Crew Scheduling Performance

Crew Autonomy through Self-Scheduling: Guidelines for Crew Scheduling Performance Envelope and Mitigation Strategies

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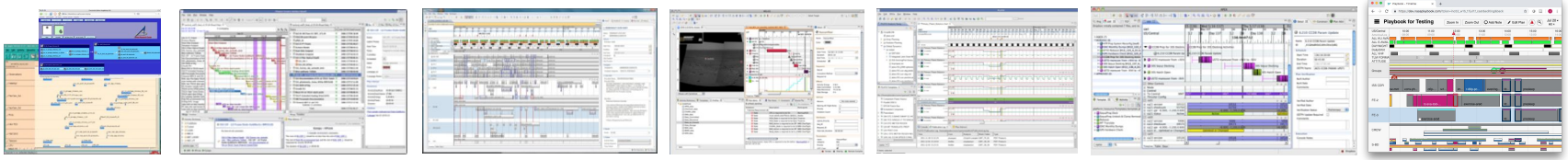
HCI Group Contribution to Spaceflight Planning & Scheduling Tools



2003

Mars Exploration Rovers
Maestro & MAPGEN

2009

Mars Phoenix Lander
Phoenix Science Interface (PSI)

2011

Mars Science Laboratory
Mars Science Laboratory Interface (MSLICE)

2013

International Space Station Program
Ops Planning, Crew & Ground (Score)
Power Analysis (PLATO)
Attitude Control/Determination (APEX)

Lunar Atmosphere and Dust Environment Explorer (LADEE)
LADEE Activity Scheduling System (LASS)

2015

Earth Analog Missions: Multiple
Playbook for NEEMO, DSH, HERA, HI-SEAS, RESOLVE, MVP, PLRP, BASALT

2017

ISS Tech Demo
Crew Autonomous Scheduling Test (CAST) using Playbook

SPIFe
Scheduling & Planning Interface for Exploration

Playbook

Self-Scheduling Enables Crew Autonomy

BENEFITS

Enables crew to contribute their insight how to best manage schedule.

Minimizes idle time waiting for Mission Control responses.

Mitigates effects of communication latency, intermittent communication, and limited bandwidth.

CHALLENGES

Different concept of operations that requires new protocols.

Do not want to overwhelm astronauts who are not expert mission planners.

Still need to ensure and retain constraint-abiding plans and schedules.

Marquez, Hillenius, Healy, & Silva-Martinez (2019)

Research Objective

Characterize the human performance envelope for the task of planning and scheduling (crew self-scheduling), develop countermeasures to mitigate adverse performance effects due to plan complexity, and inform performance standards and guidelines based on research results.

Research Aims

1. Quantify crew performance envelope for the task of self-scheduling spaceflight operational plans.

2. Develop countermeasures that mitigate deficient crew self-scheduling performance.

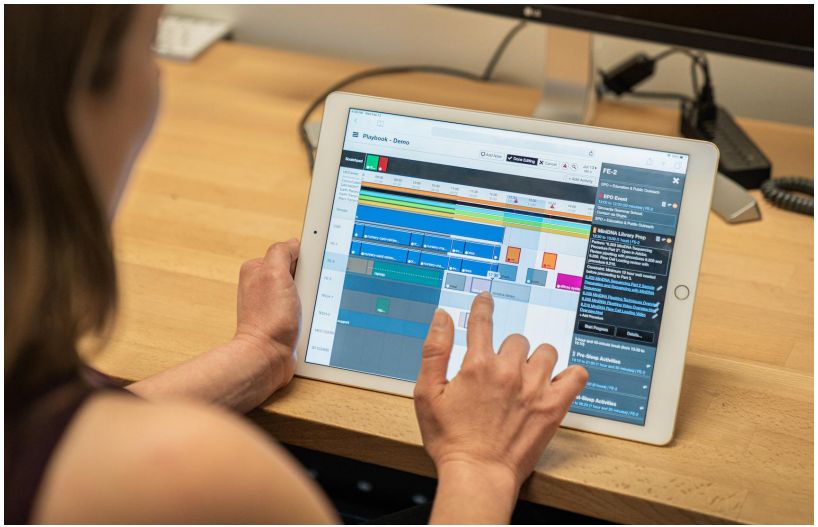
3. Validate self-scheduling countermeasures by evaluating changes in crew performance with countermeasures in spaceflight analogs.

4. Recommend standards and guidelines appropriate for autonomous crew in long duration exploration missions with regards to self-scheduling.

Preparing for Experiment

YEAR 1

- Identified human performance metrics for self-scheduling.
- Created an experimental platform to collect self-scheduling human performance data on an operational timeline tool.
- Completed pilot study (N=9) to evaluate metrics and experimental platform.
    - Lee, Marquez, & Edwards (2021)



Playbook is a next generation easy-to-use mobile web-based operational scheduling & execution tool.

Adapting to COVID Restrictions

YEAR 2: “Big” Experiment

- Initial working from home emphasized:
  - Prepping publication manuscript from pilot study.
  - Assessing data collected from previous analog missions.
  - Closing the loop on lessons learned from pilot study:
    - Which elements of scheduling complexity should be studied?
    - Which elements of scheduling complexity are most relevant operationally?
    - How do we appropriately measure Situation Awareness for scheduling task?

Interviewing Expert Planners

YEAR 2: “Big” Experiment

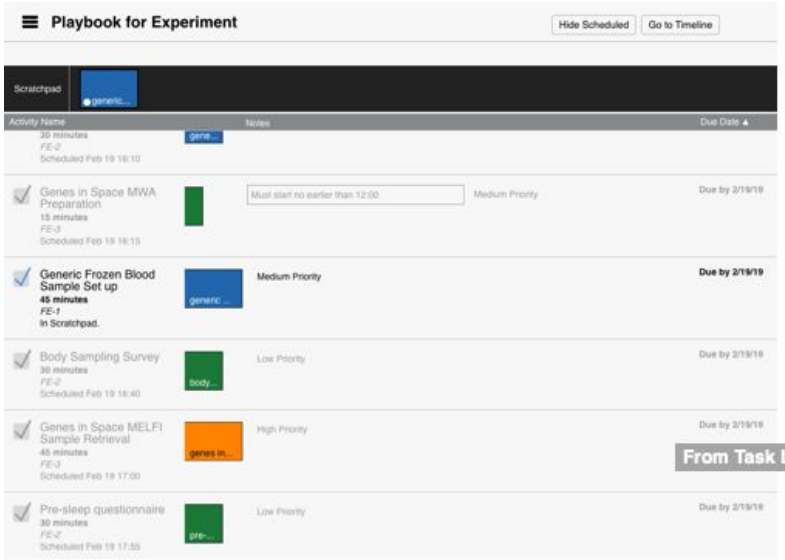
- Interviewed seven subject matter experts
  - Included current and former ISS Ops Planners, CAPCOMS, and former Shuttle Planners
  - Objective was to acquire a subjective assessment of what makes a timeline complex to schedule and what makes a good plan for crew members.
- Determined experimental parameters
  - Selection of Independent Variables for experiment
  - Improving Dependent Variables for experiments
    - See also upcoming in Edwards, Brandt, & Marquez (2021) AHFE

Remote Data Collection

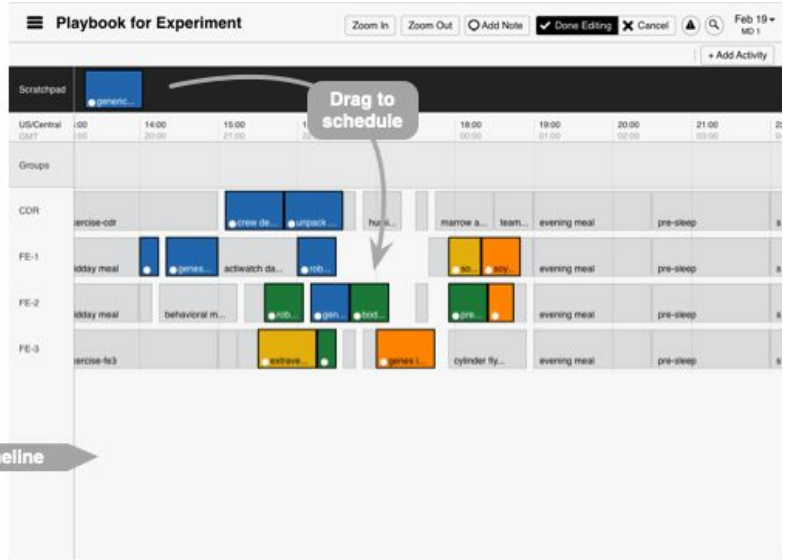
YEAR 2: “Big” Experiment

- During spring, it became apparent that we would not have the option of conducting in-person human-in-the-loop experiments in Year 2.
- Revectored resources to adapt and make robust our experimental platform (ESSEX) to collect self-scheduling human performance data completely remotely, enabling data collection for the Fall.

Self-Scheduling Task



From Task List to Timeline



Task List activities have priorities and some have constraints.

Activities are scheduled and assigned to complete a violation-free timeline.

Human Performance of Self-Scheduling

Mixed factorial design (2 x 2 x 4)

- One between-subject factor: type of task (scheduling vs. rescheduling)
- Two within-subject factors:
  - Percent of activities with constraints (⅓ vs. ⅔)
  - Type of activity constraints (equality requirement, earliest/latest, claimables, and temporal binary constraints)

Aiming for 30 participants (23/30 completed ATM)

Dependent measures include: effectiveness, efficiency, situation awareness, workload, trust, and usability.

Human Performance of Self-Scheduling

Next steps for experiment:

- Complete data collection and data post-processing.
- Statistical analysis during the springtime.
- Summarize findings, through reports and publications.

Next steps for grant:

- Conduct and complete HERA C6 experiment.
- Identify scheduling countermeasure aids.
- Begin summarizing recommended the standards and guidelines.

Questions?

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References

Marquez, J.J., Hillenius, S., Healy, M., and Silva-Martinez, J. (2019) “Lessons Learned from International Space Station Crew Autonomous Scheduling Test” Proceedings of the 11th International Workshop on Planning and Scheduling for Space, 8-10 July 2019, Berkeley, CA.

Lee, C.N., Marquez, J.J., and Edwards, T. (2021) “Crew Autonomy through Self-Scheduling: Scheduling Performance Pilot Study” AIAA SciTech Forum, 11-15 & 19-21 January 2021, Virtual Event.

Edwards, T., Brandt, S., and Marquez, J.J. (2021) “Towards a Measure of Situation Awareness for Space Mission Schedulers” Accepted to 12th International Conference on Applied Human Factors and Ergonomics.