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| **Fiscal Year:** | FY 2017 | **Task Last Updated:** | FY 05/19/2017 |
| **PI Name:** | Dinges, David F. Ph.D. | | |
| **Project Title:** | Standardized Behavioral Measures for Detecting Behavioral Health Risks during Exploration Missions | | |
| **Division Name:** | Human Research | | |
| **Program/Discipline:** | | | |
| **Program/Discipline--Element/Subdiscipline:** | HUMAN RESEARCH--Behavior and performance | | |
| **Joint Agency Name:** | | **TechPort:** | No |
| **Human Research Program Elements:** | (1) **HFBP**:Human Factors & Behavioral Performance (IRP Rev H) | | |
| **Human Research Program Risks:** | (1) **BMed**:Risk of Adverse Cognitive or Behavioral Conditions and Psychiatric Disorders<br>(2) **Team**:Risk of Performance and Behavioral Health Decrements Due to Inadequate Cooperation, Coordination, Communication, and Psychosocial Adaptation within a Team | | |
| **Space Biology Element:** | None | | |
| **Space Biology Cross-Element Discipline:** | None | | |
| **Space Biology Special Category:** | None | | |
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| **Comments:** | | | |
| **Project Type:** | Flight,Ground | **Solicitation / Funding Source:** | 2013-14 HERO NNJ13ZSA002N-BMED Behavioral Health & Performance |
| **Start Date:** | 07/21/2015 | **End Date:** | 07/20/2019 |
| **No. of Post Docs:** | 0 | **No. of PhD Degrees:** | 0 |
| **No. of PhD Candidates:** | 0 | **No. of Master' Degrees:** | 0 |
| **No. of Master's Candidates:** | 0 | **No. of Bachelor's Degrees:** | 0 |
| **No. of Bachelor's Candidates:** | 0 | **Monitoring Center:** | NASA JSC |
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| **Flight Program:** | ISS | | |
| **Flight Assignment:** | NOTE: End date changed to 7/20/2019 per NSSC information (Ed., 8/10/18)<br>NOTE: Element change to Human Factors & Behavioral Performance; previously Behavioral Health & Performance (Ed., 1/18/17) | | |
| **Key Personnel Changes/Previous PI:** | | | |

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| **Grant/Contract No.:** | NNX15AK76A |
| **Performance Goal No.:** | |
| **Performance Goal Text:** | |
| **Task Description:** | Isolated and confined environments anticipated during exploration missions will include stressors such as small teams living and working in extreme conditions for prolonged periods separated from family, friends; loss of the day/light cycle; loss or delay of communications with ground; partial gravity; and limited space, privacy, and food selection. NASA's Human Factors and Behavioral Performance Element seeks to maintain and enhance behavioral health and performance in such environments. The behavioral risk (Risk of Adverse Cognitive or Behavioral Conditions and Psychiatric Disorders) is a high priority within the NASA Human Research Program (HRP) because it has face validity, but lacks sufficient evidence due to a deficiency in measurement of the risk. Thus, there is concern that the behavioral health of the crew will be challenged in a Mars mission, however there is no standardized method to detect and quantify the magnitude of the risk or its likelihood.<br>The overarching goal of this project is to build on a successful record of software-based measurement of behavioral health indicators (e.g., mood, cognitive function, performance, physical and mental fatigue, sleep quality) to develop a complementary standardized suite of behavioral core measures (BCM) that would be quite feasible to implement within the constraints of spaceflight research, ground-based analogs (both short- and long-duration), and prolonged missions in isolated, confined, extreme environments lasting up to 12 months or longer. Achievement of this goal would permit a more rapid and reliable assessment and quantification of the Risk of Adverse Cognitive or Behavioral Conditions Psychiatric Outcomes for exploration class missions. The standardized behavioral medicine measures we are developing will be similar to the guidelines for standardization for bed rest studies. Defining standardized measures will not only allow for the systematic collection of data across multiple analogs, but it will also facilitate risk characterization for the Behavioral Medicine (BMed) risk. Without a standardized suite of behavioral health measures, the unknown BMed risk for exploration-class missions will continue to be estimated based on anecdote and conjecture.<br><br>The elements of the BCM include the following: (1) The Cognition test battery (a suite of 10 brief neuropsychological tests specifically designed for astronauts), (2) actigraphy sleep/wake data, (3) several visual analog scales and brief questionnaires with proven validity and utility in space and space analog environments, (4) Journals (Audio/Video and/or typed), (5) a robotic arm track-and-capture grappling task, (6) Team Measure Questionnaires designed to measure aspects of crew performance, team processes, team climate, and group living.<br><br>Data acquisition feasibility and flexibility, and user acceptability of BCM has been assessed in a short duration analog (4 HERA (Human Exploration Research Analog) N=16 subjects), is currently being assessed in a long-duration analog (10 months of data collection during a 12-14 month winter-over in the Antarctic Neumayer station, N=7 subjects), and will be further assessed on the International Space Station (ISS) for feasibility and acceptability (during a 6 month mission, N=2 astronauts). Mission controllers completed a team performance questionnaire during HERA missions, and flight directors will complete this brief questionnaire during the ISS study. |
| **Rationale for HRP Directed Research:** | |
| **Research Impact/Earth Benefits:** | This project will deliver a Behavioral Core Measures Tool (BCM) that will be tested for its feasibility, flexibility, and acceptability in research studies in both short and long duration space analog environments and on the ISS. With the BCM, it will be possible for NASA's HFBP (Human Factors & Behavioral Performance) program to much better assess and quantify the Risk of Adverse Cognitive or Behavioral Conditions and Psychiatric Outcomes for exploration class missions.<br>With the proposed work we will relevantly contribute to HRP's goal to provide human health and performance countermeasures, knowledge, technologies, and tools to enable safe, reliable, and productive human space exploration. More specifically, the BCM will constitute an important technology to provide mission planners and system developers with strategies for monitoring and mitigating crew health and performance risks.<br><br>Additionally, Behavioral Core Measures could also be beneficial for monitoring behavioral health during Earth-based operations, especially those involving isolated, confined and extreme environments (e.g., Antarctic research expeditions). |
| | Cognition: Data acquisition in NASA's Human Exploration Research Analog (HERA) facility was finalized on 10/26/2016. We successfully collected a total of 288 full Cognition test bouts (100% of expected) and 270 surveys (93.75% of expected) in N=16 crewmembers. During the current reporting period we have deployed and collected data on N=8 crewmembers during two out of the four Campaign 3 missions in NASA's HERA facility. In HERA research participants perform the Cognition test battery on the Apple iPad; however, through discussions with the International Space Station Medical Project (ISSMP) it was determined that the iPad is not a feasible platform for data collection on ISS. Thus a Windows PC version of the Cognition software will be used on-board the ISS and in the Neumayer III Antarctic station. The Windows version of Cognition was deployed in the Antarctic Neumayer station during the reporting period. A full test battery plus survey (i.e., all 10 Cognition tests) is performed by the crewmembers that consented on a monthly basis. We have collected 27 full batteries so far, and expect to collect 56 more batteries until 7/21/2017.<br>Self-Report and Visual Analog Scale Measures: A set of visual analog scales and brief questionnaires with proven validity and utility in space and space analog environments were chosen in order to evaluate several key aspects of behavioral health and crew interaction. These questionnaires include (a) Visual Analog Scales (VAS) to evaluate |

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| **Task Progress:** | perceived mental (mentally sharp—mentally fatigued) and physical (energetic—physically exhausted) exhaustion, fatigue (tired—fresh, ready to go), sleepiness (not sleepy at all—very sleepy), and stress (not stressed at all—very stressed); (b) the Social Desirability Scale (SDS-17) to measure one's self-desirability bias; (c) sleep diaries to evaluate sleep quality and duration; (d) the Profile of Mood States, Short Form (POMS-SF) to evaluate mood; (e) the Beck Depression Inventory (BDI-II) to evaluate depression; and (f) the Conflict Scale (CS) to evaluate perceived conflict among crewmembers and between crewmembers and mission control. These Visual Analog Scales and sleep diaries have already proven useful for measuring neurobehavioral health during 6-month missions on ISS and this data informed the need for a one-year mission.<br><br>During the four HERA missions these surveys were deployed using the University of Pennsylvania's REDCap electronic web based survey tool and data was successfully collected data on N=16 HERA crewmembers. During the current reporting period we collected data on N=8 crewmembers from the last two HERA Campaign 3 missions. Across all four Campaign 3 missions, self-report measures were successfully collected with 99.8% response adherence. A total of N=2,108 BCM questionnaires were completed: n=480 nighttime Visual Analog Scales; n=480 Conflict Scales; n=480 morning Visual Analog Scales and sleep diaries; n=572 POMS-SF, n=80 BDI-II, and n=16 SDS-17 questionnaires. Analyses show that the BCM psychological self-report scales reliably track behavioral states throughout a short-duration analog mission, including changes in mood and stress in response to sleep deprivation. Successful completion of all psychological self-report measures in HERA and thorough crew debriefs confirmed the feasibility of these BCM measures in a short-duration space-analog environment, and provided useful data to inform improvements to the implementation of each measure.<br><br>Journals: At the end of the reporting period, journal entries from all four HERA simulated asteroid rendezvous missions (N=16 crewmembers) have been completed successfully; the final few audio/video journals are currently being transcribed in preparation for analysis. Journals are currently being written using Microsoft Word at the Neumayer III Antarctic station and preparations are being made for astronauts on-board ISS to maintain journals.<br><br>ROBoT: In the second year of the ROBoT project, we worked on four main efforts. First, we continued data collection in HERA, completing Missions 3 and 4. Some 99.1% of anticipated data was successfully collected from subjects in HERA. Performance curves were preliminarily analyzed and found general improvement over the course of the mission, as would be expected from a task with a substantial learning curve, and performance differences associated with changes in grappling task difficulty. More detailed analysis is ongoing. Second, we also prepared for and initiated ROBoT deployment in Antarctica, including shipping of all hardware to Charite, Berlin, Germany and then to Neumayer station, training in Dr. Alexander Stahn on ROBoT setup and performance so he could set up the system and train the crew while visiting Neumayer, and initiating the study. We have thus far received 1 set of ROBoT data from Neumayer station—which appeared to be nominal—and expect the Neumayer crew to provide additional ROBoT data on a monthly basis, along with the other BCM measures. Third, also along with the rest of BCM, we have initiated ROBoT preparations for use aboard the International Space Station. This has involved making sure the research version of the ROBoT software is properly integrated with the operations version of the software, and planning for the uplink of that software to the ISS. Finally, we have begun collecting ROBoT data from control subjects for the HERA study in our research lab at MGH. This will begin to provide norms for performance on the ROBoT task to which HERA, Neumayer, and ISS performance can be compared. With the exception of the HERA data collection, the remainder of the above efforts will continue through the end of the current reporting period.<br><br>Team Measure Questionnaires: Data from the Team Measures battery was successfully acquired from all four 30-day HERA C3 missions (N=16 individuals) with 100% compliance. At the end of the previous reporting period, data from the initial battery of Team Measures was collected in two four-person crews (N=8) throughout two 30-day missions in the HERA facility. Preliminary analyses of the HERA data, thematic analysis of the initial Team Measures battery, and assessment of operational acceptability led to recommendations for a reduced and modified Team Measures battery and data collection schedule for long-duration missions in operational environments. This iteration of the Team Measures battery is currently being deployed and evaluated in a long-duration mission at Neumeyer Station in Antarctica (N=7 individuals). By the end of this reporting period, we expect 6 months of data from Neumayer. However, the currently available dataset (9 weeks of data) has been acquired with 87% compliance (one crewmember did not complete one session). Finally, with the assistance of ISSMP, we are also preparing for deployment on ISS Increments 55/56 along with the rest of the BCM measures. |
| **Bibliography Type:** | Description: (Last Updated: 05/08/2025) |
| **Books/Book Chapters** | Roma PG, Bedwell WL. "Key factors and threat to team dynamics in long-duration extreme environments." in "Team Dynamics Over Time. Book series: Research on Managing Groups and Teams, Vol. 18." Ed. E. Salas. Bingley, UK: Emerald Group Publishing Limited, 2017 (in press)., May-2017 |