Validation of Self-Scheduling Countermeasures in NASA's HERA Campaign 6

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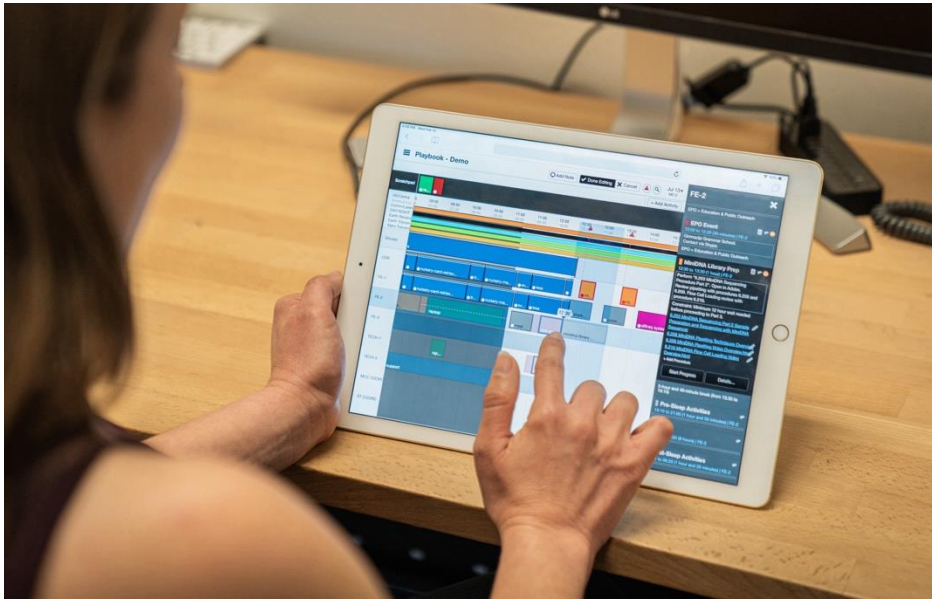
Background

- Today, International Space Station (ISS) schedules are handled by expert planners on the ground.
- During any given week, hundreds of activities are performed, each with its own resource needs (e.g., power), constraints (e.g., physical space), or crew availability (e.g., a given crew member trained for a particular task).
- Future long-duration exploration missions will require crew to take a more active role in the planning process, but crew are not expert schedulers.

Playbook

- Playbook is an interactive, web-based platform designed to facilitate crew members' visualization of their schedules and constraints.
- Playbook aims to enable effective collaboration between crew and Mission Control Center (MCC) personnel.



Self-Scheduling

- Self-scheduling is the ability for an astronaut to autonomously manipulate their own spaceflight schedule.
- Currently, ISS astronauts do not have the ability to rearrange schedules. Self-scheduling is a new concept of operations that our team has been exploring for years.

Human Exploration Research Analog (HERA)

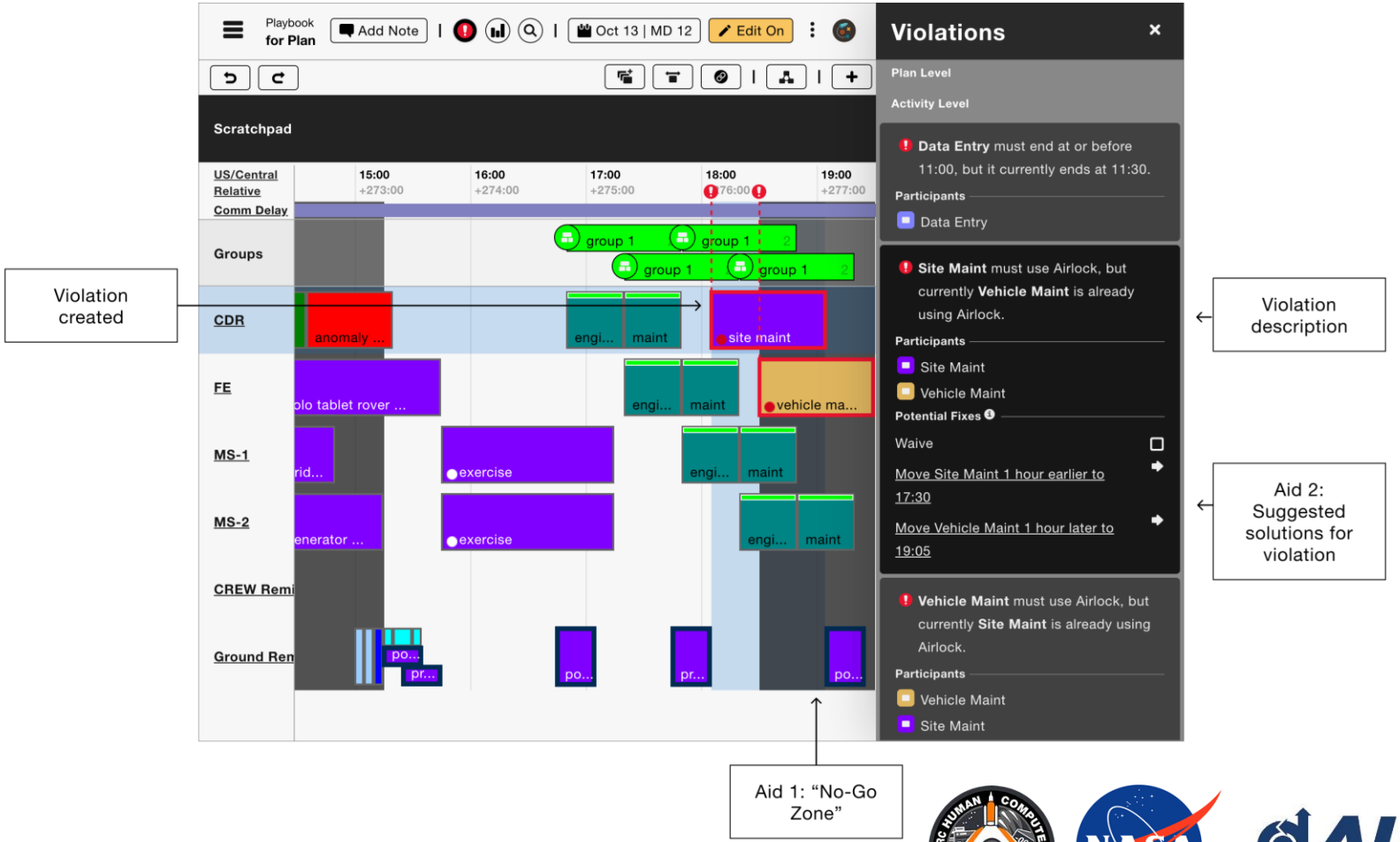
- HERA C6, conducted from September 2021 to March 2023, consisted of four missions (M1–M4) and marked the first mission-level implementation of self-scheduling within an analog setting.

Methods (1/2)

- During each of HERA C6's four missions, four astronaut-like crew members participated in a simulated 45-day mission.
- Each crew member took turns acting as the assigned planner to schedule one operational day for the entire crew.
- This resulted in a total of 16 self-scheduled days.

Methods (2/2)

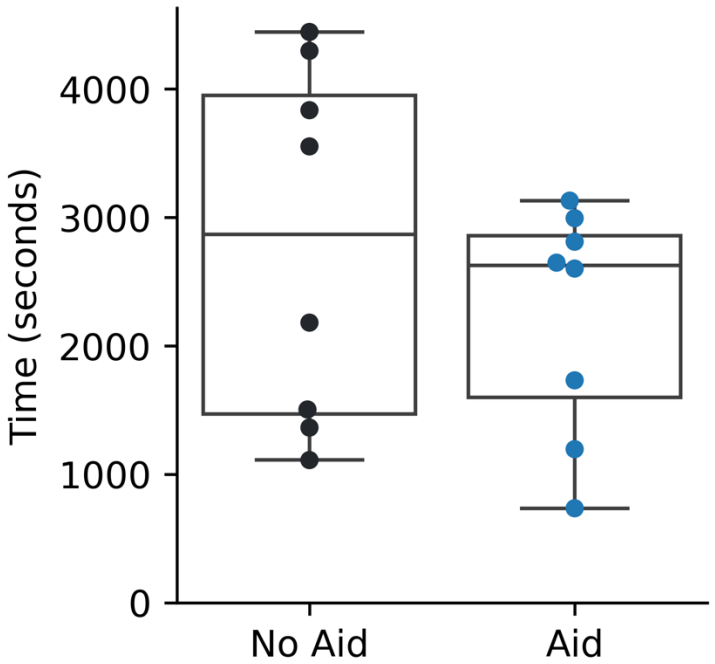
- In this study, we examined the performance of the analog crew and the workload associated with the scheduling process during HERA C6.
- All participants used Playbook to complete their scheduling sessions. Our analysis focused on a between-subjects variable of no aid (C6M1 and C6M2) and aid (C6M3 and C6M4).

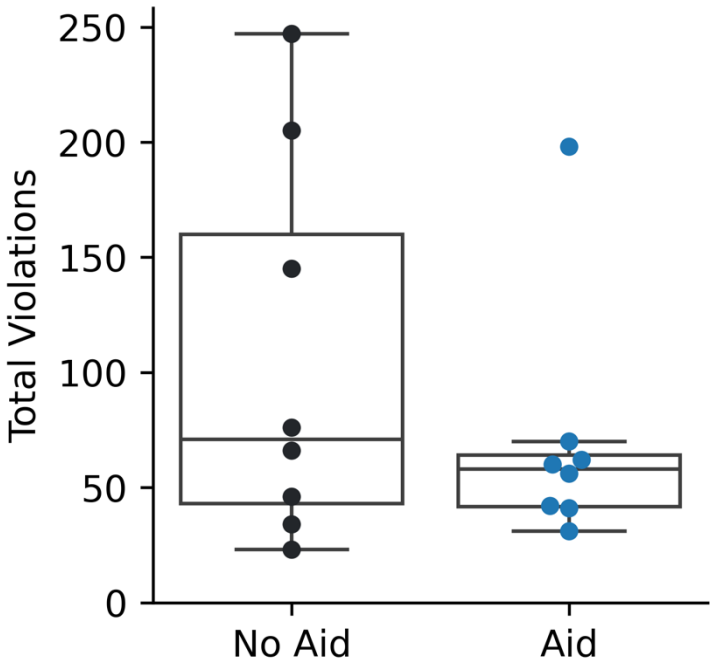

Violation created
Playbook for Plan
Add Note
Oct 13 | MD 12
Edit On
Scratchpad
US/Central
Relative
Comm Delay
15:00
+273:00
16:00
+274:00
17:00
+275:00
18:00
76:00
19:00
+277:00
Groups
group 1
group 1
group 1
group 1
CDR
anomaly ...
engi...
maint
site maint
FE
olo tablet rover ...
engi...
maint
vehicle ma...
MS-1
rid...
exercise
engi...
maint
MS-2
enerator ...
exercise
engi...
maint
CREW Remi
Ground Ren
po...
pr...
po...
pr...
po...
Violations
Plan Level
Activity Level
Data Entry must end at or before 11:00, but it currently ends at 11:30.
Participants
Data Entry
Site Maint must use Airlock, but currently Vehicle Maint is already using Airlock.
Participants
Site Maint
Vehicle Maint
Potential Fixes
Waive
Move Site Maint 1 hour earlier to 17:30
Move Vehicle Maint 1 hour later to 19:05
Vehicle Maint must use Airlock, but currently Site Maint is already using Airlock.
Participants
Vehicle Maint
Site Maint
Violation description
Aid 2: Suggested solutions for violation
Aid 1: “No-Go Zone”

Operational Constraints

- Due to the operational constraints of the HERA campaign, each crew member had a unique day to schedule, each with a different number of activities and various amounts and types of constraints.
- At least one of each constraint type was present on each crew member's scheduled day, and we attempted to select days with an even distribution of constraints.

Performance Measures



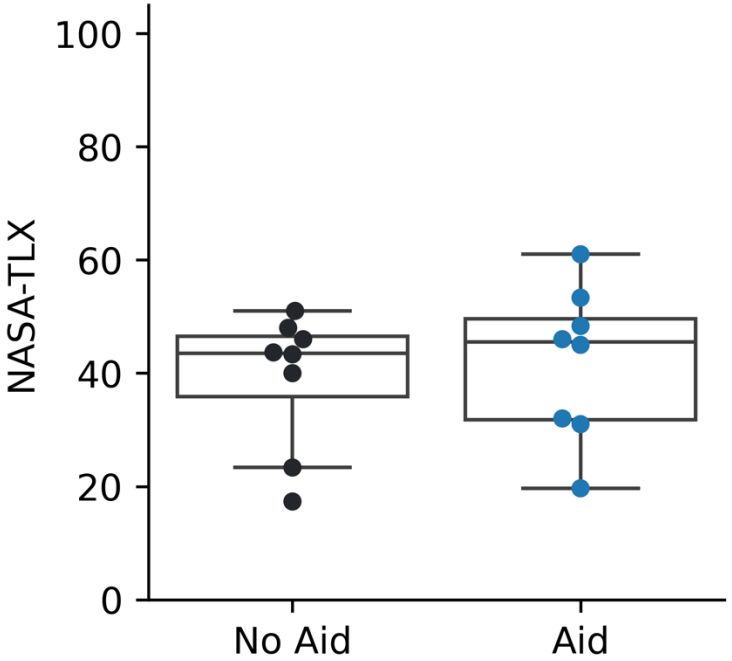


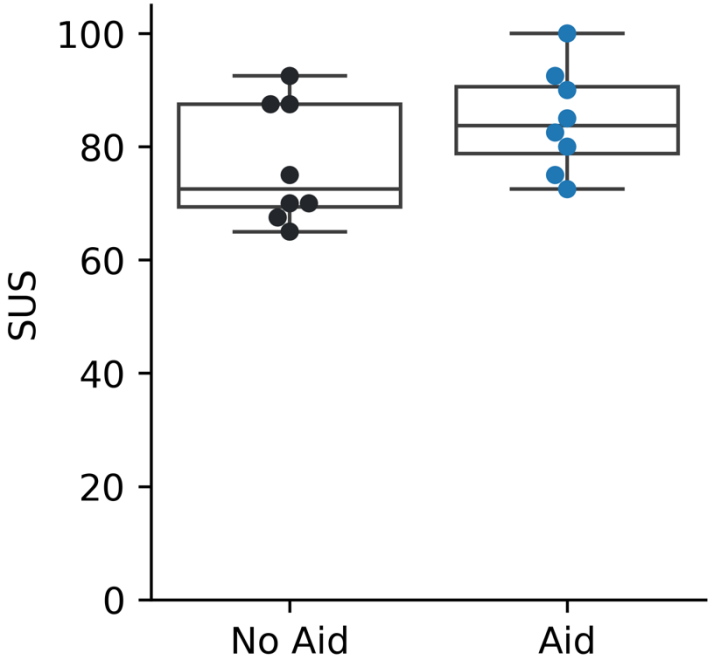
Violation Types

- Decreased total violations driven by decreased Claims and Binary constraint violations.

		Total	Claims	Binary	Assignment	Unary	Profile
Mean	No Aid	105	52	38	7	8	0
	Aid	70	29	19	16	6	2
Median	No Aid	71	35	14	5	8	0
	Aid	58	21	14	11	5	0
Standard Deviation	No Aid	84	45	52	6	6	1
	Aid	53	23	13	15	6	4

Workload and Usability Measures





Results

- Although none of the differences between the groups reached statistical significance, the Aid group exhibited trends toward better performance on several measures.
- Participants who received aids tended to complete tasks more quickly, reported higher usability scores on the SUS, and committed fewer total violations.

Discussion

- While this work provides evidence that targeted scheduling countermeasures (i.e., no-go zones) can reduce the occurrence of specific types of constraint violations, the development of additional countermeasures is ongoing.
- By introducing no-go zones, we may have inadvertently shifted the prevalence of scheduling constraint violations to Assignment constraint violations.
- HERA C7 has recently been completed and included 32 self-scheduled days.

Acknowledgments

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