Designing for Astronaut-Centric Planning and Scheduling Aids

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We have investigated and evaluated a novel concept of operations for human spaceflight: allowing astronauts to manage and schedule their own timeline. In order to evaluate this self-scheduling concept of operations, we have designed, implemented, and field-tested astronaut-centric planning and scheduling aid. Our mobile-based software aid, Playbook, has been used in a variety of Earth analogs as well as onboard the International Space Station. We will demonstrate the unique Playbook features that we have developed based on research findings during field testing that facilitate planning and scheduling in extreme environments.

INTRODUCTION

As NASA focuses more on crewed deep space missions, the need for the astronaut to take on tasks traditionally assigned to mission control becomes more of a necessity. Many of the activities currently scheduled for the astronauts onboard the International Space Station (ISS) require communications with ground personnel and mission controllers. Future deep space missions to Mars will impose a communication delay between astronauts and mission control due to the extreme distances between spacecraft and Earth. This will affect operations by making space-to-ground communications inefficient and potentially confusing due to the lag. Furthermore, there will be times of complete communication outages (such as conjunction on Mars, where the Sun blocks communication between Earth and Mars for roughly a month) where the crew will be completely on their own. As such, NASA is evaluating new methods that enable crew autonomy, i.e., where astronauts can operate and perform their work more independently from mission control.

One aspect of facilitating crew autonomy is enabling the astronaut to perform mission planning and scheduling with minimal support from mission control. Today on the ISS the mission plan is crafted and provided by mission control entirely. While there have been recent changes to allow some crew flexibility on board, their plans are still very rigid and little crew input is allowed. Enabling crewmembers to autonomously perform mission planning introduces a number of challenges. Essential to this concept of operations is the support of software aids that enable astronauts to do their own planning and scheduling. Our team has been developing crew-centric aids for several years in our software called Playbook (Figure 1). Playbook's unique features for self-scheduling have been field-tested in Earth analogs as well as onboard the ISS.

Objective

Demonstrate the variety of unique Playbook features that enable crew-centric self-scheduling.

PLAYBOOK FEATURES

Playbook was developed as a web-based schedule viewer. Based on our research (Marquez et al., 2013; Hashemi & Hillenius, 2013), we identified and incorporated into Playbook key tool requirements for a crew-centric planning and scheduling aid:

- Mobile and web-based,
- Tablet-focused interactions,
- Visual, horizontal timeline (Figure 2),
- Editable schedule,
- Live updates, shared across distributed team,
- Highly integrated embedded procedures.

Over the course of three years, the Human Research Program funded our team to investigate and enable research on crew autonomy and self-scheduling for deep space missions (Hillenius et al., 2016). New features were developed based on observations and field-tests in Earth analogs, such as NASA Extreme Environment Mission Operations (NEEMO) and Human Exploration Research Analog (HERA). We also identified more specific features to facilitate self-scheduling (Marquez et al., 2017). These features include:

- Ability to easily reschedule assigned activities,
- Ability to collaboratively plan with multiple crewmembers,
- Ability to add activities from a task list to schedule,
- Ability to add new activities to schedule,
- Ability to visualize violations when constraints in a plan are not met (Figure 3),
- Ability to manipulate grouped activities,
- Ability to show fixed resources, such as availability of satellite communication availability (Figure 3).

In 2017, Playbook was used as part of a technology demonstration onboard ISS. In Crew Autonomy Scheduling Test (CAST), we demonstrated the self-scheduling concept of operations was feasible in a spaceflight operational environment (Marquez, Hillenius, and Healy, 2018).

Figure 1: Astronaut training on Playbook in NEEMO

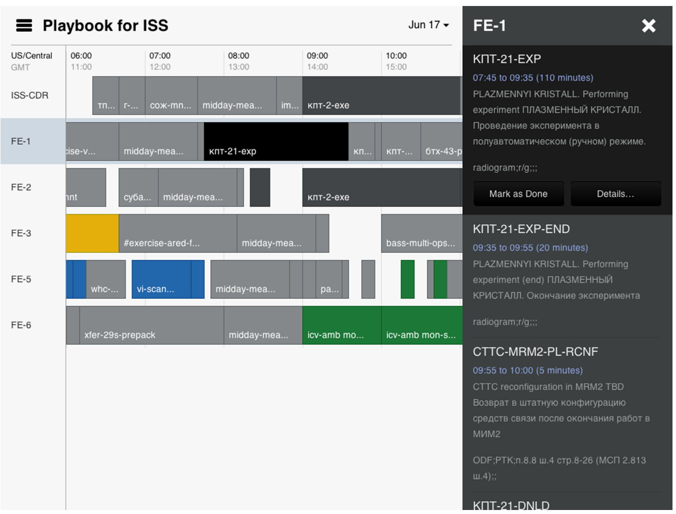

Figure 2: Playbook with horizontal timeline and activity details.

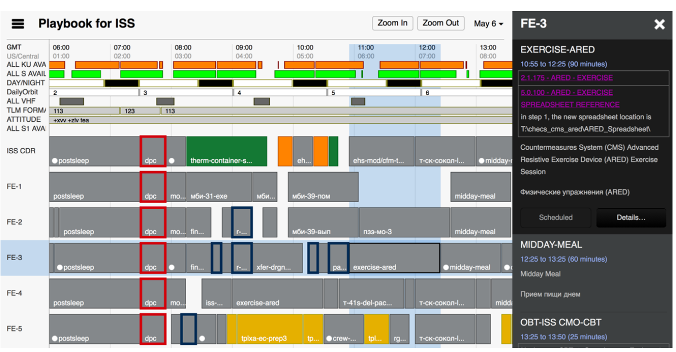

Figure 3: Playbook with violation flagging and communication bands.

DEMONSTRATION

Interactive Nature

Playbook is a mobile, collaborative web-based tool; hence the proposed demonstration will project Playbook as we go through each unique feature for self-scheduling in real-time. We will also provide an iPad so audience members can self-schedule and share their edits during the demonstration. We will show how violations are flagged and how astronauts may resolve the constraint being violated.

Possible Applications

Playbook is currently being used as a research platform to better understand human performance in self-scheduling and other methods of enabling crew autonomy. Variants of this planning and scheduling tool are in development for the Mars 2020 mission.

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