Increasing Crew Autonomy for Long Duration Exploration Missions: Self-Scheduling

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Why Crew Autonomy?

Changes in interactions between Earth-based Mission Control and astronauts in space as a result of transmission latencies and limited data bandwidth. The lack of constant communication will change the way astronauts work in space.

Crew autonomy allows astronauts to **provide inputs** about what is going on currently in space and how work is being executed in space.

Crew autonomy provides **flexibility** and potentially making operations more **efficient**.

Astronauts have been requesting more autonomy since early in NASA's space programs.

We propose opening up the door for crew autonomy through **self-scheduling**.

Enabling Self-Scheduling through Playbook

Playbook is a next generation, easy-to-use mobile web-based planning tool.

Builds upon space operation heritage tools for space exploration.

Used in dozens of Earth-based analog missions.

Playbook is unique because it allows astronauts to complete **lightweight plan editing** & execute their assigned activities.

Timeline Execution

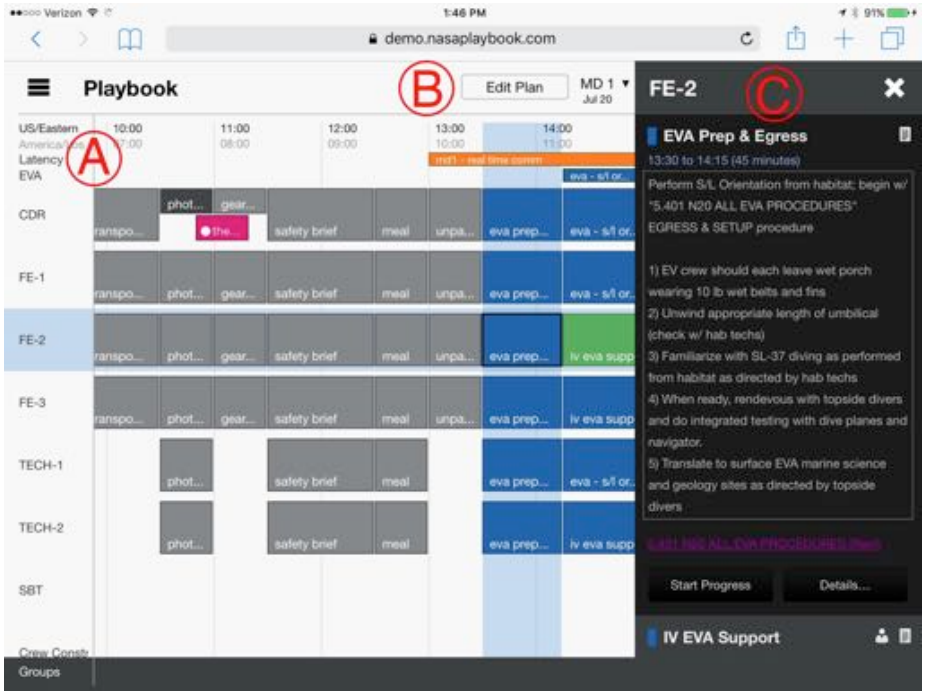
Schedule: crewmember bands, activities

Integrated state information, like communication availability

Activity details, easy access to procedures

Ability to status activities as started, completed, or aborted.

Collaborative editing and viewing



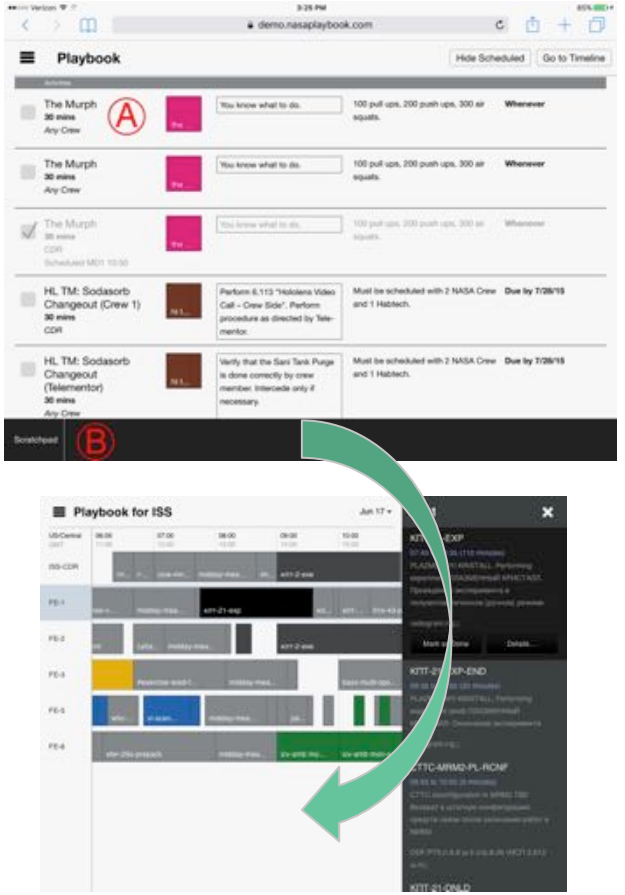
Scheduling Activities

While in editing mode …

- Rescheduling & reassigning are as easy as drag and drop to new time or new band
- Leverage Scratchpad, place holder to organize activities across days or views

Adding more activities:

- From Task List view, flexible activities or groups of activities that can be scheduled at any time
- Creating your own new activities



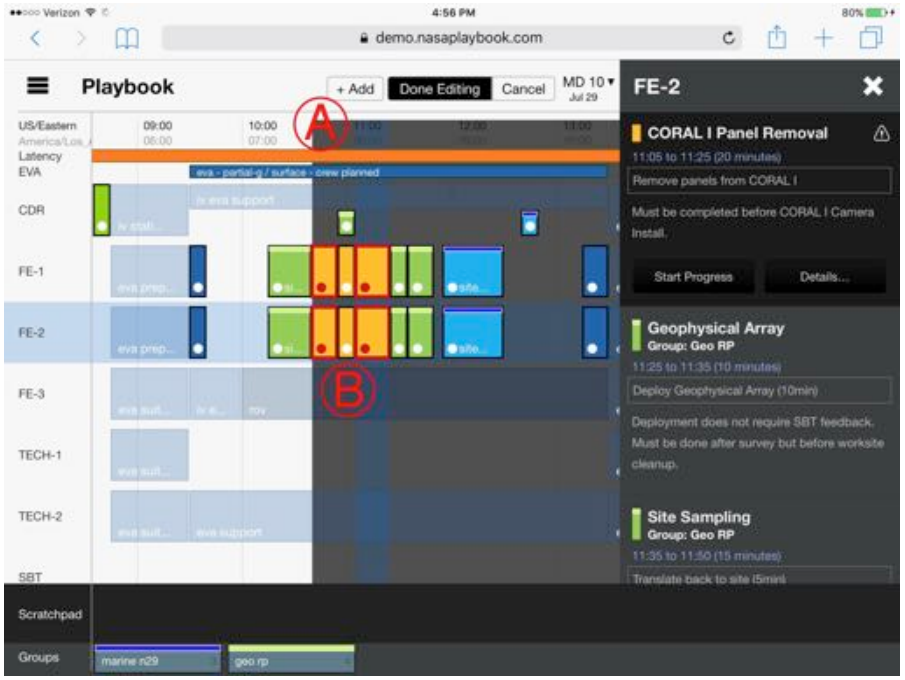
Constraints & Flagging Violations

When crew moves activities:

- No-go zones indicate areas where activity should not be scheduled
- Violations are flagged if constraints are not met

Current constraints:

- Claimables, state requirements, temporal relationships, and time-of-day requirements



NEEMO Experience

- Evaluating crew autonomy in an operational-analog environment
- Incremental approach to evaluating self-scheduling through Playbook

Astronaut Reid Wiseman, NEEMO 21

NEEMO Missions

Underwater habitat, saturation dive

Diverse, multi-national crew

Mission control team w/ CAPCOM on Topside

Simulations of communication latencies

Playbook used as the main, integrated timeline tool for crew and MCC

Playbook + Crew Autonomy since N18

NEEMO 18

Allowed for flexible activities to be rescheduled and/or reassigned.

Crew was observed rescheduling time-insensitive activities like meals & surveys.

Playbook in use in the Mission Control

NEEMO 19

Flexible activities had constraints. Playbook showed no-go zones.

Crew was observed rescheduling some activities at the time of execution.

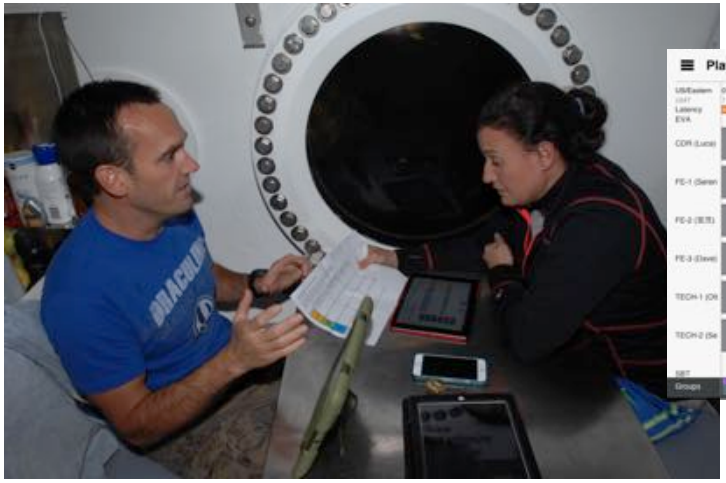
Crew successfully rearranged EVA tasks while respective temporal constraints.

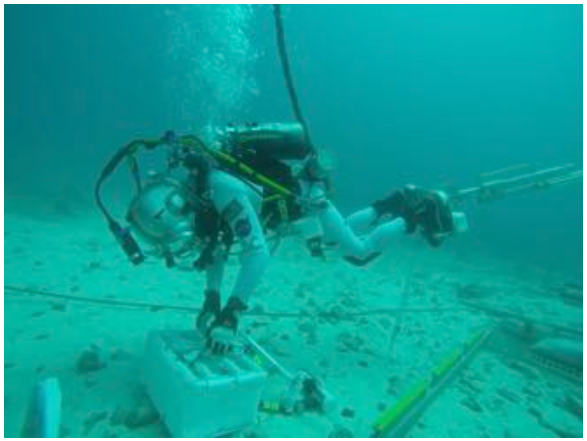
NEEMO 20

Task List activities were available, such as habitat monitoring activities.

Crew successfully timelined multiple EVAs, arranging grouped tasks.

Crew requested more Task List activities, such as personal exercise time.





EVAs plans required multiple constraints:

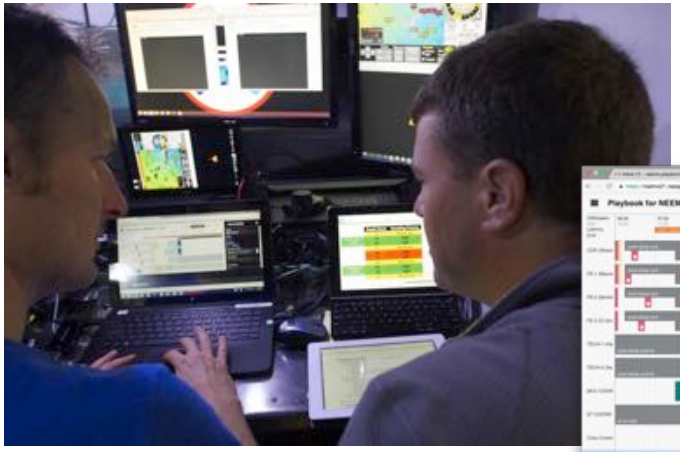
- Temporal constraints
- Scientific goals vs. Pioneering/Engineering goals
- Replanning based on previous execution.

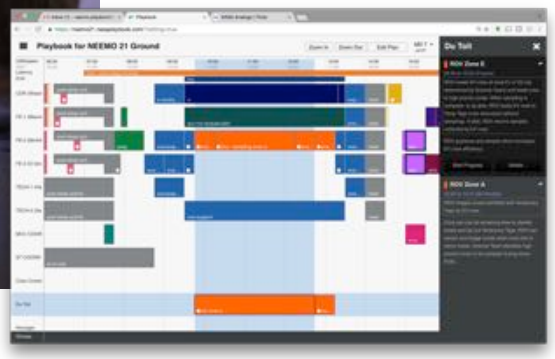
NEEMO 21

New activities could be created from scratch.

Crew successfully timelined two EVAs.

Crew added new activities unprompted by mission control.





EVAs planned had two different strategies:

- create EVA using new activities to accomplish a science goal
- create EVA using group building blocks.

Lessons Learned about Crew Autonomy

Self-scheduling can be **easy** and is **desirable**:

- "Eventually we got faster with self-scheduling and felt it did empower us to arrange the schedule as we thought best."
- "I'd love to have more flexibility in my time management and the few flex items were a good proof of concept."
- Multiple instances of unprompted self-scheduling.

Replanning can be **complex** and requires MCC buy-in:

- Some activities lend themselves to self-scheduling.
- Plan complexity needs to be managed by MCC & planners.
- Operational workflow adapted to include MCC inputs.

Future Work & Concluding Remarks

Crew autonomy through self-scheduling has been demonstrated as a valid concept of operations in Earth-based analog missions.

Future work will focus on:

- Demonstrating self-scheduling in spaceflight operations environment;
- Investigating how plan complexity impacts self-scheduling;
- New Playbook features that extend the types of planning problems that crew can manipulate.

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Backup Slides

More Lessons Learned

Surveys Feedback:

- Self Scheduling is a preferred PB capability
- Requests for more Self Scheduling capabilities (e.g., new activities)
- Requests for more flexible activities
- Requests that speak to remaining challenges
- Undo, Copy/Paste
- Awareness of plan changes

Plan Complexity:

- Communicating/visualizing constraints is not easy <<< we have tried many ways and there is still more work to be done here
- Visualizations is the direction we should go towards.
- Activity duration/size drives interaction challenges: inherent preferred plan granularity? We don't have enough evidence for this yet.

Operational Processes:

- Properly modeling constraints of flexible activities.
- Communicating real-time execution
- Time to *think* and discuss about how to plan. Takes at least 1 hour, but the scheduling time is a small portion of this time, which is delegate to one or two crewmembers.
- Setting up groups for activities can be helpful.
- Workflow between Crew and MCC: Need at least two days to review/iterate with MCC.