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Program/Discipline--Element/Subdiscipline:	HUMAN RESEARCH--Space Human Factors Engineering		
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Zip Code:	94035-0001	**Congressional District:**	18
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No. of Bachelor's Candidates:		**Monitoring Center:**	NASA JSC
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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)		
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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:	
Task Progress:	As NASA moves towards long duration deep space missions, the need for crew autonomy will only grow. Time delay due to the increased distances between spacecraft and Earth will require significant levels of autonomy. Communication windows may also be limited which will put even more pressure on the need for autonomous decision-making. In order to support these increasing needs it is necessary to develop systems that support crewmembers autonomous decision-making, while at the same time do not result in additional workload by the crew. The efforts in the proposal effort have revealed several findings. Originally when we started this work, the idea of having the crew perform mission planning had not really been explored and previous small lab tests by other groups indicated a need for better tools before attempting an operational test (Rosenbaum, "ISTAR Scheduling Exercise Results (using OSTPV)." Internal Report (2014)). We set out to build an intuitive, walk up and use mission planning tool designed for use by the crew, and we were successful in demonstrating walk up and use collaborative self-scheduling in a mission operational environment. Furthermore, our thought of what the ideal balance between mission control and crew in an autonomous environment was originally that the crew would be able to handle only lightweight plan editing, and larger more systematic plan changes would need to be delegated to mission control. From our directed research project (DRP) results the crew is capable to handle large scale planning changes such as planning and replanning an EVA (extravehicular activities), planning and replanning entire mission days, and planning out their interior science. These types of planning problems are typical of what mission planners for the International Space Station or Mars rover missions would handle and show that the crew is able to handle more complex planning problems than we originally anticipated. We have also shown in the numerous crew autonomy tests that we ran as part of this DRP that the concept of crew autonomous mission planning is no longer theoretical and we were able to demonstrate this successfully several times. New organic use cases for crew autonomy mission planning were observed which gave additional insights into how the crew progressed in their plan and may indicate unmet needs back to mission control (such as blocking off personal time, adding insights into how activity or plan execution could be improved, etc.). Additionally, the ability to add in intent

information became an important concept to clarify why a mission plan was planned or executed in a certain way.

Through the DRP efforts we found that lightweight planning such as task list scheduling, small additions, and updates of activities on the same day of execution require relatively low effort and can be done in the margins (such as in the time between activities). More complex planning such as EVA planning and replanning and interior science planning is also successfully accomplished if the crew has been scheduled explicit time to do that planning.

In conclusion, we have demonstrated through this DRP effort, that the crew can successfully autonomously plan and reschedule complex mission operation tasks if they are provided with a tool, which provides the necessary capabilities. Testing prototypes in high-fidelity analogs and on ISS has enabled identification of features required in future tools for autonomous self-scheduling. And the results from this DRP can be used to develop recommendations for necessary guidelines and standards.

For future work, the focus should be on increasing the cost benefit of using crew time for complex planning. Out of our DRP research, we have found a promising technique in the use of the Plan Fragment strategy of using nominal relative planning blocks and then tweaking them to the current mission day’s constraints. Further investigation to this technique as well as other novel planning strategies and tool features to assist in the planning process are recommended to make crew planning more efficient.

Bibliography Type:	Description: (Last Updated: 10/19/2016)