

Supplementary

SPAM Queries

The following lists the possible SPAM queries asked to operators. Queries were randomly selected from this list, however, queries were only allowed to be selected in times where they were appropriate to the situation (e.g., “Is the next planned burn more/less than 30 minutes away?” would only be asked if there was a planned burn.) Queries with a ‘/’ indicate that either option may be selected.

Level 1:

- Is the servicer’s battery greater/less than 50%?
- Is the servicer’s fuel greater/less than 50%?
- Is the servicer currently in the sunlight/shadow?
- Is the servicer’s flashlight on/off?
- Are there currently any cautions/warnings?
- Is the next planned burn more/less than 30 minutes away?
- Is there more/less than 30 minutes until the lighting conditions change?
- Is the servicer above/below the client satellite?
- Is the servicer ahead/behind of the client satellite?
- Is there a potential collision in the next 30 minutes?
- Does the servicer’s current trajectory enter the keep out zone?

Level 2:

- Is the servicer’s battery level currently increasing/decreasing?
- Is the keep out zone currently increasing/decreasing in size?
- Is the servicer’s flashlight currently aimed towards the client?
- Is there currently enough battery/fuel/time to complete an abort burn?
- Does the orbit enter the keep out zone from ahead/behind of the client satellite?
- Does the orbit enter the keep out zone from above/below the client satellite?
- Is the time to collision increasing/decreasing?
- Is the portion of the orbit line in the keep out zone increasing/decreasing?

Level 3:

- If no new unplanned actions are taken will there be a collision alert in 30 minutes?
- If no new unplanned actions are taken, will there be enough battery/fuel to complete an abort burn in 30 minutes?
- If no burns occur , will the servicer enter the keep out zone in the next 30 minutes?
- If there is not a burn, will the servicer cross orbits with the debris satellite?
- If no new unplanned actions are taken, will the servicer’s battery be greater/less than 50% in 30 minutes?
- If no action is taken, will you receive a new low battery/fuel caution/warning within the next 30 minutes?
- If no new action is taken, will the keep out zone be growing/shrinking in 30 minutes?
- If no new unplanned action is taken, will the servicer’s battery be increasing/decreasing in 30 minutes?
- will the servicer be in the sun/shadow at the early/default/late burn location?

Utility Survey

Please read EACH of the following statements, and indicate the extent to which you agree with each. The system refers to the display that you worked with today.

	Strongly disagree	Disagree	Neutral	Agree	Strongly Agree
I found the necessary information easy to find in this system.	☐	☐	☐	☐	☐
I found this system allowed me to be aware of mission critical events.	☐	☐	☐	☐	☐
I found this system enabled me to understand the uncertainties associated with the mission.	☐	☐	☐	☐	☐
I found this system promoted my understanding of collision likelihood.	☐	☐	☐	☐	☐
I found this system enabled me to understand the relative orbital motion of the satellites.	☐	☐	☐	☐	☐
I found this system allowed me to make appropriate operation decisions.	☐	☐	☐	☐	☐

Please provide any additional comments on this display and your experience performing the task.

Performance

Participants’ performance score on each trial was composed of two parts: burn decision and satellite end state. Burn decision relates to how effective the participants’ burn selection enables overall mission success. During

training, participants were instructed to always select a burn location, so no burn selection is an indication of either poor SA or poor understanding of appropriate actions. A ‘Poor’ burn decision consists of a burn location where it would be impossible to service the satellite. ‘Fair’ and ‘Good’ burn decisions are locations where servicing a satellite was possible, but different burn decisions would be more effective. ‘Excellent’ burn decisions were selections that put the participant in the best position to service the client. Not every scenario has all possible outcomes and for each trial, the location of a ‘Poor’, ‘Fair’, ‘Good’, or ‘Excellent’ may differ. The satellite end state refers to the final serviced state (collided, aborted, or serviced). The granularity of the serviced state was added by evaluating participants’ abort attempts, time to collision when aborted, use of flashlight, and end battery level. These different actions and metrics provide indirect information about the participants’ understanding of the task, awareness of the environment, and optimization of the outcome. Like the burn decision, not every trial had the full spectrum of possible scores for the satellite end state. The granularity of the scores is intended to objectively evaluate subject actions. These performance subdivisions allow for the delineation of performance but can be generalizable across scenarios. It should be noted that all scenarios cannot achieve all of the performance values.

Table 2: Burn Decision

Outcome	Score
No Selection	1
Poor	2
Fair or Good	3
Excellent	4

Table 3: End State

Outcome	Score
Collision - No Abort Attempt	1
Collision - Abort Attempt	2
Abort with > 15 minutes to collision	3
Serviced with < 5 minutes to collision or < 25 % battery	4
Abort - light use < 75%	5
Abort - light use > 75%	6
Serviced - Battery < 30 %	7
Serviced - Battery 30-50 %	8
Serviced - Battery > 50 %	9

$$\text{Total Performance} = \text{End State}(\text{battery, outcome}) + \text{Burn Decision}$$