Fiscal Year:	FY 2022	**Task Last Updated:**	FY 02/15/2022
PI Name:	Marquez, Jessica J. Ph.D.		
Project Title:	HCAAM VNSCOR: Crew Autonomy through Self-Scheduling: Guidelines for Crew Scheduling Performance Envelope and Mitigation Strategies		
Division Name:	Human Research		
Program/Discipline:			
Program/Discipline--Element/Subdiscipline:			
Joint Agency Name:		**TechPort:**	No
Human Research Program Elements:	(1) **HFBP**:Human Factors & Behavioral Performance (IRP Rev H)		
Human Research Program Risks:	None		
Space Biology Element:	None		
Space Biology Cross-Element Discipline:	None		
Space Biology Special Category:	None		
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Zip Code:	94035	**Congressional District:**	18
Comments:			
Project Type:	GROUND	**Solicitation / Funding Source:**	2017-2018 HERO 80JSC017N0001-BPBA Topics in Biological, Physiological, and Behavioral Adaptations to Spaceflight. Appendix C
Start Date:	04/15/2019	**End Date:**	04/14/2023
No. of Post Docs:		**No. of PhD Degrees:**	
No. of PhD Candidates:	2	**No. of Master' Degrees:**	1
No. of Master's Candidates:	2	**No. of Bachelor's Degrees:**	
No. of Bachelor's Candidates:	1	**Monitoring Center:**	NASA JSC
Contact Monitor:	Whitmire, Alexandra	**Contact Phone:**	
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Flight Program:			
Flight Assignment:			
Key Personnel Changes/Previous PI:	February 2020 report: Mr. Steven Hillenius (Co-Investigator) left NASA. Dr. Tamsyn Edwards is replacing Mr. Hillenius as Co-I. Dr. Edwards works at NASA Ames as part of San Jose University Research Foundation. February 2021 report: Dr. John Karasinski is now a Co-I. February 2022 report: Dr. Edwards has left NASA.		
COI Name (Institution):	Bresina, John Ph.D. (NASA Ames Research Center) Gregory, Kevin M.S. (San Jose State University Research Foundation) Zheng, Jimin M.S. (San Jose State University Research Foundation) Edwards, Tamsyn Ph.D. (San Jose State University Research Foundation) Karasinski, John Ph.D. (NASA Ames Research Center)		
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Performance Goal No.:			
Performance Goal Text:			

Task Description:	This task is part of the Human Capabilities Assessments for Autonomous Missions (HCAAM) Virtual NASA Specialized Center of Research (VNSCOR). As NASA considers long-duration exploration missions (LDEMs), it is envisioned that crew will behave more autonomously as compared to low-Earth orbit missions. In this space environment, crew will have better and more timely insight as to how best to manage their own schedule, minimizing idle time as they wait for Mission Control Center (MCC) to respond or react to a delay in activity execution. Moreover, crew must be able to self-schedule: reschedule their own timeline without creating violations. NASA currently has not characterized crew performance for self-scheduling; specifically, non-expert human performance for the task of planning and scheduling has not been characterized experimentally. The focus of this proposal is to quantify crew performance envelope for the task of planning and scheduling as a function of plan complexity, and develop mitigations that are aimed at improving performance in the face of complex planning requirements. With regards to crew performance, we will study the relationship between planning efficiency, effectiveness, crew situation awareness, trust in planning software, and plan complexity. Once a performance envelope has been identified, we will shift our research emphasis to develop and evaluate countermeasures that mitigate adverse effects on performance. These mitigations will be evaluated in analogs and recommended countermeasures will be put forward if crew performance improves as compared to the baseline. Finally, based on research results, we will recommend corresponding standards and guidelines appropriate for autonomous crew in LDEMs.
Rationale for HRP Directed Research:	
Research Impact/Earth Benefits:	NASA currently has not characterized crew performance for self-scheduling; specifically, novice human performance for the task of planning and scheduling has not been characterized experimentally. As a result of this research, we will quantify the user performance envelope for the task of planning and scheduling, which impacts many jobs both on Earth and in spaceflight. The knowledge gained from our research can be generalized to benefit our understanding on how to improve roles that require planning and scheduling, such as project planning, personnel scheduling, and operational management. Our research will also contribute to developing the next generation of planning, scheduling, and execution software tools for NASA.
Task Progress:	Task Progress Summary Year 3 As NASA considers long-duration exploration missions (LDEMs), it is envisioned that crew will behave more autonomously, as compared to low-Earth orbit missions. In this space environment, crew will have better and more timely insight into how to best manage their own schedules, minimizing idle time as they wait for Mission Control Center (MCC) to respond or react to a delay in activity execution. Moreover, crew must be able to self-schedule—that is reschedule their own timeline without creating violations. NASA currently has not characterized crew performance for self-scheduling; specifically, non-expert human performance for the task of planning and scheduling has not been characterized experimentally. The focus of this research is to quantify the crew performance envelope for the task of planning and scheduling as a function of plan complexity, and develop mitigations aimed at improving performance in the face of complex planning requirements. With regards to crew performance, we will study the relationship between planning efficiency, effectiveness, crew situation awareness, trust in planning software, and scheduling task complexity. Once a performance has been characterized, we will shift our research emphasis to develop and evaluate countermeasures that mitigate adverse effects on performance. These mitigations will be evaluated in analogs, and recommended countermeasures will be put forward if crew performance improves as compared to the baseline. Finally, based on research results, we will recommend corresponding standards and guidelines appropriate for autonomous crew in LDEMs. For Year 3 (4/2021 – 4/2022), our research team completed data post-processing and analysis for our lab-based, controlled experiment evaluating human self-scheduling performance. During Year 2, data collection was completed for 31 participants for a mixed factorial design 4 x 2 x 2 experiment design. One between-subject factor is type of task (scheduling and rescheduling), while there are two within-subject factors: number of constraints (low and high) and type of constraints (Requires, Time Range, Claims, and Ordering constraints). Dependent variables include: efficiency (e.g., time on task), effectiveness (e.g., number of violations), situation awareness, workload, trust, and usability. The results point to main effects due to number of constraints and type of constraint as key factors in scheduling task complexity. However, the type of constraint affects performance in various, different manners; there is no one type of constraint that is most difficult for novice schedulers to self-schedule. Type of task (scheduling or rescheduling) had an effect but not across all performance measures. We have published one journal paper and two conference papers on some of the results from this experiment. We also have one accepted and submitted conference paper. As part of our efforts, in Year 2 we developed and implemented an algorithm to evaluate the self-scheduling tasks in order to rank and compare against human performance measures. We refined this method in Year 3 and have validated a method for ranking difficulty of scheduling problems. Metrics generated from modeling human self-scheduling accurately ranked the difficulty of scheduling problems in a human-in-the-loop experiment. We have published one conference paper on this result. With respect to countermeasure aid development, various aids were brainstormed based on the experimental results. From these, three aids were selected to be developed. The first aid is a visualization imbedded in the Timeline that shows where activities can be scheduled without causing violations. The second aid is a set of suggested rescheduling options that would assist schedulers in resolving any activity violations. The third aid is a mixed-initiative scheduling aid that allows for certain interconnected activities to be moved without causing violations. By the end of Year 3, all three aids will have been designed and two will be implemented. Finally, Year 3 marked the start of Human Exploration Research Analog (HERA) Campaign 6, which was postponed for several months due to the pandemic. Our experiment in HERA focuses on validating countermeasure aids in a spaceflight analog. Each analog crewmember is assigned a day in the mission to self-schedule for the entire team. Activities and groups of activities have many diverse sets of constraints, driven by the operational needs of the analog. Aside from collecting self-scheduling performance data, including workload, crew are also asked for their subjective assessment on the quality of the timeline created for their team. HERA Campaign 6 is focused on crew autonomy, and as such, all crew are given the opportunity to conduct self-scheduling for most of the mission. By the end of Year 3, data collection for two (of four) missions will be completed. Previous research in HERA was published at a conference this year.

Bibliography Type:	Description: (Last Updated: 03/21/2024)
Abstracts for Journals and Proceedings	Marquez JJ, Edwards T, Karasinski J, Shyr M, Bresina J, Sullivan D, Shelat S, Brandt S. "Crew autonomy through self-scheduling: Guidelines for crew scheduling performance envelope and mitigation strategies." 2022 NASA Human Research Program Investigators' Workshop, Virtual, February 7-10, 2022. Abstracts. 2022 NASA Human Research Program Investigators' Workshop, Virtual, February 7-10, 2022 (Abstract #1133-000379). , Feb-2022
Articles in Peer-reviewed Journals	Marquez JJ, Edwards T, Karasinski JA, Lee CN, Shyr MC, Miller CL, Brandt SL. "Human performance of novice schedulers for complex spaceflight operations timelines." Hum Factors. 2021 Dec 20. https://doi.org/10.1177/00187208211058913 ; PMID: 34886710 , Dec-2021
Papers from Meeting Proceedings	Karasinski J, Bresina J, Kanefsky B, Shyr M, Marquez J. "Towards a Characterization of Scheduling Task Complexity." AIAA SCITECH 2022 Forum, San Diego, CA, January 3-7, 2022. AIAA SCITECH 2022 Forum, San Diego, CA, January 3-7, 2022. AIAA paper AIAA 2022-1412. https://doi.org/10.2514/6.2022-1412 , Jan-2022
Papers from Meeting Proceedings	Shyr M, Edwards T, Brandt S, Marquez J. "The path to crew autonomy—situational awareness in scheduling and rescheduling tasks for novice schedulers." 72nd International Astronautical Congress (IAC), Dubai, United Arab Emirates, October 25-29, 2021. Abstracts. 72nd International Astronautical Congress (IAC), Dubai, United Arab Emirates, October 25-29, 2021 (Abstract IAC-21,B3,4-B6.4,12,x66895). , Oct-2021
Papers from Meeting Proceedings	Gale JW, Yashar M, Karasinski J, Marquez J. "Evaluation of self-scheduling exercises completed by analog crewmembers in NASA's Human Exploration Research Analog (HERA)." ASCEND 2021, Las Vegas, Nevada, November 15-17, 2021. ASCEND 2021, Las Vegas, Nevada, November 15-17, 2021 (Abstract # AIAA-2021-4076). https://doi.org/10.2514/6.2021-4076 , Nov-2021