Fiscal Year:	FY 2017	**Task Last Updated:**	FY 10/18/2016
PI Name:	Hillenius, Steven M.S.		
Project Title:	Evaluation of Crew-Centric Onboard Mission Operations Planning and Execution Tool		
Division Name:	Human Research		
Program/Discipline:			
Program/Discipline--Element/Subdiscipline:	HUMAN RESEARCH--Space Human Factors Engineering		
Joint Agency Name:		**TechPort:**	No
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		
PI Email:	Steven.R.Hillenius@nasa.gov	**Fax:**	FY
PI Organization Type:	NASA CENTER	**Phone:**	650-604-2888
Organization Name:	NASA Ames Research Center		
PI Address 1:	Mail Stop 262-4, P.O. Box 1		
PI Address 2:	Bldg. N262, Room 196		
PI Web Page:			
City:	Moffett Field	**State:**	CA
Zip Code:	94035-0001	**Congressional District:**	18
Comments:			
Project Type:	FLIGHT,GROUND	**Solicitation / Funding Source:**	Directed Research
Start Date:	12/15/2014	**End Date:**	09/30/2017
No. of Post Docs:		**No. of PhD Degrees:**	
No. of PhD Candidates:		**No. of Master' Degrees:**	
No. of Master's Candidates:		**No. of Bachelor's Degrees:**	
No. of Bachelor's Candidates:		**Monitoring Center:**	NASA JSC
Contact Monitor:	Williams, Thomas	**Contact Phone:**	281-483-8773
Contact Email:	thomas.j.will1@nasa.gov		
Flight Program:	ISS		
Flight Assignment:	NOTE: Element change to Human Factors & Behavioral Performance; previously Space Human Factors & Habitability (Ed., 1/19/17)		
Key Personnel Changes/Previous PI:			
COI Name (Institution):	Marquez, Jessica Ph.D. (NASA Ames Research Center) Korth, David B.A. (NASA Johnson Space Center) Rosenbaum, Megan B.A. (NASA Johnson Space Center)		
Grant/Contract No.:	Directed Research		
Performance Goal No.:			
Performance Goal Text:			

Task Description:	Currently, mission planning for the International Space Station (ISS) is largely affected by ground operators in mission control. The task of creating a week-long mission plan for ISS crew takes dozens of people multiple days to complete, and is often created far in advance of its execution. As such, re-planning or adapting to changing real-time constraints or emergent issues is similarly taxing. As we design for future mission operations concepts to other planets or areas with limited connectivity to Earth, more of these ground-based tasks will need to be handled autonomously by the crew onboard. The ISS Program is currently working a number of potential opportunities to assess crew-self-scheduling: the International Space Station Testbed for Analog Research (ISTAR) effort, the one-year studies, and upcoming NASA/European Space Agency (ESA) missions. The goal of a study on crew self-scheduling is to assess questions of plan and constraint complexity that can be handled on crew-side, integration of collaborative and individual crew planning, and integration of crew generated plans with plans generated by ground controllers when there is time delay. Previously, ISS Mission Operations Directorate (MOD) has tried to evaluate crew self-scheduling with two sets of planning tools (Score and the On-board Short-Term Plan Viewer, OSTPV). The assessment of Score, the tool currently used for crew activity planning by MOD, was conducted as a part of the 2011 Deep Space Habitat analog study. The assessment of OSTPV was conducted in 2014 as an MOD-directed ISTAR study. From crew feedback during self-scheduling exercises, both experiences showed that neither option was viable for meeting the objective to study crew autonomy with crewmembers on ISS due to limitations in the design of current mission planning tools. Score is designed to build plans but not execute. OSTPV is designed to execute plans as scheduled but cannot easily modify or reschedule plans. There is a need for a highly usable (including low training time) tool that enables efficient self-scheduling and execution within a single package. The ISS Program has identified Playbook as a potential option. It already has high crew acceptance as a plan viewer from previous analogs and would as an ideal candidate to support a crew self-scheduling assessment on ISS or on another mission (e.g., ESA Soyuz). The work proposed here, a collaboration between the Human Research Program and the ISS Program, will not only inform the design of systems for more autonomous crew operations, it will also provide a platform for research on crew autonomy for future deep space missions. The proposed work has four specific aims: Aim 1: Support ISS Program evaluation of crew self-scheduling and plan execution through Playbook, providing a platform for future research on crew autonomy for deep space mission operations as well as an assessment of the potential for limited crew self-scheduling in more near-term ISS operations. Aim 2: Provide Playbook as an operations tool to increase the realism and efficiency of the Human Exploration Research Analog (HERA) and NASA Extreme Environment Mission Operations (NEEMO) analogs. Aim 3: Determine the appropriate level of information (e.g., constraints, plan complexity) required for crewmembers to schedule their time autonomously with limited ground support by unobtrusively (through automated software logging) gathering and analyzing Playbook use data. Aim 4: Characterize task workload (e.g., time spent planning versus execution of plans, time on self-scheduled activities) of crewmembers completing and executing self-scheduling tasks by unobtrusively (through automated software logging) gathering and analyzing initial Playbook use data.
Rationale for HRP Directed Research:	This research is directed because it contains highly constrained research, which requires focused and constrained data gathering and analysis that is more appropriately obtained through a non-competitive proposal. Since 2003, the Scheduling & Planning Interface For exploration (SPIFe) team has been building and deploying customized planning and scheduling systems for several NASA missions, ranging from the Mars Phoenix Lander (Phoenix Science Interface), Mars Rover Curiosity (Mars Surface Lander Interface, MSLICE), the Lunar Atmosphere Dust Environment Explorer (LADEE Activity Scheduling System), to the International Space Station (ADCO Planning Exchange Tool, APEX; Power Planning Analysis Tool, PLATO; Score). Essential to successful deployment of these systems is a team of applied human-computer interaction experts who use a lean UX (user experience), user-centered design approach. This user-centered approach ensures use of the unique domain of mission operations during investigations and builds usable products that are designed and developed through an iterative agile based software development process.
Research Impact/Earth Benefits:	
	During July of FY16 we were notified that Playbook is slated to be used onboard to evaluate crew autonomy as part of the CAST (Crew Autonomous Scheduling Test) technology demonstration task onboard the International Space Station. The CAST technology demonstration, which is expected to start at the end of December 2016 and extend through early 2017, involves 5 different objectives to evaluate and test crew autonomy. The CAST demonstration will involve the crew planning and executing off of their plan at different levels of granularity using the Playbook tool. As part of this effort we trained Astronaut Peggy Whitson on the Playbook tool and have been working closely with our FOD (Flight Operations Directorate) counterparts to prepare for this new technology demonstration. The goal of CAST is to inform policy and process decisions on crew autonomy for future deep space missions. In Year 2 we completed development of the Playbook Data Analysis Tool culminating in our first version that incorporates the playback and analysis features. With this tool we are able to playback the unobtrusively collected use data (clicks, gestures, etc.) from the analog missions in a video tape like fashion. The interface includes a playback interface for the session, allowing you to click to seek to the exact time you're interested in, play, and pause the playback. Below the playback controls there are individual timelines that show the frequency of usage of specific views (such as the Timeline, Mission Log, Procedures, etc.) or formulaic queries throughout the self-scheduling session. For example, one query that may be called "view=Timeline", will show me usage of the Timeline throughout the unobtrusively collected session. New queries can be added and existing queries can be edited on the fly. For example, if you were interested in sessions when the users were using the tablet in a portrait orientation but then wanted to refine that to only show the transitions from a portrait orientation to a horizontal orientation, you can update the query inline, which will render a new timeline for that result. This allows users to tweak and compare their queries as they are performing their analysis. When a user finishes adding the queries they would like to visualize, these information metrics can be exported as part of the CSV

Task Progress:	(comma-separated value) export, as well as the original raw unobtrusively collected data. Playbook continued to be deployed and used as the primary operations tool for the HERA analog in year two of this proposal effort. The HERA crew and operations staff used Playbook to communicate and simulate communication time delay, status activity plan execution, view procedures for experiments, and to status and review the mission plan. It was deployed and used as the primary mission planning and text communications tool for all four HERA Campaign 3 missions within year 2 of the proposal effort. In year 2 we were able to have the crew perform limited self-scheduling of actual mission activities and were able to fully collect unobtrusive data and user surveys, in contrast to year 1. In addition to that we were able to conduct several self-scheduling exercises to exercise and evaluate the usability of the features in the analog. These self-scheduling exercises are done using a separate fictional timeline and allow us to look at more complex self-scheduling problems as well as thoroughly evaluate the usability of the self-scheduling features. We are currently performing an initial analysis of this data as Campaign 3 wraps up. Playbook was used on NEEMO 21 in support of all four of our proposal aims. We were able to gather input and evaluate all features created for a future ISS deployment, supported NEEMO 21 operationally using Playbook, evaluated crew self-scheduling in an operationally realistic setting, and collected click and gesture data using our unobtrusive data collection functionality which we built into the Playbook tool as part of the proposal research effort. We were also able to give the crew surveys on Playbook use. This year on the NEEMO 21 mission, we had two main iterations of our crew autonomy research. Following up on our work last year, we were trying to address the issue of the cost benefit analysis of crew self-scheduling. Specifically, we were trying to figure out if we could transfer some of the more tedious tasks of self-scheduling from crew to ground to lower the overall amount of effort involved with self-scheduling. This was done in one of two ways: strategic and tactical planning. The idea was to further abstract the more tedious aspects of planning that are not necessary to be done by the crew, such as fine tuned placement of activities and manipulation of small activities, and instead focus on allowing the crew to express their overall intent. So with the strategic planning concept, which was derived from the idea of “Plan Suggestions” mentioned in the previous annual report, we allowed the crew to plan their EVA (extravehicular activities) using a new feature we introduced this year into Playbook called “Add Activities.” This feature lets you freely add, edit, or remove crew-created activities into your mission plan. For the tactical planning concept, we updated the exercise that we conducted last year with a couple of new features, the ability to have groups in the task list and the ability to move groups to and from the Scratchpad. In both strategies the crew planned out two days of their EVA activities. These concepts were executed separately with the strategic planning concept taking part in the first half of the mission and the tactical planning concept taking part in the second half of the mission. It should be noted that there was a partial crew change out during the NEEMO 21 mission so only 2 crewmembers experienced both planning strategies. The latest version of Playbook includes the ability to link to ISHORT procedures if the activity has an associated ISHORT procedure. This feature was built and deployed out for the NEEMO 21 analog; however, since ISHORT was not on NEEMO 21, it is yet to be tested in an analog environment. We tested the linking behavior internally in the lab environment during development.
Bibliography Type:	Description: (Last Updated: 10/19/2016)
Abstracts for Journals and Proceedings	Hillenius SR, Marquez JJ, Deiz B, Kanefsky B, Korth D, Healy M, Gibson S, Zheng J. "Designing and Building a Crew-Centric Mobile Scheduling and Planning Tool for Exploring Crew Autonomy Concepts Onboard the International Space Station." International Space Station (ISS) Research and Development Conference 2016, San Diego, California, July 12-16, 2016. International Space Station (ISS) Research and Development Conference 2016, San Diego, California, July 12-16, 2016. , Jul-2016
Abstracts for Journals and Proceedings	Hillenius SR, Marquez JJ, Korth D, Rosenbaum M. "Evaluation of Crew-Centric Onboard Mission Operations Planning and Execution Tool." 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	Hillenius S. "Designing Interfaces for Astronaut Autonomy in Space." Invited Speech. Webstock 2016, Wellington, New Zealand, February 9-12, 2016. Webstock 2016, Wellington, New Zealand, February 9-12, 2016. , Feb-2016
Abstracts for Journals and Proceedings	Hillenius S. "Designing Interfaces for Astronaut Autonomy in Space." Invited Speech. CanUX 2015, Ottawa, Canada, November 7-8, 2015. CanUX 2015, Ottawa, Canada, November 7-8, 2015. , Nov-2015
Awards	Playbook Team (Ivy Deliz, Steve Hillenius, Jessica Marquez, Bob Kanefsky). "NASA Team Honor Award: Playbook. July 2016." Jul-2016