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Promoting Crew Autonomy in a Human Spaceflight Earth Analog Mission through Self-Scheduling

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Introduction

- Astronauts must operate more autonomously from ground stations during long duration exploration missions.
- We envision self-scheduling as a critical part of autonomous crew capabilities.
- Self-scheduling is the ability for crew to manipulate their timeline.
- Conducting research in Human Exploration Research Analog (HERA) centered crew autonomy.

Credit: NASA

HERA Campaign 6 (C6)

- HERA is an isolation analog located at NASA Johnson Space Center (JSC) that simulates future long duration exploration missions.
- For each of C6's four missions, four astronaut-like crew members live in the habitat for 45 days.
- Crew only interacts with their family, friends, and mission control remotely.

From www.nasa.gov/image-feature/human-exploration-research-analog-hera-external-view

HERA Campaign 6 (C6)

- Crew are assigned a variety of tasks:
  - Research-centered activities
  - Operational-relevant activities
  - Daily activities (e.g., meals, hygiene)
- Large portion of mission, communication transmission is delayed between 30 seconds to 5 minutes each way.
- C6 focuses on crew autonomy.

Credit: NASA

Research Objectives

- There are three C6 objectives regarding crew autonomy and self-scheduling:
  1) Assess self-scheduling performance in an operationally-relevant analog environment.
  2) Validate self-scheduling countermeasure aids in an operationally-relevant analog environment.
  3) Explore the impact of self-scheduling & crew autonomy at a mission-level.

Experiment Design

Crew Autonomy in HERA C6

Pre-Mission

Train crew to use self-scheduling software with various constraints

No Autonomy

No self-scheduling allowed

Limited Autonomy

Self-scheduling is available. Four mission days to be completely self-scheduled by single crew for team.

High Autonomy

Self-scheduling available, completely initiated by crew.

Post-Mission

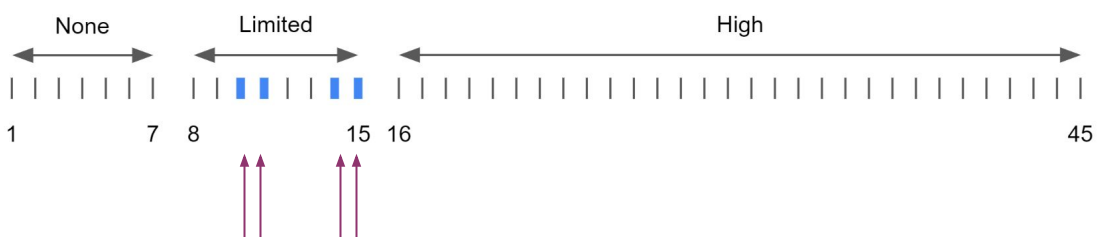
Crew fills out surveys and conducts debrief.

Crew Autonomy in HERA C6

In-Mission

1

5



Mission Days to self-schedule

Pre-Mission

Train crew to use self-scheduling software with various constraints

Post-Mission

Crew fills out surveys and conducts debrief.

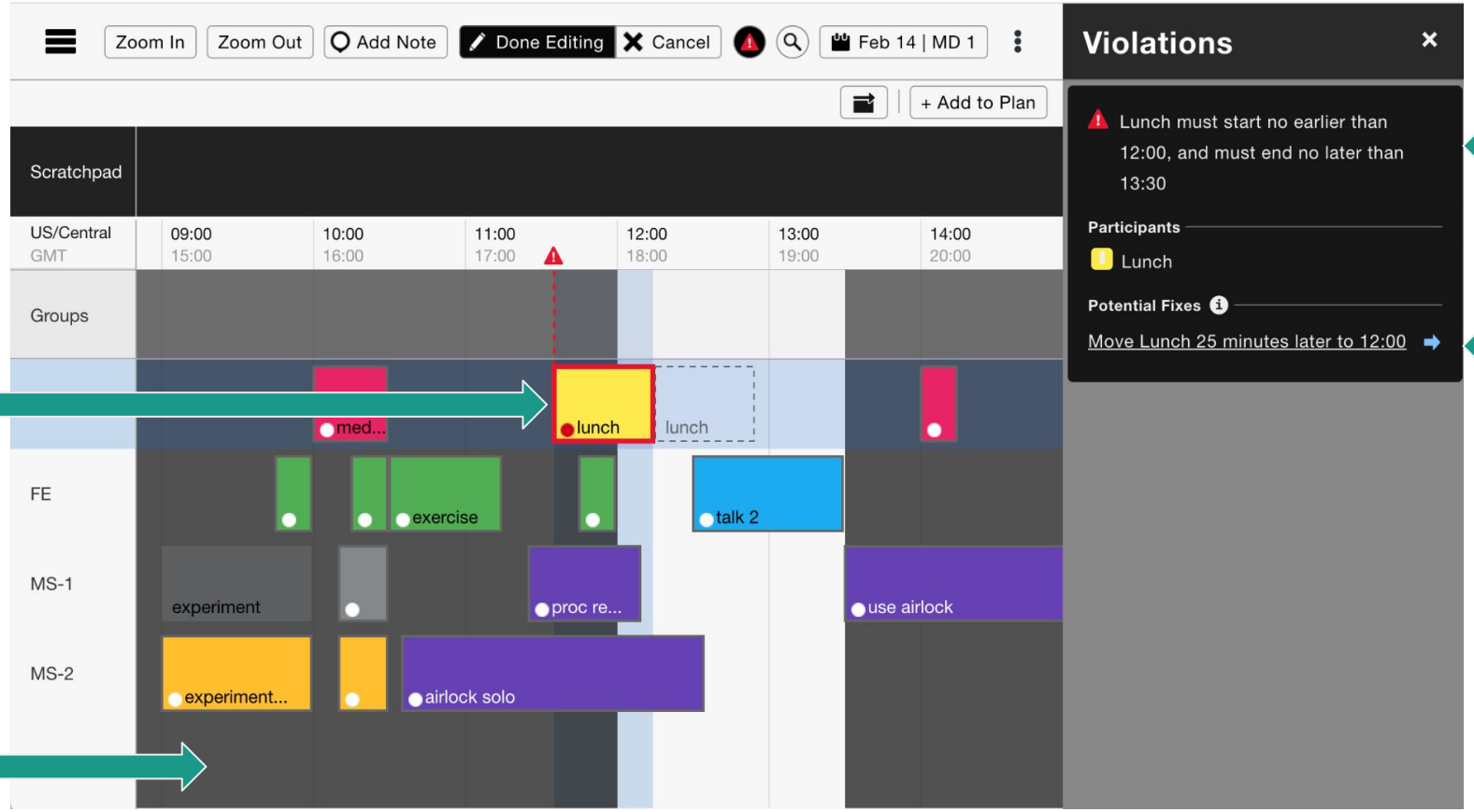
Experimental Setup & Data Collection

Team Preferences	Self-Scheduling	Execution
Crew was given time to discuss as a team what their scheduling preferences may be. This is to be completed before self-scheduling is to be done.	Each crew self-schedules a list of activities (and groups) from Task List, creating the team's schedule for one mission day. Self-scheduling occurs at least two days before day must be executed. They receive feedback from MCC about schedule.	Crew executes self-scheduled timeline. At the end of the day, crew that self-scheduled provides feedback about how the day went.

Self-Scheduling Software: Playbook

Scheduling Interface Aids

- Aid 1: “No-Go Zones”
  - Activities have certain constraints, e.g. must be completed before 14:00.
  - This aid visualizes the constraints and highlights on the timeline where not to schedule an activity.
- Aid 2: “Suggested Fixes”
  - When violations are made, the interface will suggest an edit that makes the timeline feasible.



Violation created

Aid 1: "No-Go Zone"

Violation description

Aid 2: "Suggested Fix"

Performance Measures

Data Collection and Performance Measures

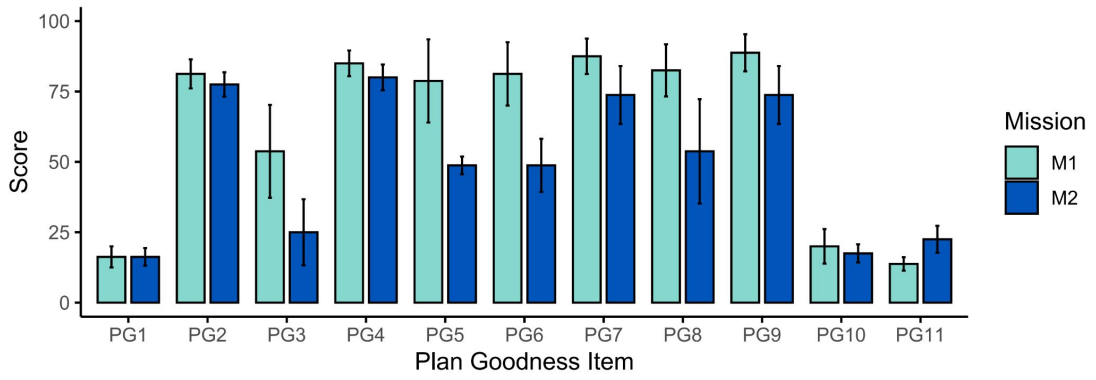
- Voice recordings
  - Proxy for “observing” planning and scheduling process.
  - First time collecting this data in analog.
- Interaction data logs
  - Post-process to obtain self-scheduling performance measures related to efficiency and effectiveness.
  - Counting every instance of self-scheduling across mission.
- Surveys
  - Workload NASA-TLX
  - Usability User Experience Questionnaire
  - “Plan Goodness”

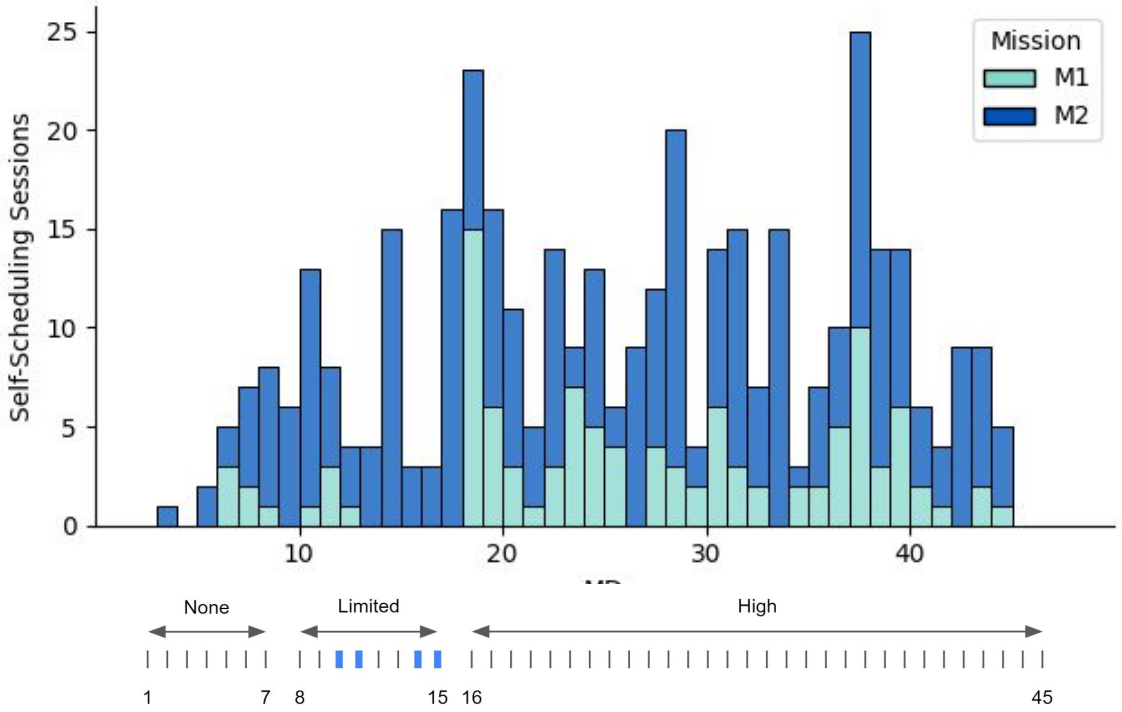
New Measure: “Plan Goodness”

- Developed a novel **self-report measure** that captures individual attitudes toward planning and execution to get additional information about the quality of schedule created.
  - Currently, we have objective metrics for efficiency and effectiveness, such as time to self-schedule and number of violations created.
  - However, we know how *good* a plan is relates to execution.
- The measure:
  - 11 statements rated on a 100-point scale
  - A high rating indicating that the subject strongly agrees with the statement

Preliminary Results & Future Work

Preliminary Results





Future Work

- Finish collecting data
  - Mission 4 is scheduled to end in October 2022.
  - Likely participate in HERA Campaign 7, allowing for more data collection.
- Post-process interaction data logs for measuring self-scheduling performance. Evaluate effect of countermeasure aids across various measures.
- Explore variations in “Plan Goodness” responses.
- Transcribe voice recordings to assess nature of crew collaboration, strategies, and preferences while self-scheduling.