Fiscal Year:	FY 2016	**Task Last Updated:**	FY 06/10/2016
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:**	12/31/2017
No. of Post Docs:	0	**No. of PhD Degrees:**	0
No. of PhD Candidates:	1	**No. of Master' Degrees:**	2
No. of Master's Candidates:	4	**No. of Bachelor's Degrees:**	0
No. of Bachelor's Candidates:	0	**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: 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 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 (Michigan State University) Chang, Chu-Hsiang (Michigan State University)		
Grant/Contract No.:	NNX13AM77G		
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.
	Our efforts duration of the project thus far have focused primarily 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). Until this year, we lacked sufficient data from efforts (1) and (2) to make progress on (3). This year, we have been able to begin to tackle this aspect of the research program. Benchmark Long Duration Team Functioning in ICE Analog Environments A significant portion of research effort was invested in continuing the multiple benchmarking data collections we have developed for this project. We have ongoing data collections in the Antarctic (i.e., science teams camped on the ice and station teams for winter over-missions) and in NASA mission simulations (i.e., an asteroid transit simulation and a Mars surface exploration simulation). In addition, we previously collected data in an underwater (i.e., low gravity) exploration simulation. A description of our research activities follows. Australian Antarctic Division (AAD) Stations and Field Teams in Aurora Basin (AB). Our collaborative research with Dr. Jeff Ayton of the AAD was extended (see prior reporting) with approval to continue data collection through the 2016-2017 ADD deployment. This year, we continued and concluded the 2014-2015 data collection of approximately 49 participants from Mawson, Davis, and Casey Stations, and participants from Macquarie Island. We also initiated new data collections with station personnel who deployed to winter-over for 2015-2016. This involved extending our research protocol with AAD; renewing IRB approvals by the AAD, MSU (Michigan State University), and NASA; and working with our collaborator and his team to recruit participants. Approximately 24 participants from Mawson, Davis, and Casey Stations, as well as participants from Macquarie Island, 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.

To date, we have completed data collection from 124 individuals who wintered over in the Antarctic. Participants spent between 9-15 months in their stations and reported a total of 5,161 daily survey data points. Additional data is currently being collected from 24 new participants. Descriptive data have shown that individuals have different dynamic patterns in terms of their daily reports on different individual and team-level indicators over time. These patterns can be differentiated into four categories: rock solid, uni-varier, multi-varier, or stabilizer. Individuals with a rock solid pattern did not vary in their responses to most of the questions over time. Individuals who are uni-variers primarily varied on one variable, such as daily task or social cohesion. Individuals who are multi-variers varied daily in their responses across a range of indicators. This may be because they perceived more variability in the environment or because they were more impacted by external factors in the environment. Finally, individuals who are stabilizers initially varied in many variables, but then achieved and maintained a stable equilibrium across the mission.

We previously conducted variance decomposition analysis and found that most of the variance in team process indicators (e.g., cohesion, conflict) was at the individual or day level, with little variance attributed to the teams (Baard, Kermond, Pearce, Ayton, Change, & Kozlowski, 2014). This indicates that the team level had little meaningful impact and suggests that individuals may not be working on highly interdependent tasks as a team. The nature of the winter-over crew—individuals with diverse occupations working in isolation from each other—likely explains this pattern. On the other hand, it also means that most of the variability was accounted for by the person and environment.

Finally, random coefficients modeling revealed that relationships between some variables were reciprocal, while relationships between other variables were directional. Cohesion and performance had reciprocal, positive relationship with each other. This suggests that prior cohesion predicted future performance positively, and prior performance positively contributed to future cohesion ratings. Positive affect and team conflict had reciprocal, negative relationship with each other, suggesting that prior positive mood was related to less future conflict, and conflict was predictive of lower positive mood. On the other hand, conflict management had directional relationship with cohesion, such that prior conflict management was positively related to subsequent team cohesion. This finding suggests that teams engaging in conflict management felt more cohesive the next day, but that being cohesive may not necessarily make the team more effective at managing their conflict. Finally, prior positive affect also had directional, negative relationship with subsequent negative affect, supporting the buffering role of positive mood.

Recently we began to compare descriptive team process data across the different AAD missions (Olenick, Santoro, Kozlowski, Chang, & Dixon, 2015). For the three years of available data, we observed that overall team cohesion was relatively high and stable over time for two teams, while the third year exhibited very low cohesion at the beginning and end of their missions, with a plateau of moderate cohesion in between, likely resulting from a high number of conflicts at the beginning and end points of the missions. Performance trends for all teams were stable and not significantly different from year to year. Additionally, social and task conflict for all teams was relatively low and stable for all three teams until approximately 80% of the way through the season. At that point, for one team, social and task conflict began to decline while it began to increase for the other two teams, including the team exhibiting deficiencies in cohesion. Relatedly, all three teams reported similar levels of conflict management for most of their seasons, until about 75% through their time together. At this point, the team which showed less conflict at the end of their season began to show slightly more conflict management.

Although (given the sample size) we consider these findings preliminary, they suggest that selection of individuals for winter-over deployments should consider the utility of assessing for positive affectivity, an individual disposition (i.e., personality characteristic) that supports positive mood states. It also suggests that conflict management skills, bolstered by training, could help individuals and teams maintain effective working relationships across the long span of winter-over deployments to the Antarctic.

Science Field Teams in Antarctica. We also extended our ongoing collaboration with science teams that deploy to the ice during the Antarctic summer for 2015-2016. This marks our sixth season of data collection with this research team. This involved extending our research protocol, renewing MSU and NASA IRB approvals, and recruiting participants from the science teams. Approximately 7 participants contributed to the data collection, providing daily Experience Sampling Methodology (ESM) reports. The data for 2015-2016 have been compiled and data analyses are in progress. We routinely report findings for each mission back to team leadership, although the report findings are not summarized for this NASA annual report.

Results based on the data collected through the prior mission year suggest that teams vary in the key indicators of team processes both in terms of the levels (e.g., average cohesion across members) and the degree of agreement (e.g., standard error of cohesion across members; Pearce, Baard, Harvey, Karner, Chang, & Kozlowski, 2014; Pearce, Baard-Perry, Harvey, Karner, & Ayton, 2015). Moreover, cohesion and adaptability showed reciprocal relationships over time, such that higher cohesion on the prior day predicted higher adaptability on the subsequent day and vice versa. In addition, cohesion and negative affect also showed reciprocal relationships over time, such that high negative affect on the prior day predicted low cohesion the subsequent day and vice versa. These results suggest that high cohesion may be crucial in buffering the negative effects of poor individual psychosocial well-being on team effectiveness.

Human Exploration Research Analog (HERA). We continued benchmarking research in HERA, a NASA mission simulation located at the Johnson Space Center (JSC), that was initiated in 2014. HERA missions involve a crew of 4 members, selected from NASA volunteers. HERA simulates a transit mission for exploration of an asteroid. In Campaign 1, mission duration was approximately 7 days for 4 crews of 4 members each. Campaign 2, initiated in January 2015, extended the missions to 14 days for 4 crews of 4 members each. Campaign 3, initiated in January 2016, extended the missions to 30 days for 4 crews of 4 members each. Data collection for Campaign 3, Mission 2 is just about to conclude. 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 have also been 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 employ 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.

We found that based on the data collected from HERA Campaign 1 (106 daily reports from 16 participants) and HERA Campaign 2 (220 daily reports from 16 participants) different teams had different experiences throughout the mission and responded differently to the same environmental stressors (e.g., sleep deprivation, communication delays; Dixon & Vessey, 2015; Dixon, Santoro, Lauricella, Chang, & Kozlowski, 2016). In addition, analysis of agreement between crew members' ratings on team processes indicated that within the same team, individual members do not always view their team or their shared experiences the same way. Finally, across the four missions in Campaign 1 and Campaign 2, there was no apparent generalizable pattern of reactions to experiences across teams that can be identified, despite the seemingly similar exposure to the simulated stimuli. In other words, thus far, each team experience (based on descriptive data) has its own distinct ecology that does not replicate to other teams. In part, this is the challenge of identifying stable and reliable patterns with small sample data. It may be possible that with additional data and analyses, replicable patterns across team experiences will be identified. However, in the meantime, these preliminary results show that the continued data collections with more teams in the HERA environment are needed to determine a normative profile of the team experience in HERA.

Hawai'i Space Exploration Analog and Simulation (HI-SEAS). We continued our 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. When we initiated our collaboration with HI-SEAS mission 2, this involved extending our protocol; securing IRB approvals from the University of Hawai'i (under PI Kim Binsted), MSU, and NASA; and substantially aiding HI-SEAS mission design. We contributed to crew selection (we screened on the five factor model of personality and cognitive ability), the mission story / script, mission EVA / scenario design, and problem-solving on a variety of issues that arise across the arc of the missions.

We have completed data collections from the five-person crew (1 team member withdrew shortly after the mission began) of mission 2 (4 months) and the six-person crew of mission 3 (8 months). We are currently collecting ESM data from the six-person crew of mission 4 (12 months). The crew is also using the MSU monitoring badge so that we can enlarge the pool of benchmarking data for interactions over time.

Overall, the five-person crew from mission 2 provided a total of 485 daily surveys (Santoro & Binsted, 2015) and the six-person crew from mission 3 provided a total of 1303 daily surveys. Random coefficient modeling showed that team processes were reciprocally related to one another. As we reported last year for mission 2, positive autoregressive effects were found for the indicators for individual members' psychosocial health (e.g., positive and negative affect) and other team process and effectiveness indicators (e.g., cohesion, conflict, performance) from the previous day to the next. In addition, cohesion played a major role in affecting other team processes, such as positively impacting performance and affect. Additionally, improvements in particular team processes and individual psychosocial well-being (i.e., cohesion, negative affect, and positive affect) from one day to the next benefited team effectiveness on the next day.

In mission 3, positive autoregressive effects were found for the same indicators as in mission 2 (e.g., psychosocial health and other team process and effectiveness indicators). Moreover, improvements in particular team processes (i.e., cohesion and negative affect) benefited team effectiveness the next day, similarly to mission 2. Unlike mission 2, however, the prior day's positive affect only had an autoregressive effect, not impacting other team processes or team effectiveness.

Thus, similar to the long duration findings for the AAD stations, we see evidence that positive affect (which can be selected based on individual dispositions) and cohesion (which can be bolstered by team interactions and team leadership) have potential buffering effects on negative factors that impede individual and team psychosocial health.

Task Progress:

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. Engineering activity was mainly focused around areas-- 1) Development of algorithms and software for run-time dynamic badge-id allocation, 2) Detection of swallow monitoring using wearable sensors, and 3) integration of a Bluetooth hardware module and development of the associated software.

Development of algorithms and software for run-time dynamic badge-id allocation. In the previous versions of the badge software, the unique identification (ID) number for a badge used to be statically pre-allocated. While providing a simpler boot and start-up sequence, this arrangement leads to complications and management overhead in the event of badge hardware failures. When a badge fails, a new badge needs to be programmed with the same identifier before it can be used as a replacement of the failed unit. To ameliorate this issue, the engineering team developed a new dynamic ID management algorithm which auto-allocates unique IDs to the badges at boot-time. The algorithm is implemented using the TinyOS operating system within the badge software, TinyOS in the base station, and in the PC-based dashboard software that is written in Java. This new system was thoroughly tested in the lab and then for the data collection sessions ongoing both in HERA and HI-SEAS.

Swallow monitoring. We have developed a wearable solid food intake monitoring system that analyzes human breathing signals 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 the 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.

During this reporting year, we have performed detailed in-lab validation of the proposed system. Swallow detection was performed using just the SVM classifier and also with HMM followed by SVM classifier. To evaluate the detection performance (i.e., both SVM-only and SVM followed by HMM), we adopted the metrics Precision and Recall, commonly used 614 in biomedical signal processing and information retrieval.

Recognized swallows (i.e., true positives, TP) indicates the number of swallow events that are correctly detected. Retrieved swallows correspond to the number of detected swallows including both the TPs and the incorrectly detected swallows (i.e., false positives, FP). Relevant swallows (i.e., positive, P) refer to the number of actual swallow events annotated from video observations reflecting ground truth.

Six participants were evaluated. The results demonstrate that SVM+HMM performs consistently better than the SVM-only solution when the optimum threshold of posterior probability is unknown. These results validate the overall usefulness of the proposed HMM processing by leveraging known swallow sequence locality information for removing certain classification errors that are introduced by the SVM-only approach.

Bluetooth (BT) hardware and software integration. When we started this project, wearable sensors were a novelty. However, over the course of technology development, wearable sensor technology has exploded across a variety of activity monitors (mostly wrist mounted) in the commercial market place. As they are proliferating, they are also becoming increasingly sophisticated. We anticipate that in the future, it is likely that commercial monitors will provide sensor data that are useful to our effort to diagnose team member psychosocial health. Thus, to provide flexibility for the technology platform, we have initiated a new effort (with NASA concurrence) to integrate a BT module with the badge sensor processor. This is supplemental effort that was initiated in January 2016.

The engineering team has started the integration process. As the first step, a Bluetooth Low Energy (BLE) module, supplied by Laird Technologies Inc., has been chosen for integration with the MSU badge system. The module can be used in Peripheral mode or in Central mode depending on the specific applications. We intend to use the Central mode for collecting sensor data (e.g., heart rate) from other sensors to the badge, and the Peripheral mode for uploading data from the badge to a base station or mobile phone. In the first phase, we started the development in the Central mode.

Thus far, a software driver module has been successfully developed for reading heart rate data from a Polar H7 (http://www.polar.com/) heart rate monitor over Bluetooth Low Energy (BLE) link. The driver is currently run on the Laird Technologies BLE module in an isolated mode. The next step will be to integrate the BLE module with the MSU badges over a serial link so that the collected heart rate data can be integrated with the existing badge database and uploaded to the base station. Then we will try out other peripheral devices for testing the general BLE based data collection ability.

Develop Teamwork Interaction Metrics and Support Systems.

Metrics. Depending on teamwork activity, interaction data streams can be dense (e.g., most members of the team are engaged in an intensive interaction) or quite sparse (e.g., members interact as dyads every so often but mostly work apart) or anywhere in between. Yet, even when team interactions are intensive, everyone on the team will not be interacting with everyone else at exactly the same time, which means that there will be many “holes” or “gaps” in the interaction data. At this point in the development of the system, we need to use standard statistical analyses to link the interactions and physiological indicators. Statistical software requires specific data structures. Thus, in order to analyze interaction level data, the raw data collected by the badges have to be filtered to target those points in time when one member is interacting with another member and then the interaction and associated physiological data have to be parsed (i.e., extracted) and rewritten to a new data file without gaps that can be analyzed with appropriate statistical tools (i.e., random coefficient models). Our ultimate aim is to accomplish the filtering process algorithmically. However, to develop appropriate algorithms, one needs to first develop the logic, instantiate it in code, and evaluate the integrity of the resulting data set. This is the current focus of our research activity.

Data filtering and parsing. We have previously developed computer code for our laboratory evaluation of the badges. That code was used to filter the raw data files from the badges and to parse and transform (i.e., recompile) it into a dataset that is appropriate for statistical analysis. We are now engaged in systematically extending, generalizing, and evaluating the code for badge data collected in HERA and then to HI-SEAS. The initial extension of the code to the HERA environment is challenging because it is a less controlled environment in which two interactions may be going on at the same time. Therefore, we had to elaborate the code to ensure that it uniquely captures both of those simultaneous interactions. As the code was extended, it was then evaluated to ensure that captured all valid interactions and filtered out spurious interactions. Discriminant analyses were used to identify predictors of valid interactions. We then used the predictors to filter out spurious interactions so they are omitted from the final output the code produces.

The next step – extending and applying the code to HI-SEAS – is particularly challenging because there are two additional participants relative to the HERA code extensions. This increases the number of possible dyadic interactions from 6 to 15. The challenge is allowing for the additional dyad combinations without significantly increasing the time the code takes to process the raw data. To address this issue, we extended the code to 15 dyads in a way that simultaneously enhances the efficiency of the code. Initial pilot evaluation indicates that the code is functioning, although a more comprehensive evaluation is in progress.

The next major challenge is to extend the code to apply to unstructured interactions. To date, we have evaluated badge interaction data collected in both laboratory and field environments in which dyadic interactions are highly structured. That is, participants have worked on a task in which they follow a specific protocol regarding who interacts with whom and in what order the interactions take place. This has allowed a phased validation of the badge as we transition it from the laboratory (3-person teams) to a controlled field setting (HERA; 4-person teams) and to a less controlled field setting (HI-SEAS; 6-person teams). With the phased validation in place, the next major extension will advance the code and parameters to assess dyadic interactions for unstructured or natural interactions.

Data fusion. Having filtered, parsed, and transformed the badge data, the multivariate time series metrics need to be fused into a coherent assessment of ongoing individual and team functioning. As previously reported (see Kozlowski, Biswas, & Chang, 2014), we have preliminary evidence that positive and negative reactions based on interaction-level data can be predicted from heart rate (HR), HR variability (HRV), and their interaction. These data are collected by the badge system. As we continue to develop the badge technology system as a sensor integration platform (i.e., the new initiative to integrate a BT module) that adds additional sensing modalities, the physiological data available for inferring psychological states will expand and reliability will improve.

Distributed networked dashboard. A system architecture is needed to integrate sensor information. A backend server infrastructure has been developed during this reporting period for supporting the proposed distributed network dashboard. The server, which is hosted at MSU Engineering Building, has a JAVA based remote connection to the existing PC-based dashboard software. All data collected by the base station is pushed up to this remote server via the PC-based dashboard software. The server then makes the data available via a web service. This provides the opportunity for accessing badge-collected data to be exported to any remote web client running on PCs, tablets, phones, and other handheld devices. The server part is completed and tested during this reporting period. The engineering team is now preparing to develop the client side as needed by various teams that are using the system.

References

Baard, S. K., Kermond, C., Pearce, M., Ayton, J., Chang, C.-H., & Kozlowski, S. W. J. (2014, August). Understanding team affect, cohesion and performance dynamics in long duration Antarctic missions. In J. Ayton (Chair), Human biology and Medicine. Symposium presented at 2014 Open Science Conference XXXIII SCAR Biennial Meetings, Auckland, New Zealand.

Dixon, A. J., Santoro, J. M., Lauricella, T. K., Chang, C.-H., & Kozlowski, S.W.J. (2016, February). An investigation into team dynamics within the Human Exploration Research Analog. Poster presented at the Human Research Program Investigators' Workshop, Galveston, TX.

Dixon, A. J. & Vessey, W. B. (2015, April). Research on team processes in the Human Exploration Research Analog. In S. W. J. Kozlowski & C.-H. Chang (Chairs), Team dynamics: Capturing process phenomena in extreme teams. Symposium conducted at the 30th Annual Conference of the Society for Industrial and Organizational Psychology, Philadelphia, PA.

Kozlowski, S. W. J., Biswas, S., & Chang, C.-H. (2014). Monitoring and regulating teamwork. Final Report, National Aeronautics and Space Administration (NNX12AR15G). Houston, TX.

Olenick, J., Santoro, J. M., Chang, C-H., Kozlowski, S.W.J., & Dixon, A. J. (2015). Investigating teams in isolated, confined, and extreme environments: A look into AAD missions. Department of Psychology, Michigan State University, East Lansing, MI.

Pearce, M., Baard-Perry, S. K., Harvey, R. P., Karner, J., & Ayton, J. (2015). The dynamics of teamwork in the Antarctic: A multi-year, multi-national effort. In S. W. J. Kozlowski and C.-H. Chang (Co-chairs), Team dynamics: Capturing process phenomena in extreme teams. Symposium presented at the 30th Annual Conference of the Society for Industrial and Organizational Psychology, Philadelphia, PA.

Pearce, M., Baard, S. K., Harvey, R. P., Karner, J., Chang, C.-H., & Kozlowski, S. W. J. (2014, August). Tracking the psychosocial health of ICE teams. Poster presented at the XXXIII Scientific Committee on Antarctic Research (SCAR) Biennial Meetings and Open Science Conference, Auckland, New Zealand.

Bibliography Type:	Description: (Last Updated: 07/05/2023)
Abstracts for Journals and Proceedings	Kozlowski SWJ. "Dynamic processes in space teams." In L Larson, B Jones, & L DeChurch (Chairs), Organizing that's out of this world! Ignite Panel Discussion presented at the 31st Annual Conference of the Society for Industrial and Organizational Psychology, Anaheim, CA, April 14-16, 2016. 31st Annual Conference of the Society for Industrial and Organizational Psychology, Anaheim, CA, April 14-16, 2016. , Apr-2016
Abstracts for Journals and Proceedings	Kozlowski SWJ. "Research relevance." In S. Fiore (Chair), Developing national research policy with use-inspired science for organizational research. Panel Discussion presented at the 31st Annual Conference of the Society for Industrial and Organizational Psychology, Anaheim, CA, April 14-16, 2016. 31st Annual Conference of the Society for Industrial and Organizational Psychology, Anaheim, CA, April 14-16, 2016. , Apr-2016
Abstracts for Journals and Proceedings	Kozlowski SWJ, Chang C-H, Baard-Perry SK, Biswas S. "Capturing real-time team process dynamics." In G. Plummer & N. Contractor (Chairs), Novel ways to understand and assess teamwork. Symposium presented at the 31st Annual Conference of the Society for Industrial and Organizational Psychology, Anaheim, CA, April 14-16, 2016. 31st Annual Conference of the Society for Industrial and Organizational Psychology, Anaheim, CA, April 14-16, 2016. , Apr-2016
Abstracts for Journals and Proceedings	Kozlowski SWJ, Chang C-H, Biswas S. "Measuring the dynamics of teamwork." Poster presented at the 2016 NASA Human Research Program Investigators' Workshop, Galveston, TX, February 8-11, 2016. 2016 NASA Human Research Program Investigators' Workshop, Galveston, TX, February 8-11, 2016. , Feb-2016
Abstracts for Journals and Proceedings	Santoro JM, Dixon AJ, Binsted K, Chang C-H, Kozlowski SWJ. "Tracking long-term dynamics: The Hawai'i Space Exploration Analog and Simulation." Poster presented at the 2016 NASA Human Research Program Investigators' Workshop, Galveston, TX, February 8-11, 2016. 2016 NASA Human Research Program Investigators' Workshop, Galveston, TX, February 8-11, 2016. , Feb-2016
Abstracts for Journals and Proceedings	Santoro JM, Olenick J, Dixon AJ, Ayton J, Chang C-H, Kozlowski SWJ. "Tracking long-term team dynamics in the Antarctic." Poster presented at the 2016 NASA Human Research Program Investigators' Workshop, Galveston, TX, February 8-11, 2016. 2016 NASA Human Research Program Investigators' Workshop, Galveston, TX, February 8-11, 2016. , Feb-2016
Abstracts for Journals and Proceedings	Kozlowski SWJ. "Using big data to unpack team process dynamics." In R. R. Piccolo & C. Buengeler (Chairs), Big data in team research: Applications, techniques, and implications. Symposium presented at the 75th Annual Convention of the Academy of Management Association, Vancouver, British Columbia, Canada, August 7-11, 2015. 75th Annual Convention of the Academy of Management Association, Vancouver, British Columbia, Canada, August 7-11, 2015. , Aug-2015
Abstracts for Journals and Proceedings	Kozlowski SWJ, Chang C-H, Baarde SK, Biswas S. "Capturing team process dynamics." In A. Yu (Chair), Unobtrusive measures in organizational research: The potential of wearable sensor technology. Symposium presented at the 75th Annual Convention of the Academy of Management Association, Vancouver, British Columbia, Canada, August 7-11, 2015. 75th Annual Convention of the Academy of Management Association, Vancouver, British Columbia, Canada, August 7-11, 2015. , Aug-2015

Abstracts for Journals and Proceedings	Kozlowsk SWJ, Chang C-H, Biswas S, Baard SK, Golden S, Santoro J, Dison A, Lauricella T, Stobaugh D. "A sensor technology for capturing real-time team process dynamics." In N. Contractor & L. DeChurch (Chairs), Technology for studying and enabling teams. Symposium presented at the 10th Annual Conference of the Interdisciplinary Network for Group Research Conference, Pittsburgh, PA, July 23-25, 2015. 10th Annual Conference of the Interdisciplinary Network for Group Research Conference, Pittsburgh, PA, July 23-25, 2015. , Jul-2015
Abstracts for Journals and Proceedings	Kozlowski SWJ. "The science of team effectiveness." In M. Hilton & N. Cooke (Chairs), The National Academy of Sciences (NAS) report: Enhancing the effectiveness of team science. Panel discussion presented at the Science of Team Science (SciTS) Conference, National Institute of Health, Bethesda, MD, June 3-5, 2015. Science of Team Science (SciTS) Conference, National Institute of Health, Bethesda, MD, June 3-5, 2015. , Jun-2015
Abstracts for Journals and Proceedings	Chang C.-H. "Connecting the moving dots: Examining the effects of team processes and their dynamics from a multi-level perspective." Presented to the National Science Foundation, Washington, D.C., August 2015. National Science Foundation, Washington, D.C., August 2015. , Aug-2015
Articles in Peer-reviewed Journals	Kozlowski SWJ. "Advancing research on team process dynamics: Theoretical, methodological, and measurement considerations." Organizational Psychology Review. 2015 Nov;5(4):270-99. http://dx.doi.org/10.1177/2041386614533586 , Nov-2015
Articles in Peer-reviewed Journals	Kozlowski SWJ, Mak S, Chao GT. "Team-centric leadership: An integrative review." Annual Review of Organizational Psychology and Organizational Behavior. 2016 Mar;3:21-54. http://dx.doi.org/10.1146/annurev-orgpsych-041015-062429 , Mar-2016
Articles in Peer-reviewed Journals	Dong B, Biswas S. "Analyzing breathing signal and swallow sequence locality for solid food intake monitoring." Journal of Medical and Biological Engineering, in press as of June 2016. , Jun-2016
Books/Book Chapters	Santoro JM, Dixon AJ, Chang C-H, Kozlowski SWJ. "Measuring and monitoring the dynamics of team cobesion: Methods, emerging tools, and advanced technologies." in "Team cohesion: Advances in psychological theory, methods, and practice." Ed. E. Salas, W.B. Vessey, A.X. Estrada. Bingley, UK: Emergald Group Publishing, 2015. p. 115-145. http://dx.doi.org/10.1108/S1534-085620150000017006 (Research on Managing Groups and Teams series, vol. 17), Nov-2015