Fiscal Year:	FY 2021	**Task Last Updated:**	FY 01/06/2021
PI Name:	Selva, Daniel Ph.D.		
Project Title:	HCAAM VNSCOR: Virtual Assistant for Spacecraft Anomaly Treatment During Long Duration Exploration Missions		
Division Name:	Human Research		
Program/Discipline:			
Program/Discipline--Element/Subdiscipline:			
Joint Agency Name:		**TechPort:**	Yes
Human Research Program Elements:	(1) **HFBP**:Human Factors & Behavioral Performance (IRP Rev H)		
Human Research Program Risks:	(1) **HSIA**:Risk of Adverse Outcomes Due to Inadequate Human Systems Integration Architecture		
Space Biology Element:	None		
Space Biology Cross-Element Discipline:	None		
Space Biology Special Category:	None		
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Zip Code:	77843-0001	**Congressional District:**	17
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:	03/06/2019	**End Date:**	03/05/2023
No. of Post Docs:	0	**No. of PhD Degrees:**	0
No. of PhD Candidates:	2	**No. of Master' Degrees:**	0
No. of Master's Candidates:	1	**No. of Bachelor's Degrees:**	0
No. of Bachelor's Candidates:	2	**Monitoring Center:**	NASA JSC
Contact Monitor:	Whitmire, Alexandra	**Contact Phone:**	
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Flight Program:			
Flight Assignment:			
Key Personnel Changes/Previous PI:			
COI Name (Institution):	Diaz Artiles, Ana Ph.D. (Texas A&M Engineering Experiment Station) Dunbar, Bonnie Ph.D. (Texas A&M Engineering Experiment Station) Wong, Raymond Ka Wai Ph.D. (Texas A & M, College Station)		
Grant/Contract No.:	80NSSC19K0656		
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). The research objective of this proposal is to investigate the impact of using Virtual Assistants (VA) to support crew members in the context of anomaly treatment during Long Duration Exploration Missions (LDEM), when ground support will be limited. A VA will be developed building upon the software architecture from existing VAs developed by the Principal Investigator (PI) for similar purposes. The VA will provide support for various aspects of anomaly treatment, including detecting and diagnosing the anomaly, as well as recommending a course of action. It will also have the ability to take initiative in the dialog with the user (mixed-initiative mode), and the ability to provide explanations for its actions. The impact of the VA on performance, cognitive workload, situational awareness, and trust, will be assessed through a set of three experiments with human subjects in a laboratory environment. The first experiment will establish the baseline impact (master-slave, no explanations), and subsequent experiments will study the effect of switching to the mixed-initiative mode and adding explanations. The system will also be deployed and tested in the Human Exploration Research Analog (HERA) analog environment.
Rationale for HRP Directed Research:	
Research Impact/Earth Benefits:	This project will provide standards and guidelines that will help NASA design similar virtual assistants to support astronauts during future long duration exploration missions. Such standards and guidelines will concern both the functionality and the user interface of the virtual assistant.
Task Progress:	In Year 2 of this project, we have completed the first round of testing of the Daphne-AT prototype and conducted a pilot study. We worked closely with HERA throughout the integration and testing of our study as part of the C6 campaign. We are now getting ready for a final training documentation delivery to NASA this month, and a first system-level test of our study with the entire team at Johnson Space Center (JSC), assuming the COVID situation permits it. To be able to do experiments at Texas A&M, we developed an immersive 3d user interface to simulate the Human Exploration Research Analog (HERA) habitat during our experiments at TAMU. The goal was for the simulator to have reasonable fidelity in terms of the general dimensions and shape as well as the main components present in the habitat related to the ECLSS system. The simulator is basically a first-person game developed in Unreal Engine 4 (UE4). All of the major components of the HERA Environmental Control and Life Support Subsystem (ECLSS) system are present and the user can interact with them (e.g., press buttons, open/close panels) as required by the anomaly resolution procedures. More details about this simulator are provided in Woodruff R, Beebe N, Josan PK, Wong RKW, Dunbar BJ, Selva D, Diaz-Artiles A. (2021). 3D Interactive Model of HERA to support ECLSS anomaly resolution using a Virtual Assistant. 2021 IEEE Aerospace Conference Proceedings. After validation of the UE4 simulator, we designed and conducted a pilot study of the first “Baseline” prototype of the assistant. It included five male subjects within the age range of 22-40 years old, and with a Standard Deviation (SD) of ±7.2. Prior to the experimental sessions, subjects were provided a 2-hour virtual training session about all the experiment elements (Daphne-AT, ECLSS subsystems, 3D virtual HERA environment, and experimental protocols) and they were guided through an example anomaly scenario. After the training, subjects participated in two in-person experiment sessions: one with Daphne-AT and the other one without Daphne-AT (counterbalanced among subjects). These sessions were conducted in two consecutive days at approximately the same time of the day. In each one of the sessions, the subjects solved four anomalies. Once the experiment sessions were over, the subjects completed a set of surveys. Dependent variables included performance, cognitive workload, situational awareness, and trust in the context of ECLSS anomaly treatment, with and without the use of a VA. Performance is described as an individual’s ability to successfully treat the anomaly. On average, subjects solved 3.2 ± 0.37 anomalies using Daphne-AT and 2.0 ± 0.without Daphne-AT. Based on these limited data, our preliminary results support the hypothesis that the use of Daphne-AT will increase performance in the context of ECLSS anomaly resolution operations. The NASA Task Load Index (TLX) survey was used to measure the effect of using Daphne-AT on cognitive workload. NASA TLX is an evaluation technique developed by NASA to assess relative importance of six pre-determined factors in determining how much workload a subject experience during a particular task, in this case, the task of anomaly treatment. These six factors include mental demand, physical demand, temporal demand, perceived performance, perceived effort, and frustration level. On average, subjects indicated higher cognitive workload during the sessions with Daphne-AT (57.2 ± 5.78 with Daphne-AT and 66 ± 7.31 without Daphne). These preliminary results support the hypothesis that the use of Daphne-AT will decrease cognitive workload. More details about this pilot study can be found in: Josan PK, Dutta P, Woodruff R, Beebe N, York K, Balcells-Quintana O, Kluis L, Viros-i-Martin A, Dunbar BJ, Wong RKW, Selva D, Diaz-Artiles A. (2021). Experimental Design & Pilot Testing for ECLSS Anomaly Resolution using Daphne-AT Virtual Assistant. 2021 IEEE Aerospace Conference Proceedings. As a result of the pilot testing and HERA integration activities, we have substantially refined the VA interface and added functionality to the back end. Specifically: 1) We adapted the telemetry feed to the new version of the HERA Environmental Control and Life Support System (ECLSS) simulator (now called Habitat System Simulator or HSS). 2) We updated the anomaly database to include more information for each anomaly (e.g., a time signature). 3) We expanded the knowledge base with more information about ECLSS anomalies, their associated risks, and how to resolve them. 4) We expanded the anomaly detection functions beyond basic thresholding to be able to detect outliers in the telemetry feed. 5) We made slight changes to the knowledge graph and procedures to adapt to HERA C6 schedule constraints. In terms of publications, we had two papers accepted at the 2021 IEEE Aerospace Conference which will be presented in March. We also gave a presentation at the 2020 American Institute of Aeronautics and Astronautics (AIAA) ASCEND conference (Ed. note 1/7/2021: see FY2020 Bibliography in Task Book report) and will have one talk presentation and one poster presentation at the 2021 Human Research Program workshop in February.

Bibliography Type:	Description: (Last Updated: 02/23/2024)
Papers from Meeting Proceedings	Woodruff R, Beebe N, Josan PK, Wong RKW, Dunbar BJ, Selva D, Diaz-Artiles A. "A 3D Interactive Model of HERA to Support ECLSS Anomaly Resolution Using a Virtual Assistant." 2021 IEEE Aerospace Conference, Big Sky, MT, Virtual, March 6-13, 2021. 2021 IEEE Aerospace Conference, Big Sky, MT, Virtual, March 6-13, 2021. Meeting paper. https://doi.org/10.1109/AERO50100.2021.9438341 , Mar-2021
Papers from Meeting Proceedings	Josan PK, Dutta P, Woodruff R, Beebe N, York K, Balcells-Quintana O, Kluis L, Viros-i-Martin A, Dunbar BJ, Wong RKW, Selva D, Diaz-Artiles A. "Experimental Design & Pilot Testing for ECLSS Anomaly Resolution Using Daphne-AT Virtual Assistant." 2021 IEEE Aerospace Conference, Big Sky, MT, Virtual, March 6-13, 2021. 2021 IEEE Aerospace Conference, Big Sky, MT, Virtual, March 6-13, 2021. Meeting paper. https://doi.org/10.1109/AERO50100.2021.9438497 , Mar-2021