A stylized space-themed illustration. On the left, a white and orange rocket with a blue nose cone is shown launching from a blue launch pad. The background is dark blue with a white moon, a red planet (Mars), and several yellow stars. Two orange streaks representing meteors or comets are also visible.

# CREW AUTONOMY THROUGH SELF-SCHEDULING: GUIDELINES FOR CREW SCHEDULING PERFORMANCE ENVELOPE AND MITIGATION STRATEGIES

2024 Human Research Program Investigators' Workshop

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# Crew Autonomy in HERA C6

Summarizing preliminary results from Crew Autonomy through Self-Scheduling research performed in HERA Campaign 6 (C6).

No crew  
autonomy

Limited crew  
autonomy

High crew  
autonomy

Part of crew autonomy experience was to give crew the ability to conduct **self-scheduling** throughout mission.



# What is 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.





Software  
Tool



Performance



Operations

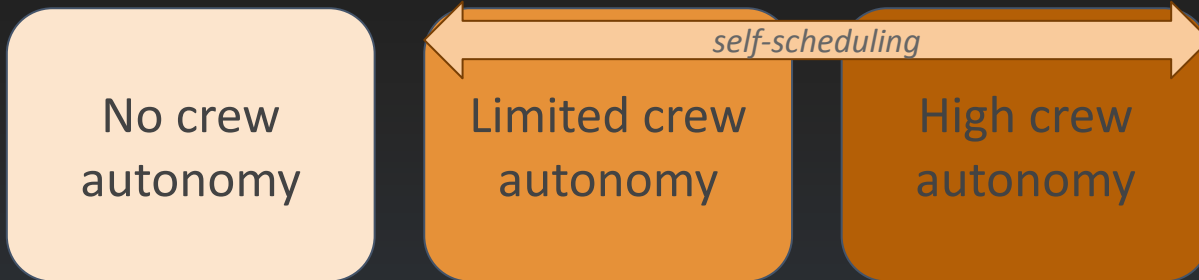
Crew Autonomy through Self-Scheduling



# Crew Autonomy in HERA C6

Crew self-scheduled:

- one day for their whole team (required);
- any flexible day (optional).

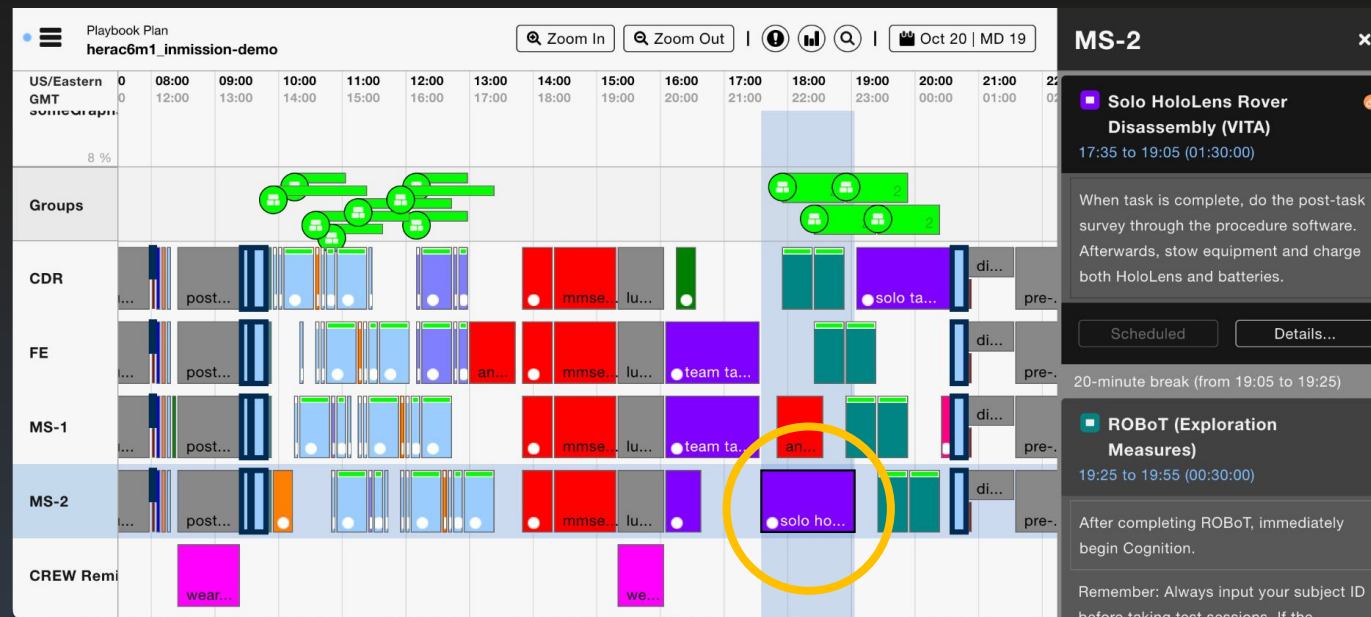


Assessing performance and operational impact within missions; evaluating countermeasures between missions.



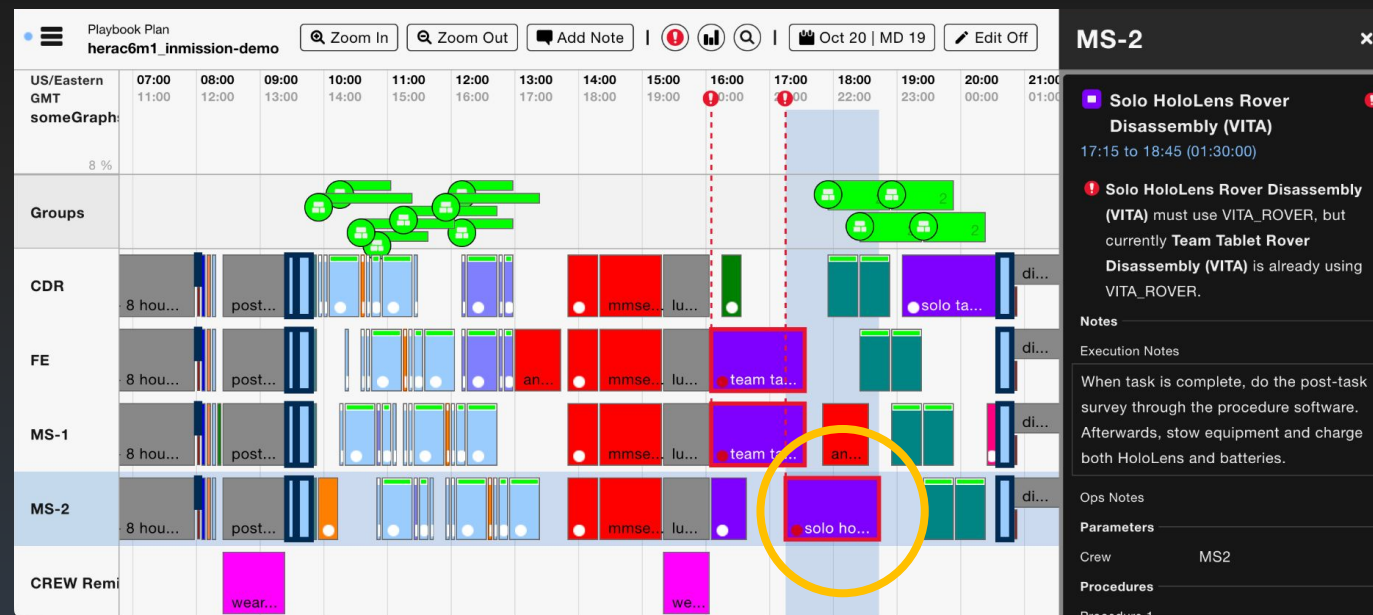
# Self-Scheduling in HERA C6

Timeline has activities / groups that are either flexible or not flexible.



# Self-Scheduling in HERA C6

Rescheduling can lead to violations — i.e., activity doesn't meet plan requirements and/or constraints.



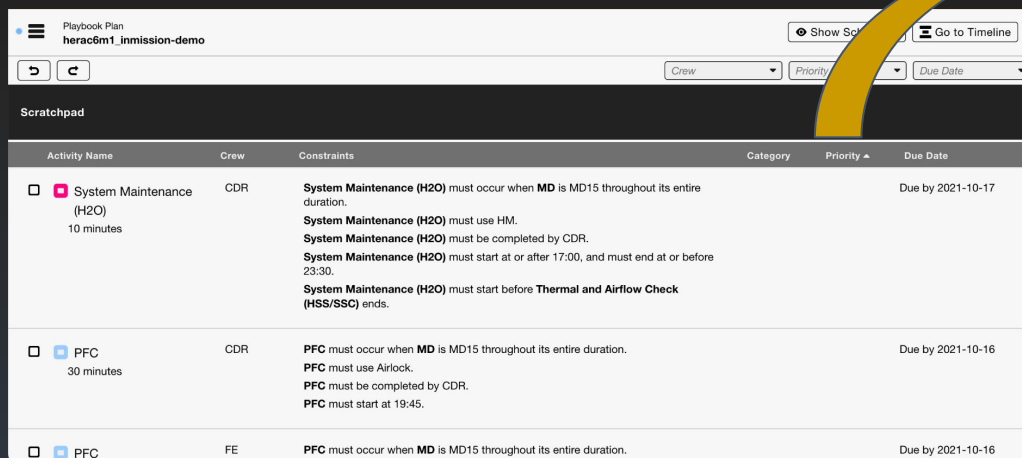
# Self-Scheduling in HERA C6

Playbook provides visual countermeasures to help crew fix scheduling violations.

The screenshot displays the HERA C6 self-scheduling interface. At the top, there is a header with 'Playbook Plan herac6m1\_inmission-demo', zoom controls, and a date 'Oct 20 | MD 19'. Below the header is a 'Scratchpad' section. The main area is a Gantt chart showing tasks for various crew members: US/Eastern GMT, CDR, FE, MS-1, MS-2, and CREW Remi. Tasks are represented by colored bars across a timeline from 07:00 to 21:00. A yellow circle highlights a red exclamation mark icon in the top toolbar. A yellow arrow points from this icon to a 'Violations' panel on the right. The 'Violations' panel lists participants and provides a detailed description of a violation: 'Solo HoloLens Rover Disassembly (VITA) must use VITA\_ROVER, but currently Team Tablet Rover Disassembly (VITA) is already using VITA\_ROVER.' Below this, it lists 'Potential Fixes' with arrows pointing to specific tasks in the Gantt chart: 'Move Solo HoloLens Rover Disassembly (VITA) 20 minutes later to 17:35' and 'Move Team Tablet Rover Disassembly (VITA) 20 minutes earlier to 15:45'. Another yellow circle highlights a task in the Gantt chart, and a yellow arrow points from the 'Potential Fixes' section to it.

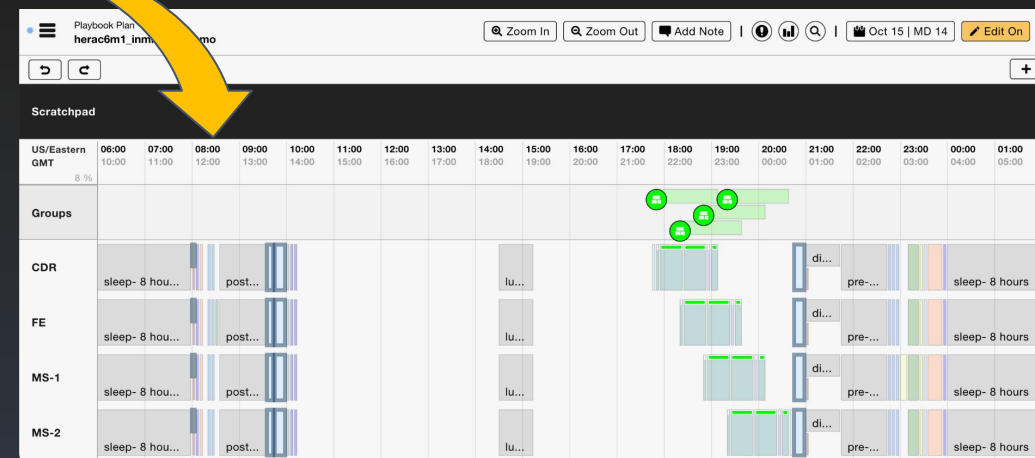
# Self-Scheduling in HERA C6

One day is completely scheduled by each crew member, creating a timeline of dozens of activities and groups for team.



Scratchpad

Activity Name	Crew	Constraints	Category	Priority	Due Date
<input type="checkbox"/> System Maintenance (H2O) 10 minutes	CDR	<b>System Maintenance (H2O)</b> must occur when MD is MD15 throughout its entire duration. <b>System Maintenance (H2O)</b> must use HM. <b>System Maintenance (H2O)</b> must be completed by CDR. <b>System Maintenance (H2O)</b> must start at or after 17:00, and must end at or before 23:30. <b>System Maintenance (H2O)</b> must start before <b>Thermal and Airflow Check (HSS/SSC)</b> ends.			Due by 2021-10-17
<input type="checkbox"/> PFC 30 minutes	CDR	<b>PFC</b> must occur when MD is MD15 throughout its entire duration. <b>PFC</b> must use Airlock. <b>PFC</b> must be completed by CDR. <b>PFC</b> must start at 19:45.			Due by 2021-10-16
<input type="checkbox"/> PFC	FE	<b>PFC</b> must occur when MD is MD15 throughout its entire duration.			Due by 2021-10-16



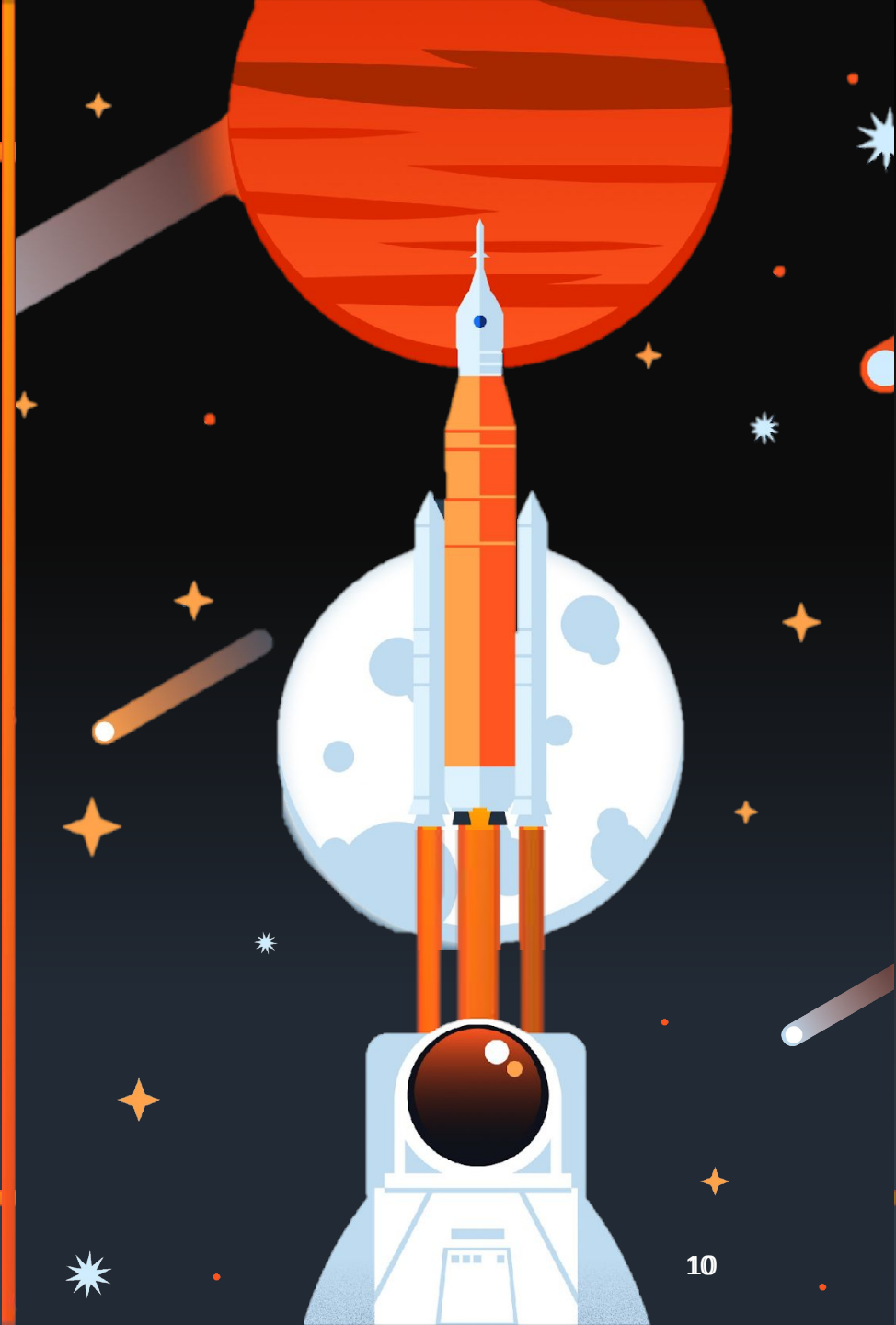
Scratchpad

US/Eastern GMT 8 %

Groups	06:00	07:00	08:00	09:00	10:00	11:00	12:00	13:00	14:00	15:00	16:00	17:00	18:00	19:00	20:00	21:00	22:00	23:00	00:00	01:00	02:00	03:00	04:00	05:00
CDR	sleep- 8 hou...		post...						lu...								di...				pre...			sleep- 8 hours
FE	sleep- 8 hou...		post...						lu...								di...				pre...			sleep- 8 hours
MS-1	sleep- 8 hou...		post...						lu...								di...				pre...			sleep- 8 hours
MS-2	sleep- 8 hou...		post...						lu...								di...				pre...			sleep- 8 hours

# Data Collection

- Counts for spontaneous self-scheduling throughout mission.
- Required self-scheduling day:
  - Voice recordings as proxy for “observing” planning and scheduling process: content analysis of recordings
  - Interaction logs will be post-processed to obtain performance measures related to efficiency and effectiveness: time on task, number of violations
  - Surveys capture workload (NASA-TLX), perceived plan quality (plan goodness), usability

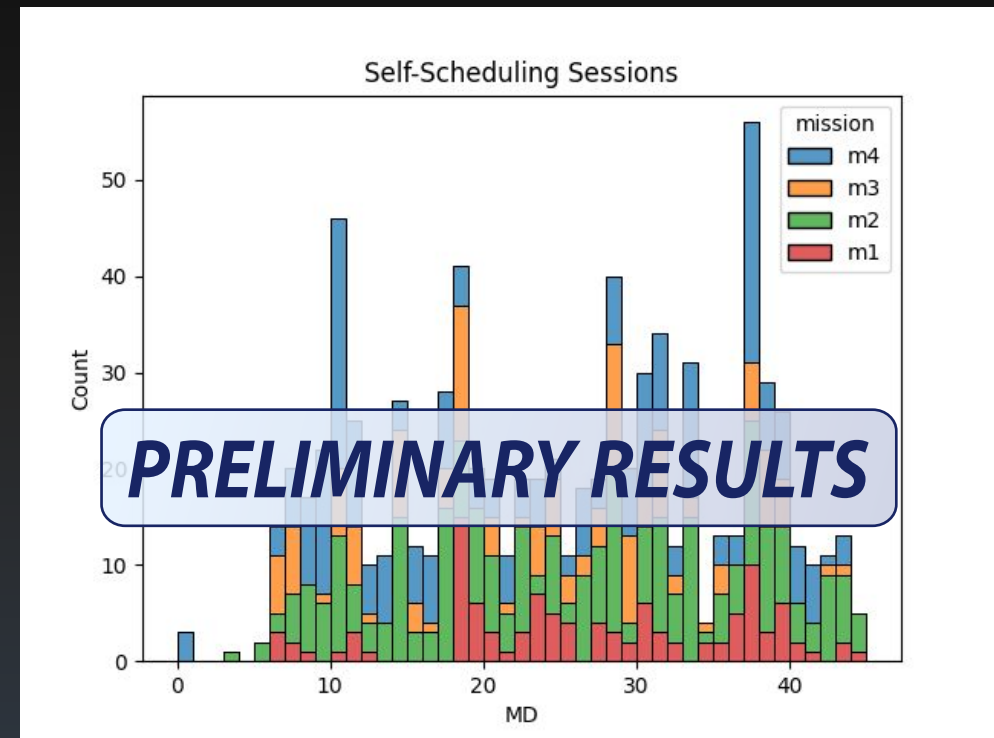


# Counts of Self-Scheduling Events

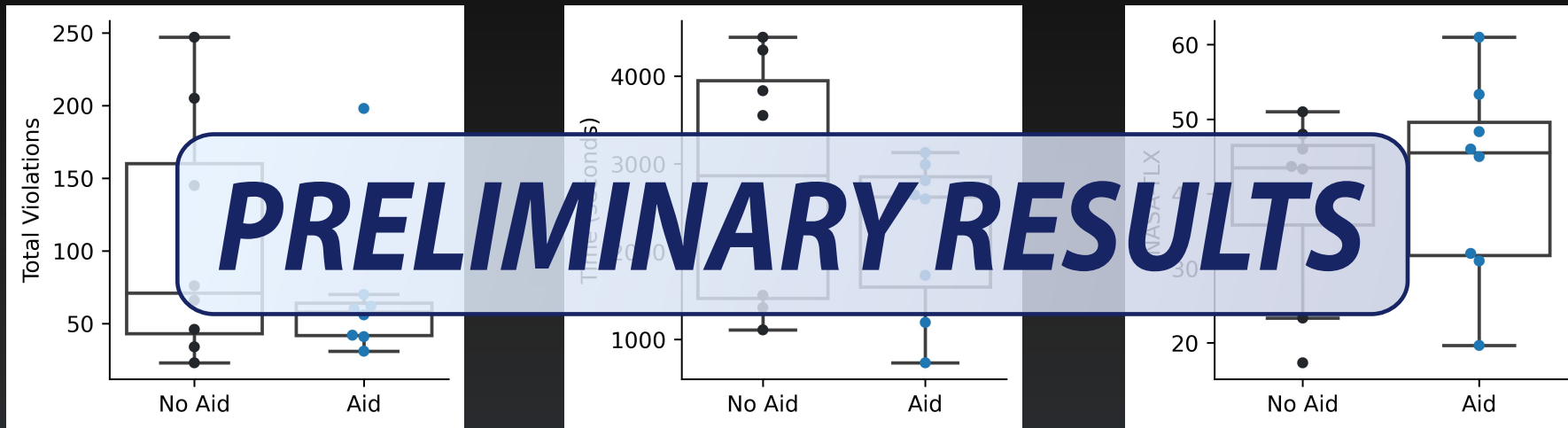
HERA C6 crew conducted spontaneous self-scheduling regularly throughout the mission.

Amount not seemingly affected by presence of countermeasure.

Self-scheduling is impacted by operational circumstances that are not easily tracked or noted.



# Individual Human Performance (C6)



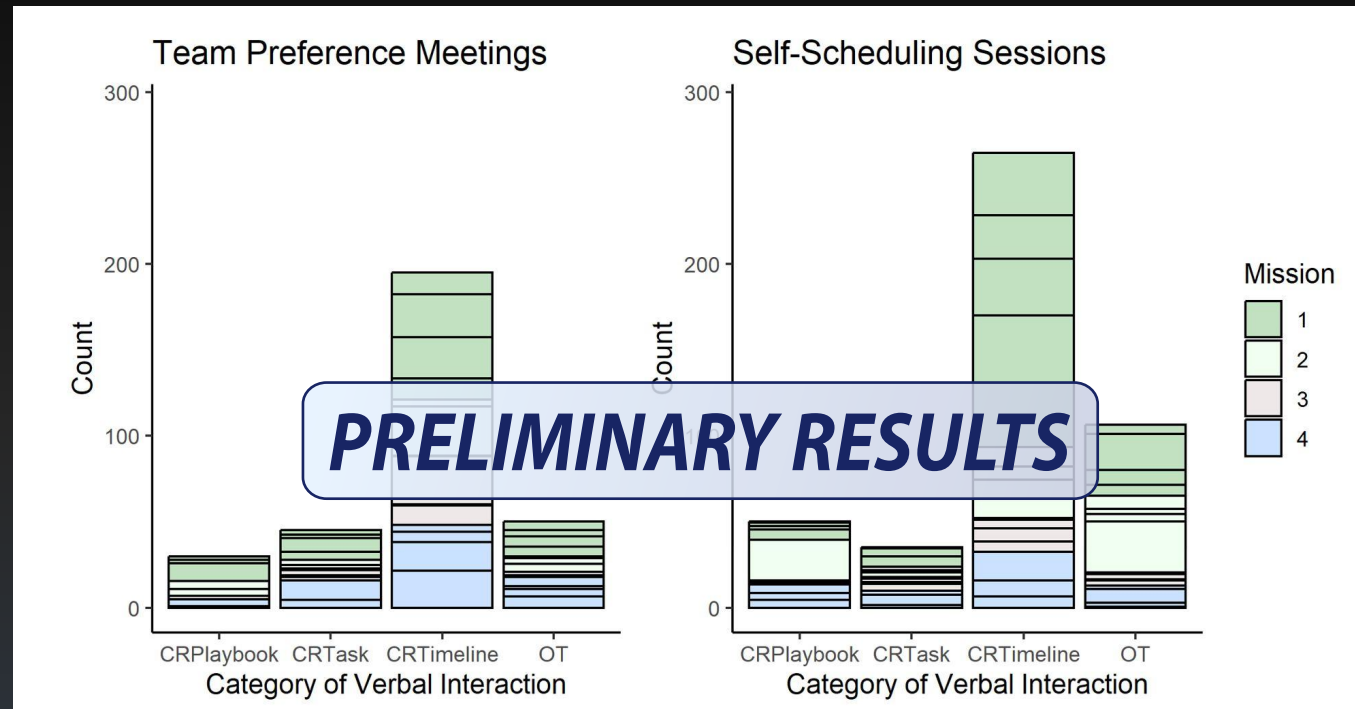
Countermeasure reduced the number of violations created by crew (from median of 71 to 58).

Countermeasure reduced the time spent on self-scheduling crew (from median of 2866 to 2624; 47.8 min to 43.7 min).

Countermeasure had no effect on workload (from median 43 to 45).

*T-tests were not significant*

# Content Analysis



Self-scheduling is more of a collaborative task than expected, despite asking crew to complete task individually.



# Future Work

## Continued analysis:

- spontaneous self-scheduling: individual session performance is not feasible but we can investigate operational circumstances (e.g., type of task, comm delay).
- relationship of plan goodness measure against HFBP-Exploration Measures (BHP).

## More data collection: participation in HERA C7

- Each crew are required to self-schedule two days, totaling 18% of mission.

Collaboration with Mosier & Fischer addressing improving negotiating crew autonomy between crew and MCC, including self-scheduling.

Questions?





# Relevant Publications from Last Year

Zheng, J., Shelat, S., and Marquez, J.J. (2023, June) Facilitating Crew-Computer Collaboration During Mixed-Initiative Space Mission Planning. *SpaceCHI*. Cambridge, MA.

Marquez, J.J., Shivang, S., Zheng, J., & Karasinski, J.A. (2023, August) Inferring Collaboration Strategies and Usability from Remote Observations in a Spaceflight Analog Environment. *Applied Human Factors and Ergonomics (AHFE) Conference*. San Francisco, CA.

Marquez, J.J., Landon, L.B., & Salas, E. (2023) The Next Giant Leap for Space Human Factors: The Opportunities. *Human Factors*. 65(6). <https://doi.org/10.1177/00187208231174955>.

Shelat, S., Marquez, J.J., Zheng, J., & Karasinski, J.A. (under review) Collaborative System Usability in Spaceflight Analog Environments through Remote Observations. *Applied Sciences*.

# Categorizing Crew Interactions

Label	Category	Description	Example
CRTimeline	Collaboration Regarding Timeline	Discussion on timeline content and preferences	<i>"I personally like the questionnaires stacked together... knock 'em all out."</i>
CRTask	Collaboration Regarding Task	Discussion on the nature of the assigned task at hand (either TPM or SS)	<i>"We can talk about what our preferences are."</i>
CRPlaybook	Collaboration Regarding Playbook	Discussion on how to use the tool or navigate the interface	<i>"But where do you see the tasks?" "They're right there on add-to-plan."</i>
OT	Off-Topic	Jokes, tangents, or unrelated topics	<i>"Have you watched the latest season of that show?"</i>