Fiscal Year:	FY 2018	**Task Last Updated:**	FY 11/13/2018
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		
PI Email:	swjkozlowski@gmail.com	**Fax:**	FY
PI Organization Type:	UNIVERSITY	**Phone:**	813-974-0352
Organization Name:	University of South Florida		
PI Address 1:	4202 East Fowler Avenue PCD 4118G		
PI Address 2:	Department of Psychology		
PI Web Page:			
City:	Tampa	**State:**	FL
Zip Code:	33620	**Congressional District:**	12
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:**	08/15/2018
No. of Post Docs:	0	**No. of PhD Degrees:**	0
No. of PhD Candidates:	3	**No. of Master' Degrees:**	2
No. of Master's Candidates:	3	**No. of Bachelor's Degrees:**	1
No. of Bachelor's Candidates:	5	**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: New end date is 8/15/2018 per NSSC information (Ed., 3/14/18) NOTE: Element change to Human Factors & Behavioral Performance; previously Behavioral Health & Performance (Ed., 1/18/17) NOTE: End date changed to 12/31/2017 per NSSC information (Ed., 6/16/16)		
Key Personnel Changes/Previous PI:	June 2017 report: Co-Investigator Chu-Hsiang (Daisy) Chang's leave assignment to serve as NSF Science of Organizations Program Officer has been extended an additional year. June 2016 report: Co-Investigator Chu-Hsiang (Daisy) Chang will be starting a one-year leave to assume the role of NSF (National Science Foundation) Science of Organizations Program Officer.		
COI Name (Institution):	Biswas, Subir Ph.D. (Michigan State University) Chang, Chu-Hsiang Ph.D. (Michigan State University)		
Grant/Contract No.:	NNX13AM77G		
Performance Goal No.:			
Performance Goal Text:			

Task Description:

Teamwork processes –cognitive, motivational, affective, and behavioral – have been researched in the psychological sciences for well over a half century. Several lines of systematic research, large scale literature reviews, and meta-analytic summaries have firmly established that team processes, as key indicators of psycho-social team health, are critical contributors to team effectiveness, especially for “action” teams performing complex, interdependent tasks (Kozlowski & Ilgen, 2006). Disruptions to teamwork, due to conflict, low cohesion, or poor collaboration, have the potential to threaten team effectiveness. This is particularly the case under the isolated, confined, and extreme (ICE) conditions that can be anticipated for long duration space missions. These difficult operating environments are further challenged by high team autonomy and time lagged communications with ground. For high reliability teams, a disruption in good teamwork, especially at an inopportune time when well-coordinated teamwork is critical, can have disastrous consequences (Salas, Tannenbaum, Kozlowski, Miller, Mathieu, & Vessey, 2015; Slack, Williams, Schneiderman, Whitmire, & Picano, 2016). Thus, the capability for NASA to measure, monitor, and facilitate good teamwork interactions for flight crews is essential for overall mission effectiveness for the NASA strategic plan for space exploration. Developing this capability has been the goal of this research program.
This ground-based research was designed to address the following Program Requirements Document (PRD) Risk and Behavioral Health and Performance (BHP) Integrated Research Plan (IRP; 2011).

PRD Risk: Risk of Performance Decrements Due to Inadequate Cooperation, Coordination, Communication, and Psychosocial Adaptation within a Team.

IRP (Integrated Research Plan) Gap – Team1: We need to understand the key threats, indicators, and life cycle of the team for autonomous, long duration and/or distance exploration missions.

The research targeted three specific aims that comprised an integrated approach for measuring, monitoring, and regulating teamwork processes and long-term team functioning:

(1) Benchmark long duration team functioning in ICE analog environments. This research used Experience Sampling Methods (ESM; daily assessments) to assess team functioning across a range of ICE environments (short and long duration; Antarctica and NASA mission simulations). The purpose of this research aim was to characterize patterns of variation and dynamics for key teamwork processes (e.g., cohesion, collaboration, conflict). Benchmark data in ICE analog environments are important for developing insights into the nature of problems that may emerge that challenge team member interactions and team functioning. Findings from the benchmark studies are informative of the types of challenges that may be faced by space crews on long duration missions.

(2) Extend development of the team interaction sensor (TIS) technology (i.e., a wearable wireless sensor package). The purpose of this research aim was to advance development of a sensor technology to capture dynamic multimodal (i.e., physiological and behavioral) data that unobtrusively assesses team member interactions. Initial laboratory validation demonstrated the reliability and accuracy of the monitoring technology (Kozlowski, Biswas, & Chang, 2013) and its ability to predict affective reactions to stressed interactions (Kozlowski, Biswas, & Chang, 2014) sufficient to establish proof of concept. The extensions (a) added an additional sensing capability (i.e., swallow monitoring); (b) technology development to make the system more robust (i.e., packaging, energy efficiency; hardware, Bluetooth integration, algorithms, and software); and technology transfer to the NASA Wearable Electronics Application and Research Lab (WEAR Lab) at the Johnson Space Center (JSC).

(3) Develop a teamwork interaction metric and support system. The TIS provides high frequency data on team interaction indicators. The purpose of this research aim was to develop supporting components required for the data to be utilized as a countermeasure for team members to regulate psycho-social health: (a) Metrics – algorithms were developed to filter and parse the raw data streams into a meaningful measure that reflects teamwork functioning. The metric was then validated against prior laboratory data and in NASA mission simulation. (b) Distributed Networked Dashboard – a prototype system architecture / design was developed to distribute sensor information to computers and mobile devices, and (c) design concepts for a team effectiveness dashboard were developed for displaying teamwork interaction metrics and feedback to team members. The ultimate implementation and utilization of the system, however, will necessitate the direct involvement of NASA Operations personnel and astronaut end-users.

Products and findings from this research have the capability of reducing the risk of team performance decrements due to poor teamwork interactions by (a) characterizing normative and anomalous patterns of team functioning; (b) developing a technology to unobtrusively monitor team member interaction patterns; and (c) providing support to maintain teamwork.

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Rationale for HRP Directed Research:

Research Impact/Earth Benefits:	Team cohesion is not only 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 experiencing work situations together is associated with cohesion formation and maintenance, but the mechanisms remain unknown. This research, which focuses on the dynamics of collaboration, cohesion, and effective team functioning, and is creating 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.
Task Progress:	This project was designed to (a) benchmark long duration team functioning in isolated, confined, and extreme environments (ICE); (b) extend development of an unobtrusive team interaction sensor (TIS) technology, and (c) design interaction metrics for the sensor technology and a support system to aid the maintenance of long duration team functioning. The project resulted in important developments and some critical findings. First, given the relative absence of well-designed longitudinal observational studies of long duration ICE team functioning, it examined a range of ICE team types (i.e., Antarctica and NASA mission simulations) across a range of durations (i.e., 1 week to 52 weeks). Although all types of teams and durations evidenced variation in functioning, the most noteworthy observation was the destabilization and decline of social cohesion for missions longer than 6 months in the Hawai‘i Space Exploration Analog and Simulation (HI-SEAS). Second, focusing on the Human Exploration Research Analog (HERA) and HI-SEAS environments, we provided a series of analyses using TIS data and the Interaction Density Algorithm (IDA) metric we developed demonstrating that the destabilization and declines in daily social cohesion ratings that were self-reported by participants were significantly captured by the IDA metric. This provides compelling field-based evidence that the unobtrusive data captured by the TIS can be used to monitor individual and team functioning for long duration missions. Third, the TIS technology was extended and transferred to the NASA Wearable Electronics Application and Research Lab (WEAR Lab) where a redesigned technology platform is under development. Finally, we created a distributed networked dashboard system architecture and notional team effectiveness dashboard display designs so that TIS data may be used to help long duration astronaut team members self-manage their interactions and team functioning to maintain effectiveness. Further development and refinement of the system will necessitate direct involvement with NASA Operations and astronauts. Project Summary Teamwork processes –cognitive, motivational, affective, and behavioral – have been researched in the psychological sciences for well over a half century. Several lines of systematic research, large scale literature reviews, and meta-analytic summaries have firmly established that team processes, as key indicators of psycho-social team health, are critical contributors to team effectiveness, especially for “action” teams performing complex, interdependent tasks (Kozlowski & Ilgen, 2006). Disruptions to teamwork, due to conflict, low cohesion, or poor collaboration, have the potential to threaten team effectiveness. This is particularly the case under the isolated, confined, and extreme (ICE) conditions that can be anticipated for long duration space missions. These difficult operating environments are further challenged by high team autonomy and time lagged communications with ground. For high reliability teams, a disruption in good teamwork, especially at an inopportune time when well-coordinated teamwork is critical, can have disastrous consequences (Salas, Tannenbaum, Kozlowski, Miller, Mathieu, & Vessey, 2015; Slack, Williams, Schneiderman, Whitmire, & Picano, 2016). Thus, the capability for NASA to measure, monitor, and facilitate good teamwork interactions for flight crews is essential for overall mission effectiveness for the NASA strategic plan for space exploration. Developing this capability has been the goal of this research program. 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