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| <b>Fiscal Year:</b>                                    | FY 2023   | <b>Task Last Updated:</b>                 | FY 01/10/2023   |
| <b>PI Name:</b>  | Selva, Daniel Ph.D.   |   |   |
| <b>Project Title:</b>                                  | HCAAM VNSCOR: Virtual Assistant for Spacecraft Anomaly Treatment During Long Duration Exploration Missions  |   |   |
| <b>Division Name:</b>                                  | Human Research  |   |   |
| <b>Program/Discipline:</b>                             |   |   |   |
| <b>Program/Discipline--<br/>Element/Subdiscipline:</b> |   |   |   |
| <b>Joint Agency Name:</b>                              |   | <b>TechPort:</b>                          | Yes   |
| <b>Human Research Program Elements:</b>                | (1) <b>HFBP</b> :Human Factors & Behavioral Performance (IRP Rev H)   |   |   |
| <b>Human Research Program Risks:</b>                   | (1) <b>HSIA</b> :Risk of Adverse Outcomes Due to Inadequate Human Systems Integration Architecture  |   |   |
| <b>Space Biology Element:</b>                          | None  |   |   |
| <b>Space Biology Cross-Element<br/>Discipline:</b>     | None  |   |   |
| <b>Space Biology Special Category:</b>                 | None  |   |   |
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| <b>Zip Code:</b>                                       | 77843-0001  | <b>Congressional District:</b>            | 17  |
| <b>Comments:</b>                                       |   |   |   |
| <b>Project Type:</b>                                   | GROUND  | <b>Solicitation / Funding<br/>Source:</b> | 2017-2018 HERO 80JSC017N0001-BPBA<br>Topics in Biological, Physiological, and<br>Behavioral Adaptations to Spaceflight. Appendix<br>C |
| <b>Start Date:</b>                                     | 03/06/2019  | <b>End Date:</b>                          | 02/28/2025  |
| <b>No. of Post Docs:</b>                               | 1   | <b>No. of PhD Degrees:</b>                | 0   |
| <b>No. of PhD Candidates:</b>                          | 2   | <b>No. of Master' Degrees:</b>            | 0   |
| <b>No. of Master's Candidates:</b>                     | 0   | <b>No. of Bachelor's Degrees:</b>         | 2   |
| <b>No. of Bachelor's Candidates:</b>                   | 2   | <b>Monitoring Center:</b>                 | NASA JSC  |
| <b>Contact Monitor:</b>                                | Whitmire, Alexandra   | <b>Contact Phone:</b>                     |   |
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| <b>Flight Program:</b>                                 |   |   |   |
| <b>Flight Assignment:</b>                              | NOTE: End date changed to 02/28/2025 per A. Beitman/JSC (Ed., 1/25/23)  |   |   |
| <b>Key Personnel Changes/Previous PI:</b>              |   |   |   |
| <b>COI Name (Institution):</b>                         | Diaz Ariles, Ana Ph.D. ( Texas A&M Engineering Experiment Station )<br>Dunbar, Bonnie Ph.D. ( Texas A&M Engineering Experiment Station )<br>Wong, Raymond Ka Wai Ph.D. ( Texas A & M, College Station ) |   |   |
| <b>Grant/Contract No.:</b>                             | 80NSSC19K0656   |   |   |
| <b>Performance Goal No.:</b>                           |   |   |   |
| <b>Performance Goal Text:</b>                          |   |   |   |

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| <b>Task Description:</b>                    | <p>This task is part of the Human Capabilities Assessments for Autonomous Missions (HCAAM) Virtual NASA Specialized Center of Research (VNSCOR).</p> <p>The research objective of this proposal is to investigate the impact of using Virtual Assistants (VA) to support crewmembers 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.</p>  |
| <b>Rationale for HRP Directed Research:</b> |  |
| <b>Research Impact/Earth Benefits:</b>      | <p>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.</p>   |
| <b>Task Progress:</b>                       | <p>In Year 4 of this project, we worked primarily on specific Aims 2 and 3, although we also submitted the journal paper corresponding to specific Aim 1 (validation of the baseline agent in a lab environment).</p> <p>Concerning Specific Aim 2, we added the explanation capabilities to the VA and started data collection and analysis for Lab Experiment 2. This experiment addresses the following research question: How do explanations affect human performance, trust, cognitive workload (CW), situational awareness (SA), user satisfaction, and self-confidence for different levels of accuracy and uncertainty in human-AI collaborative anomaly diagnosis?</p> <p>The protocol is as follows. Subjects start with a background survey and test, and then they proceed to do two sessions, one in each explanation condition (order counterbalanced). In each session, they work on 8 anomaly scenarios, 4 with high uncertainty and 4 with low uncertainty, in random order. After each anomaly, subjects fill out a confidence survey, a Jian survey, and a satisfaction survey. After each session, they also fill out a NASA Task Load Index (TLX), a Situational Awareness Rating Technique (SART) questionnaire, another Jian survey, and another satisfaction survey. A Situation Awareness Global Assessment Technique (SAGAT) test is done twice per session (once per uncertainty level).</p> <p>So far, 18 subjects have been recruited and performed the experiment, but data for 3 subjects had to be deleted because of a procedural mistake during those sessions. Currently, data collection is halted while we wait for approval of an IRB modification regarding the details of this experiment's protocol and compensation. The major findings from the preliminary results (N=15) are as follows: 1. Explanations improve trust (<math>p=0.01</math>) 2. Explanations do not significantly improve performance; #anomalies correctly diagnosed increases (<math>p=0.14</math>), but time to diagnosis also increases (<math>p=0.30</math>) 3. Explanations improve SA (<math>p=0.018</math>), primarily by improving understanding (<math>P&lt;0.01</math>) 4. Explanations increase CW but effect is not significant (<math>p=0.14</math>) 5. Explanations improve user satisfaction (<math>p&lt;0.01</math>) 6. Explanations improve user confidence (<math>p&lt;0.01</math>) 7. Performance is higher for low uncertainty (<math>p&lt;0.01</math>) 8. Trust is higher for low uncertainty (<math>p&lt;0.01</math>)</p> <p>A more detailed analysis, including the accuracy levels, will be done with the full dataset (N=36).</p> <p>Concerning Specific Aim 3, we completed the C6M3 mission and will complete the last mission by the end of this year's period of performance, which should get us close to completing the nominal scope of Specific Aim 3, pending publication of the results. The major findings from the HERA C6M1-M3 missions (N=12) are as follows: 1. All subjects correctly resolved all scenarios. 2. Time to resolution is lower without Daphne but not significant (<math>p=0.2</math>). We attribute this to some logon issues we encountered, especially in mission 1. Our perception is that the diagnosis was very fast, both with and without Daphne, suggesting that the anomaly scenarios were "too easy." The subjects did spend considerable time conducting the procedures to resolve the anomalies, but that was not the focus of our study. 3. CW is higher with Daphne, but this difference was not significant (<math>p=0.3</math>). 4. SA is lower with Daphne, but this difference was not significant (<math>p=0.19</math>).</p> <p>Some of the insights we got from the exit interviews are as follows: The crew generally exhibited a strong interest in using VAs for anomaly resolution and enjoyed using Daphne. Most of them showed an interest in the social aspects of VA and mentioned that they "attributed a personality to Daphne" and "talked about her as if she were another crewmember." They all mentioned establishing trust very quickly once and for all thanks to Daphne "getting it right the first 3 times or so." Almost none of them found the question-answering capabilities essential because they were "going for speed" and didn't feel like they needed to ask any questions. However, many subjects mentioned that question-answering would be very useful in cases where Daphne recommended more than one diagnosis with the same confidence level. Moreover, crewmembers expressed an interest in the more interactive diagnosis and advanced explanations capabilities we are currently developing as something that would "significantly increase the usefulness" of the tool. Finally, they all confirmed that the scenarios generally felt very easy to diagnose and adding some more complexity would make it more interesting and fun. Note that detailed data regarding the interactions between the crewmembers and Daphne has not been analyzed yet.</p> <p>The final data analysis will be done once the C6M4 mission is complete. Of note, we have extended the scope of specific Aim 3 through an extension of the grant that will allow us to participate in the HERA C7 campaign, which we have started to prepare. In C7, we will be able to test a more advanced version of the Daphne agent while also testing more complex anomaly scenarios.</p> <p>In terms of publications, we submitted a journal paper on Specific Aim 1 to the Human Factors journal, which is currently under a second round of review and presented a paper on Specific Aim 2 at the 2022 Applied Human Factors and Ergonomics (AHFE) conference [15]. We will also have one talk and one poster presentation at the 2023 Human Research Project Investigator's Workshop (HRP IWS) in February.</p> <p>As for the next steps, in Year 4, we will finalize the C6 campaign and start C7 (Specific Aim 3). We plan on publishing a journal paper with the results of C6. Otherwise, most of the activity will focus on finalizing lab experiments 2 and 3.</p> |

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| We will work on additional journal papers on lab experiment, lab experiment 3, and the C7 campaign. |  |
| <b>Bibliography Type:</b>   | Description: (Last Updated: 02/23/2024)  |
| <b>Abstracts for Journals and Proceedings</b>   | Selva D, Dutta P, Josan PK, Dunbar, BJ, Wong RKW, Diaz-Artiles A. "Virtual Assistant for anomaly resolution in long duration exploration missions: Preliminary results and next steps." 2023 NASA Human Research Program Investigators' Workshop, Galveston, Texas, February 7-9, 2023.<br>Abstracts, 2023 NASA Human Research Program Investigators' Workshop, Galveston, Texas, February 7-9, 2023. , Feb-2023 |
| <b>Abstracts for Journals and Proceedings</b>   | Dutta P, Josan PK, Dunbar, BJ, Wong RKW, Diaz-Artiles A, Selva D. "Effects of explanations by virtual assistant for anomaly resolution tasks in long duration exploration missions." 2023 NASA Human Research Program Investigators' Workshop, Galveston, Texas, February 7-9, 2023.<br>Abstracts, 2023 NASA Human Research Program Investigators' Workshop, Galveston, Texas, February 7-9, 2023. , Feb-2023    |
| <b>Papers from Meeting Proceedings</b>  | Dutta P, Josan PL, Wong RKK, Dunbar BJ, Diaz Artiles A, Selva D. "Effect of Explanations in AI-Assisted Anomaly Treatment for Human Spaceflight Missions." 2022 Human Factors and Ergonomics Society Annual Meeting, Atlanta, GA, Oct 10 - 14, 2022.<br>2022 Human Factors and Ergonomics Society Annual Meeting, Atlanta, GA, Oct 10 - 14, 2022.. Vol 66(1), pp. 697-701. , Oct-2022                            |