hsiang (Michigan State University)		
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Performance Goal No.:			
Performance Goal Text:			

Task Description:	This proposal is for ground-based research: PRD (Program Requirements Document) Risk: Risk of Performance Decrements Due to Inadequate Cooperation, Coordination, Communication, and Psychosocial Adaptation within a Team. IRP (Integrated Research Plan) Gap – Team1: Understand the key threats, indicators, and life cycle of the team for autonomous, long duration, and/or distance exploration missions. Collaboration, cohesion, and coordination are essential teamwork processes, especially for long duration space crews that perform in isolated, confined, and extreme (ICE) environments. Teamwork is critical for minimizing errors and enhancing team performance and reflects team adaptation to the rigors of long duration missions. Over 50 years of research documents the contribution of team processes to team effectiveness. Unfortunately, the vast majority of this research is cross-sectional (static). Thus, there is little scientific knowledge regarding how team processes and psycho-social health vary over long durations in ICE conditions, the persistence of disruptive internal and external shocks, and the types of countermeasures that can regulate effective teamwork. The proposed research has three specific aims and deliverables that yield an integrated approach for measuring, monitoring, and regulating teamwork processes and team functioning: (1) Benchmark long duration team functioning in ICE analog environments. This research will use Experience Sampling Methods (daily assessments) to assess team functioning in ICE environments. The goal is to quantify expected variation in key team processes, identify internal and external shocks, and assess dynamic effects on team performance. Such data are essential for developing standards to distinguish normative variation from anomalies indicative of a threat to team functioning which are necessary for triggering countermeasures. (2) Extend engineering development of an unobtrusive monitoring technology (wearable wireless sensor package). The product is to further develop a prototype monitoring technology of teamwork interactions. Initial validation has demonstrated reliability and accuracy sufficient to establish proof of concept. Proposed extensions are designed to (a) add sensing capabilities (swallow monitoring for food intake, stress assessment) and (b) technology development to make the system more robust (packaging, energy efficiency; hardware, algorithms, and software) for out-of-lab field demonstration. (3) Develop teamwork interaction metrics and regulation support systems. The monitoring technology provides continuous data on a range of teamwork processes. Three additional components are required for a countermeasure system. (a) Metrics: Algorithms need to be developed that parse the raw data streams into meaningful measures, then the metrics need to be validated; (b) Data Fusion and Team Regulation Protocols: The multivariate time series metrics need to be fused into a coherent assessment of individual and team functioning. Anomalies that signal a departure from normative functioning have to be classified to drive the provision of feedback and/or team regulation interventions; (c) Distributed Networked Dashboard: A system architecture is needed to integrate sensor information and data fusion, direct feedback to maintain good teamwork and, when the system detects an anomaly in team functioning, trigger appropriate feedback and countermeasures to help an individual or the team regulate team processes. Flexible options for distributing and displaying team status assessments and countermeasures need to be provided (e.g., individual team member, dyads, team leader, ground control). These specific aims will contribute to reducing the risk of team performance decrements by characterizing normative and anomalous patterns of team functioning; monitoring team member interactions; and providing regulation support to maintain teamwork and to trigger countermeasures when needed to aid team recovery.
Rationale for HRP Directed Research:	
Research Impact/Earth Benefits:	Team cohesion is not just a critical factor for astronaut teams and ground crews; cohesion is important to the effectiveness of all teams and especially those that operate in critical, high reliability settings. Of the many team process factors that support team effectiveness, team cohesion is the most studied with over a half century of research. Yet, remarkably, very little is known about the characteristics that promote its development and maintenance. For example, we know that experience working together is associated with cohesion formation and maintenance, but what are the mechanisms? Teams that do not cohere replace problematic members or disintegrate so experience only reveals those teams that survive, but that does not tell us why or how. This research, which will uncover the dynamics of collaboration, cohesion, and effective team functioning and will create technologies to monitor team cohesion and guide interventions to restore it, has the potential for wide utility in aviation, military, medical, industrial, and other environments where society depends on the effective performance of high reliability teams.
	At this writing the project has been underway for a little less than 9 months. Much of our initial activity is a continuation of work developed under prior awards (NNX09AK47G & NNX12AR15G), with particular attention focused on (1) benchmarking data collections in ICE analogs and NASA mission simulations and (2) evaluating the monitoring technology in mission simulations. The other project focus, (3) developing interaction metrics and teamwork support, is dependent on data and techniques developed in (1) and (2) and is not part of our research activities this year and so does not appear in this report. Benchmark Long Duration Team Functioning in ICE Analog Environments A significant portion of research effort was invested in developing, initiating, and conducting benchmarking data collections over the last several months. A description of our research activities follows. Australian Antarctic Division (AAD) Stations and Field Teams in Aurora Basin (AB). We extended our collaborative research with Dr. Jeff Ayton of the AAD. We initiated new data collections with station personnel who deployed to winter-over for 2013-2014. This involved extending our research protocol with AAD; renewing IRB (Institutional Review Board) approvals by the AAD, MSU (Michigan State University), and NASA; and working with our collaborator and his team to recruit participants. Approximately 44 participants from Mawson, Davis, and Casey Stations, as well as field science teams, are participating in this ongoing effort to benchmark individual and team functioning in ICE settings. This ongoing research assesses daily teamwork processes using Experience Sampling Methodology (ESM), which captures a snapshot of key individual and team reactions to events of the day. Although the absolute sample sizes tend to be small, the primary focus of the research is on the dynamics of reactions over a period of nine months to a year (i.e., approximately 270 to 360 measurement periods), which yields insights into long duration individual and team functioning.

Task Progress:	Science Field Teams in Antarctica. We also extended our ongoing collaboration with science teams that deploy to the ice during the Antarctic summer for 2013-2014. This involved extending our research protocol, renewing MSU and NASA IRB approvals, and recruiting participants from the science teams. Approximately 10 participants are contributing to the research effort, providing daily ESM reports. Human Exploration Research Analog (HERA). We initiated new benchmarking research in a NASA transit mission simulation, HERA, which is located at the Johnson Space Center (JSC). HERA missions involve a crew of members, selected from NASA volunteers. HERA simulates transit for exploration of an asteroid. Thus far, mission duration is approximately 7 days. This research has involved extending our protocol, securing IRB approvals from NASA and MSU, training personnel, and coordinating research activities with several other investigator teams. We also have taken on the responsibility of coordinating several end-of-day measures across investigators and then compiling and sharing the data. We are also the lead team for coordinating interaction badge data (the “SS” badge provides shared data; the other MSU badge is under development and evaluation). In addition to the use of our standard ESM protocol, we also have developed a “simulation within the simulation” that is used to evaluate our monitoring technology. Heretofore, the monitoring “badge” has only been evaluated in lab settings for basic validation. This effort is extending evaluation for field testing and user reactions. Thus far, we have collected data for the first two HERA missions in February and April of 2014. Mission 3 is about to commence and a fourth mission is planned for the Campaign this year; another Campaign of four missions is planned for next year. Hawai’i Space Exploration Analog and Simulation (HI-SEAS). We initiated new benchmarking research in a surface exploration simulation, HI-SEAS, which is located at 8200 feet on Mt. Mona Loa on the big island of Hawai’i. This has involved extending our protocol; securing IRB approvals from the University of Hawai’i (under the PI, Kim Binsted), MSU, and NASA; and substantially aiding the HI-SEAS mission design. We have contributed to crew selection (we screened on the five factor model of personality and cognitive ability), the mission story / script, and mission EVA / scenario design. We are currently collecting ESM data from the 5-person crew during their 4-month mission that started in April 2014. The crew is also using the SS badge so we can enlarge the pool of benchmarking data for interactions over time. We are now in preparation mode for the next HI-SEAS mission that will involve a crew of 6 for 8 months. A 12 month mission is planned for the following year. NASA Extreme Environment Mission Operations (NEEMO) Mission 18. Finally, we are preparing for data collection from a crew of four astronauts for NEEMO18. Training at JSC for the crew is about to begin and the roughly one week mission will run in July. The astronauts represent a mix of agencies, so the crew is international. NEEMO18 data collection has involved extension / modification of our protocol; coordinating IRB approvals with NASA, MSU, and several international space agencies; training revisions; and coordination among investigating teams and NASA elements. We are, once again, responsible for coordinating EOD and badge data. Extend Engineering Development of an Unobtrusive Monitoring Technology The monitoring technology under development has been successfully validated in the laboratory and is now under evaluation in NASA mission simulations. Primary objectives for engineering development center on: (1) improved packaging and enhancing robustness of the wearable interaction monitoring badges and (2) detection of swallow monitoring using the wearable sensor system. Packaging and robustness. We have developed a 3-D printed case for the wearable badge and for the radio access point. The case contributes to robustness in terms of the badge's abilities to withstand rough handling in variable environmental conditions. The new access point is also capable of all the sensing possible using the badges. To improve energy-efficiency, we have employed a series of transmission power control protocols (developed by Co-PI Biswas’ group) running on the badge hardware. A novel measurement based link power control mechanism with closed-loop feedback control techniques was used. These protocols have improved the battery life of the system. The current version of the badge with all these new software and protocol can run up to 6 hours of data collection in one recharge. These new robust badges were used in the HERA data collection sessions during this reporting period. Swallow monitoring. We have developed a wearable solid food intake monitoring system that analyzes human breathing signal and swallow sequence locality for solid food intake monitoring. Food intake is identified by the way of detecting a person’s swallow events. The system works based on a key observation that the otherwise continuous breathing process is interrupted by a short apnea during swallowing. A Support Vector Machine (SVM) is first used for detecting such apneas in breathing signals collected from a wearable chest-belt. The resulting swallow detection is then refined using a Hidden Markov Model (HMM) based mechanism that leverages known locality in the sequence of human swallows. Using the developed system in this reporting period we are experimentally able to demonstrate the effectiveness of such two-stage SVM-HMM based mechanism for solid food intake detection via analyzing breathing signal and human swallow sequence locality. Apnea detection also has potential as an additional data modality for assessing stress during team member interactions. As this badge capability develops, it will be integrated into our phased lab validation process.
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