Background:

The study, as presented in the paper *"I Need Your Help... Or Do I? Maintaining Situation Awareness Through Performative Autonomy"* (Roy et al., 2023), explores the impact of three distinct performative autonomy strategies—silent, yes/no, and wh-questions—on cognitive load and situational awareness in a mission control setting. These strategies were examined under three levels of imposed workload—low, medium, and high—resulting in a 3×3 experimental design. The objective was to determine whether these strategies influence cognitive load and situational awareness across different workload conditions.

Two experimental studies were conducted:

1. **Non malfunction Experiment:** The robot was tasked with placing a bag onto one of three berths in the International Space Station (ISS). If an obstruction was present in front of a berth, the robot utilized one of the three performative autonomy strategies to communicate with the mission control operator. This study is conducted as a between-subjects design, where each participant was exposed to only one of the nine conditions (i.e., workload level × autonomy strategy).
2. **Malfunction Experiment:** This scenario introduced a sensor malfunction in the robot, causing it to misperceive which berth was obstructed. Consequently, the robot communicated incorrect information to the mission control operator. Similar to the first experiment, this study is also conducted as a between-subjects design, limiting each participant to one of the nine conditions.

The primary aim of both studies was to identify the optimal performative autonomy strategy for each workload condition. The collected data was intended to inform a Partially Observable Markov Decision Process (POMDP) solver, with the experimental design structured to align with the solver's requirements.

Challenges:

1. Large POMDP model to solve
2. Due to human experiment – plenty of data collected and since there are 30-40 participants in each condition – hence a lot of similarity in the data – we need to design a POMDP solver that tackles transition matrix with duplicate data and update belief state accordingly.
3. Update the reward values to update the belief function as per NASA research criteria.

All Possible POMDP state transition in a tabular format: Highlighted ones are mostly seen in malfunction condition :

Silent communication :

Start state	Action	Observation	End state	Approx Reward
LowSA_LowWL_blocked_berth1	Silent_drop_berth1	command none	Invalid	-100
LowSA_LowWL_blocked_berth1	Silent_drop_berth2	command none	LowSA_LowWL_drop_berth2	10
LowSA_LowWL_blocked_berth1	Silent_drop_berth3	command none	LowSA_LowWL_drop_berth3	10-2=8
LowSA_LowWL_blocked_berth2	Silent_drop_berth1	command none	LowSA_LowWL_drop_berth1	10
LowSA_LowWL_blocked_berth2	Silent_drop_berth2	command none	invalid	-100
LowSA_LowWL_blocked_berth2	Silent_drop_berth3	command none	LowSA_LowWL_drop_berth3	10-2=8
LowSA_LowWL_blocked_berth3	Silent_drop_berth1	command none	LowSA_LowWL_drop_berth1	10
LowSA_LowWL_blocked_berth3	Silent_drop_berth2	command none	LowSA_LowWL_drop_berth2	10-2=8
LowSA_LowWL_blocked_berth3	Silent_drop_berth3	command none	invalid	-100
LowSA_MediumWL_blocked_berth1	Silent_drop_berth1	command none	invalid	-100
LowSA_MediumWL_blocked_berth1	Silent_drop_berth2	command none	LowSA_MediumWL_drop_berth2	10
LowSA_MediumWL_blocked_berth1	Silent_drop_berth3	command none	LowSA_MediumWL_drop_berth3	10-2=8
LowSA_MediumWL_blocked_berth2	Silent_drop_berth1	command none	LowSA_MediumWL_drop_berth1	10
LowSA_MediumWL_blocked_berth2	Silent_drop_berth2	command none	invalid	-100
LowSA_MediumWL_blocked_berth2	Silent_drop_berth3	command none	LowSA_MediumWL_drop_berth3	10-2=8
LowSA_MediumWL_blocked_berth3	Silent_drop_berth1	command none	LowSA_MediumWL_drop_berth1	10
LowSA_MediumWL_blocked_berth3	Silent_drop_berth2	command none	LowSA_MediumWL_drop_berth2	10-2=8
LowSA_MediumWL_blocked_berth3	Silent_drop_berth3	command none	invalid	-100
LowSA_HighWL_blocked_berth1	Silent_drop_berth1	command none	invalid	-100
LowSA_HighWL_blocked_berth1	Silent_drop_berth2	command none	LowSA_HighWL_drop_berth2	10
LowSA_HighWL_blocked_berth1	Silent_drop_berth3	command none	LowSA_HighWL_drop_berth3	10-2=8
LowSA_HighWL_blocked_berth2	Silent_drop_berth1	command none	LowSA_HighWL_drop_berth1	10
LowSA_HighWL_blocked_berth2	Silent_drop_berth2	command none	invalid	-100
LowSA_HighWL_blocked_berth2	Silent_drop_berth3	command none	LowSA_HighWL_drop_berth3	10-2=8
LowSA_HighWL_blocked_berth3	Silent_drop_berth1	command none	LowSA_HighWL_drop_berth1	10
LowSA_HighWL_blocked_berth3	Silent_drop_berth2	command none	LowSA_HighWL_drop_berth2	10-2=8
LowSA_HighWL_blocked_berth3	Silent_drop_berth3	command none	invalid	-100
HighSA_LowWL_blocked_berth1	Silent_drop_berth1	command none	invalid	-100
HighSA_LowWL_blocked_berth1	Silent_drop_berth2	command none	HighSA_LowWL_drop_berth2	10
HighSA_LowWL_blocked_berth1	Silent_drop_berth3	command none	HighSA_LowWL_drop_berth3	10-2=8
HighSA_LowWL_blocked_berth2	Silent_drop_berth1	command none	HighSA_LowWL_drop_berth1	10
HighSA_LowWL_blocked_berth2	Silent_drop_berth2	command none	invalid	-100
HighSA_LowWL_blocked_berth2	Silent_drop_berth3	command none	HighSA_LowWL_drop_berth3	10-2=8
HighSA_LowWL_blocked_berth3	Silent_drop_berth1	command none	HighSA_LowWL_drop_berth1	10
HighSA_LowWL_blocked_berth3	Silent_drop_berth2	command none	HighSA_LowWL_drop_berth2	10-2=8
HighSA_LowWL_blocked_berth3	Silent_drop_berth3	command none	invalid	-100
HighSA_MediumWL_blocked_berth1	Silent_drop_berth1	command none	invalid	-100
HighSA_MediumWL_blocked_berth1	Silent_drop_berth2	command none	HighSA_MediumWL_drop_berth2	10
HighSA_MediumWL_blocked_berth1	Silent_drop_berth3	command none	HighSA_MediumWL_drop_berth3	10-2=8
HighSA_MediumWL_blocked_berth2	Silent_drop_berth1	command none	HighSA_MediumWL_drop_berth1	10
HighSA_MediumWL_blocked_berth2	Silent_drop_berth2	command none	invalid	-100
HighSA_MediumWL_blocked_berth2	Silent_drop_berth3	command none	HighSA_MediumWL_drop_berth3	10-2=8
HighSA_MediumWL_blocked_berth3	Silent_drop_berth1	command none	HighSA_MediumWL_drop_berth1	10
HighSA_MediumWL_blocked_berth3	Silent_drop_berth2	command none	HighSA_MediumWL_drop_berth2	10-2=8
HighSA_MediumWL_blocked_berth3	Silent_drop_berth3	command none	invalid	-100
HighSA_HighWL_blocked_berth1	Silent_drop_berth1	command none	invalid	-100
HighSA_HighWL_blocked_berth1	Silent_drop_berth2	command none	HighSA_HighWL_drop_berth2	10
HighSA_HighWL_blocked_berth1	Silent_drop_berth3	command none	HighSA_HighWL_drop_berth3	10-2=8
HighSA_HighWL_blocked_berth2	Silent_drop_berth1	command none	HighSA_HighWL_drop_berth1	10
HighSA_HighWL_blocked_berth2	Silent_drop_berth2	command none	invalid	-100
HighSA_HighWL_blocked_berth2	Silent_drop_berth3	command none	HighSA_HighWL_drop_berth3	10-2=8
HighSA_HighWL_blocked_berth3	Silent_drop_berth1	command none	HighSA_HighWL_drop_berth1	10
HighSA_HighWL_blocked_berth3	Silent_drop_berth2	command none	HighSA_HighWL_drop_berth2	10-2=8
HighSA_HighWL_blocked_berth3	Silent_drop_berth3	command none	invalid	-100

Subtract – 1 on top of this reward for asking question in WH strategy –the robot actions depends on human intervention – that's why invalid states could occur if humans are not situationally aware and respond wrongly – this could occur in non-malfunction experiment as well – so not highlighted.

Start State	Action	Observation	End state	Approx Reward
LowSA_LowWL_blocked_berth1	wh drop	Command_wh_drop_berth1	Invalid	-100
LowSA_LowWL_blocked_berth1	wh drop	Command_wh_drop_berth2	LowSA_LowWL_drop_berth2	10
LowSA_LowWL_blocked_berth1	wh drop	Command_wh_drop_berth3	LowSA_LowWL_drop_berth3	10-2=8
LowSA_LowWL_blocked_berth2	wh drop	Command_wh_drop_berth1	LowSA_LowWL_drop_berth1	10
LowSA_LowWL_blocked_berth2	wh drop	Command_wh_drop_berth2	invalid	-100
LowSA_LowWL_blocked_berth2	wh drop	Command_wh_drop_berth3	LowSA_LowWL_drop_berth3	10-2=8
LowSA_LowWL_blocked_berth3	wh drop	Command_wh_drop_berth1	LowSA_LowWL_drop_berth1	10
LowSA_LowWL_blocked_berth3	wh drop	Command_wh_drop_berth2	LowSA_LowWL_drop_berth2	10-2=8
LowSA_LowWL_blocked_berth3	wh drop	Command_wh_drop_berth3	invalid	-100
LowSA_MediumWL_blocked_berth1	wh drop	Command_wh_drop_berth1	invalid	-100
LowSA_MediumWL_blocked_berth1	wh drop	Command_wh_drop_berth2	LowSA_MediumWL_drop_berth2	10
LowSA_MediumWL_blocked_berth1	wh drop	Command_wh_drop_berth3	LowSA_MediumWL_drop_berth3	10-2=8
LowSA_MediumWL_blocked_berth2	wh drop	Command_wh_drop_berth1	LowSA_MediumWL_drop_berth1	10
LowSA_MediumWL_blocked_berth2	wh drop	Command_wh_drop_berth2	invalid	-100
LowSA_MediumWL_blocked_berth2	wh drop	Command_wh_drop_berth3	LowSA_MediumWL_drop_berth3	10-2=8
LowSA_MediumWL_blocked_berth3	wh drop	Command_wh_drop_berth1	LowSA_MediumWL_drop_berth1	10
LowSA_MediumWL_blocked_berth3	wh drop	Command_wh_drop_berth2	LowSA_MediumWL_drop_berth2	10-2=8
LowSA_MediumWL_blocked_berth3	wh drop	Command_wh_drop_berth3	invalid	-100
LowSA_HighWL_blocked_berth1	wh drop	Command_wh_drop_berth1	invalid	-100
LowSA_HighWL_blocked_berth1	wh drop	Command_wh_drop_berth2	LowSA_HighWL_drop_berth2	10
LowSA_HighWL_blocked_berth1	wh drop	Command_wh_drop_berth3	LowSA_HighWL_drop_berth3	10-2=8
LowSA_HighWL_blocked_berth2	wh drop	Command_wh_drop_berth1	LowSA_HighWL_drop_berth1	10
LowSA_HighWL_blocked_berth2	wh drop	Command_wh_drop_berth2	invalid	-100
LowSA_HighWL_blocked_berth2	wh drop	Command_wh_drop_berth3	LowSA_HighWL_drop_berth3	10-2=8
LowSA_HighWL_blocked_berth3	wh drop	Command_wh_drop_berth1	LowSA_HighWL_drop_berth1	10
LowSA_HighWL_blocked_berth3	wh drop	Command_wh_drop_berth2	LowSA_HighWL_drop_berth2	10-2=8
LowSA_HighWL_blocked_berth3	wh drop	Command_wh_drop_berth3	invalid	-100
HighSA_LowWL_blocked_berth1	wh drop	Command_wh_drop_berth1	invalid	-100
HighSA_LowWL_blocked_berth1	wh drop	Command_wh_drop_berth2	HighSA_LowWL_drop_berth2	10
HighSA_LowWL_blocked_berth1	wh drop	Command_wh_drop_berth3	HighSA_LowWL_drop_berth3	10-2=8
HighSA_LowWL_blocked_berth2	wh drop	Command_wh_drop_berth1	HighSA_LowWL_drop_berth1	10
HighSA_LowWL_blocked_berth2	wh drop	Command_wh_drop_berth2	invalid	-100
HighSA_LowWL_blocked_berth2	wh drop	Command_wh_drop_berth3	HighSA_LowWL_drop_berth3	10-2=8
HighSA_LowWL_blocked_berth3	wh drop	Command_wh_drop_berth1	HighSA_LowWL_drop_berth1	10
HighSA_LowWL_blocked_berth3	wh drop	Command_wh_drop_berth2	HighSA_LowWL_drop_berth2	10-2=8
HighSA_LowWL_blocked_berth3	wh drop	Command_wh_drop_berth3	invalid	-100
HighSA_MediumWL_blocked_berth1	wh drop	Command_wh_drop_berth1	invalid	-100
HighSA_MediumWL_blocked_berth1	wh drop	Command_wh_drop_berth2	HighSA_MediumWL_drop_berth2	10
HighSA_MediumWL_blocked_berth1	wh drop	Command_wh_drop_berth3	HighSA_MediumWL_drop_berth3	10-2=8
HighSA_MediumWL_blocked_berth2	wh drop	Command_wh_drop_berth1	HighSA_MediumWL_drop_berth1	10
HighSA_MediumWL_blocked_berth2	wh drop	Command_wh_drop_berth2	invalid	-100
HighSA_MediumWL_blocked_berth2	wh drop	Command_wh_drop_berth3	HighSA_MediumWL_drop_berth3	10-2=8
HighSA_MediumWL_blocked_berth3	wh drop	Command_wh_drop_berth1	HighSA_MediumWL_drop_berth1	10
HighSA_MediumWL_blocked_berth3	wh drop	Command_wh_drop_berth2	HighSA_MediumWL_drop_berth2	10-2=8
HighSA_MediumWL_blocked_berth3	wh drop	Command_wh_drop_berth3	invalid	-100
HighSA_HighWL_blocked_berth1	wh drop	Command_wh_drop_berth1	invalid	-100
HighSA_HighWL_blocked_berth1	wh drop	Command_wh_drop_berth2	HighSA_HighWL_drop_berth2	10
HighSA_HighWL_blocked_berth1	wh drop	Command_wh_drop_berth3	HighSA_HighWL_drop_berth3	10-2=8
HighSA_HighWL_blocked_berth2	wh drop	Command_wh_drop_berth1	HighSA_HighWL_drop_berth1	10
HighSA_HighWL_blocked_berth2	wh drop	Command_wh_drop_berth2	invalid	-100
HighSA_HighWL_blocked_berth2	wh drop	Command_wh_drop_berth3	HighSA_HighWL_drop_berth3	10-2=8
HighSA_HighWL_blocked_berth3	wh drop	Command_wh_drop_berth1	HighSA_HighWL_drop_berth1	10
HighSA_HighWL_blocked_berth3	wh drop	Command_wh_drop_berth2	HighSA_HighWL_drop_berth2	10-2=8
HighSA_HighWL_blocked_berth3	wh drop	Command_wh_drop_berth3	invalid	-100

Yes and No communication Strategy – Same logic as Wh , - 1 on top of reward as communication strategy used in yes or no the berth no is specifically mentioned the communication strategy. The immediate next table shows what happens if the user reponds yes.

Start State	Action	Observation	End state	Approx Reward
LowSA_LowWL_blocked_berth1	Yes/no_drop_berth1	Command_yes_drop_berth1	Invalid	-100
LowSA_LowWL_blocked_berth1	Yes/no_drop_berth2	Command_yes_drop_berth2	LowSA_LowWL_drop_berth2	10
LowSA_LowWL_blocked_berth1	Yes/no_drop_berth3	Command_yes_drop_berth3	LowSA_LowWL_drop_berth3	10-2=8
LowSA_LowWL_blocked_berth2	Yes/no_drop_berth1	Command_yes_drop_berth1	LowSA_LowWL_drop_berth1	10
LowSA_LowWL_blocked_berth2	Yes/no_drop_berth2	Command_yes_drop_berth2	invalid	-100
LowSA_LowWL_blocked_berth2	Yes/no_drop_berth3	Command_yes_drop_berth3	LowSA_LowWL_drop_berth3	10-2=8
LowSA_LowWL_blocked_berth3	Yes/no_drop_berth1	Command_yes_drop_berth1	LowSA_LowWL_drop_berth1	10
LowSA_LowWL_blocked_berth3	Yes/no_drop_berth2	Command_yes_drop_berth2	LowSA_LowWL_drop_berth2	10-2=8
LowSA_LowWL_blocked_berth3	Yes/no_drop_berth3	Command_yes_drop_berth3	invalid	-100
LowSA_MediumWL_blocked_berth1	Yes/no_drop_berth1	Command_yes_drop_berth1	invalid	-100
LowSA_MediumWL_blocked_berth1	Yes/no_drop_berth2	Command_yes_drop_berth2	LowSA_MediumWL_drop_berth2	10
LowSA_MediumWL_blocked_berth1	Yes/no_drop_berth3	Command_yes_drop_berth3	LowSA_MediumWL_drop_berth3	10-2=8
LowSA_MediumWL_blocked_berth2	Yes/no_drop_berth1	Command_yes_drop_berth1	LowSA_MediumWL_drop_berth1	10
LowSA_MediumWL_blocked_berth2	Yes/no_drop_berth2	Command_yes_drop_berth2	invalid	-100
LowSA_MediumWL_blocked_berth2	Yes/no_drop_berth3	Command_yes_drop_berth3	LowSA_MediumWL_drop_berth3	10-2=8
LowSA_MediumWL_blocked_berth3	Yes/no_drop_berth1	Command_yes_drop_berth1	LowSA_MediumWL_drop_berth1	10
LowSA_MediumWL_blocked_berth3	Yes/no_drop_berth2	Command_yes_drop_berth2	LowSA_MediumWL_drop_berth2	10-2=8
LowSA_MediumWL_blocked_berth3	Yes/no_drop_berth3	Command_yes_drop_berth3	invalid	-100
LowSA_HighWL_blocked_berth1	Yes/no_drop_berth1	Command_yes_drop_berth1	invalid	-100
LowSA_HighWL_blocked_berth1	Yes/no_drop_berth2	Command_yes_drop_berth2	LowSA_HighWL_drop_berth2	10
LowSA_HighWL_blocked_berth1	Yes/no_drop_berth3	Command_yes_drop_berth3	LowSA_HighWL_drop_berth3	10-2=8
LowSA_HighWL_blocked_berth2	Yes/no_drop_berth1	Command_yes_drop_berth1	LowSA_HighWL_drop_berth1	10
LowSA_HighWL_blocked_berth2	Yes/no_drop_berth2	Command_yes_drop_berth2	invalid	-100
LowSA_HighWL_blocked_berth2	Yes/no_drop_berth3	Command_yes_drop_berth3	LowSA_HighWL_drop_berth3	10-2=8
LowSA_HighWL_blocked_berth3	Yes/no_drop_berth1	Command_yes_drop_berth1	LowSA_HighWL_drop_berth1	10
LowSA_HighWL_blocked_berth3	Yes/no_drop_berth2	Command_yes_drop_berth2	LowSA_HighWL_drop_berth2	10-2=8
LowSA_HighWL_blocked_berth3	Yes/no_drop_berth3	Command_yes_drop_berth3	invalid	-100
HighSA_LowWL_blocked_berth1	Yes/no_drop_berth1	Command_yes_drop_berth1	invalid	-100
HighSA_LowWL_blocked_berth1	Yes/no_drop_berth2	Command_yes_drop_berth2	HighSA_LowWL_drop_berth2	10
HighSA_LowWL_blocked_berth1	Yes/no_drop_berth3	Command_yes_drop_berth3	HighSA_LowWL_drop_berth3	10-2=8
HighSA_LowWL_blocked_berth2	Yes/no_drop_berth1	Command_yes_drop_berth1	HighSA_LowWL_drop_berth1	10
HighSA_LowWL_blocked_berth2	Yes/no_drop_berth2	Command_yes_drop_berth2	invalid	-100
HighSA_LowWL_blocked_berth2	Yes/no_drop_berth3	Command_yes_drop_berth3	HighSA_LowWL_drop_berth3	10-2=8
HighSA_LowWL_blocked_berth3	Yes/no_drop_berth1	Command_yes_drop_berth1	HighSA_LowWL_drop_berth1	10
HighSA_LowWL_blocked_berth3	Yes/no_drop_berth2	Command_yes_drop_berth2	HighSA_LowWL_drop_berth2	10-2=8
HighSA_LowWL_blocked_berth3	Yes/no_drop_berth3	Command_yes_drop_berth3	invalid	-100
HighSA_MediumWL_blocked_berth1	Yes/no_drop_berth1	Command_yes_drop_berth1	invalid	-100
HighSA_MediumWL_blocked_berth1	Yes/no_drop_berth2	Command_yes_drop_berth2	HighSA_MediumWL_drop_berth2	10
HighSA_MediumWL_blocked_berth1	Yes/no_drop_berth3	Command_yes_drop_berth3	HighSA_MediumWL_drop_berth3	10-2=8
HighSA_MediumWL_blocked_berth2	Yes/no_drop_berth1	Command_yes_drop_berth1	HighSA_MediumWL_drop_berth1	10
HighSA_MediumWL_blocked_berth2	Yes/no_drop_berth2	Command_yes_drop_berth2	invalid	-100
HighSA_MediumWL_blocked_berth2	Yes/no_drop_berth3	Command_yes_drop_berth3	HighSA_MediumWL_drop_berth3	10-2=8
HighSA_MediumWL_blocked_berth3	Yes/no_drop_berth1	Command_yes_drop_berth1	HighSA_MediumWL_drop_berth1	10
HighSA_MediumWL_blocked_berth3	Yes/no_drop_berth2	Command_yes_drop_berth2	HighSA_MediumWL_drop_berth2	10-2=8
HighSA_MediumWL_blocked_berth3	Yes/no_drop_berth3	Command_yes_drop_berth3	invalid	-100
HighSA_HighWL_blocked_berth1	Yes/no_drop_berth1	Command_yes_drop_berth1	invalid	-100
HighSA_HighWL_blocked_berth1	Yes/no_drop_berth2	Command_yes_drop_berth2	HighSA_HighWL_drop_berth2	10
HighSA_HighWL_blocked_berth1	Yes/no_drop_berth3	Command_yes_drop_berth3	HighSA_HighWL_drop_berth3	10-2=8
HighSA_HighWL_blocked_berth2	Yes/no_drop_berth1	Command_yes_drop_berth1	HighSA_HighWL_drop_berth1	10
HighSA_HighWL_blocked_berth2	Yes/no_drop_berth2	Command_yes_drop_berth2	invalid	-100
HighSA_HighWL_blocked_berth2	Yes/no_drop_berth3	Command_yes_drop_berth3	HighSA_HighWL_drop_berth3	10-2=8
HighSA_HighWL_blocked_berth3	Yes/no_drop_berth1	Command_yes_drop_berth1	HighSA_HighWL_drop_berth1	10
HighSA_HighWL_blocked_berth3	Yes/no_drop_berth2	Command_yes_drop_berth2	HighSA_HighWL_drop_berth2	10-2=8
HighSA_HighWL_blocked_berth3	Yes/no_drop_berth3	Command_yes_drop_berth3	invalid	-100

If no is used in yes/no communication is used, consecutive pair of yes/no and wh forms a communication strategy

Start State	Action	Observation	End state	Approx Reward
LowSA_LowWL_blocked_berth1	Yes/no_drop_berth1	Command_no	wait	
wait	wh drop	Command_wh_drop_berth1	Invalid	-100
LowSA_LowWL_blocked_berth1	Yes/no_drop_berth2	Command_no	wait	
wait	wh drop	Command_wh_drop_berth2	LowSA_LowWL_drop_berth2	10
LowSA_LowWL_blocked_berth1	Yes/no_drop_berth3	Command_no	wait	
wait	wh drop	Command_wh_drop_berth3	LowSA_LowWL_drop_berth3	10-2=8
LowSA_LowWL_blocked_berth2	Yes/no_drop_berth1	Command_no	wait	
wait	wh drop	Command_wh_drop_berth1	LowSA_LowWL_drop_berth1	10
LowSA_LowWL_blocked_berth2	Yes/no_drop_berth2	Command_no	wait	
wait	wh drop	Command_wh_drop_berth2	invalid	-100
LowSA_LowWL_blocked_berth2	Yes/no_drop_berth3	Command_no	wait	
wait	wh drop	Command_wh_drop_berth3	LowSA_LowWL_drop_berth3	10-2=8
LowSA_LowWL_blocked_berth3	Yes/no_drop_berth1	Command_no	wait	
wait	wh drop	Command_wh_drop_berth1	LowSA_LowWL_drop_berth1	10
LowSA_LowWL_blocked_berth3	Yes/no_drop_berth2	Command_no	wait	
wait	wh drop	Command_wh_drop_berth2	LowSA_LowWL_drop_berth2	10-2=8
LowSA_LowWL_blocked_berth3	Yes/no_drop_berth3	Command_no	wait	
wait	wh drop	Command_wh_drop_berth3	invalid	-100
LowSA_MediumWL_blocked_berth1	Yes/no_drop_berth1	Command_no	wait	
wait	wh drop	Command_wh_drop_berth1	invalid	-100
LowSA_MediumWL_blocked_berth1	Yes/no_drop_berth2	Command_no	wait	
wait	wh drop	Command_wh_drop_berth2	LowSA_MediumWL_drop_berth2	10
LowSA_MediumWL_blocked_berth1	Yes/no_drop_berth3	Command_no	wait	
wait	wh drop	Command_wh_drop_berth3	LowSA_MediumWL_drop_berth3	10-2=8
LowSA_MediumWL_blocked_berth2	Yes/no_drop_berth1	Command_no	wait	
wait	wh drop	Command_wh_drop_berth1	LowSA_MediumWL_drop_berth1	10
LowSA_MediumWL_blocked_berth2	Yes/no_drop_berth2	Command_no	wait	
wait	wh drop	Command_wh_drop_berth2	invalid	-100
LowSA_MediumWL_blocked_berth2	Yes/no_drop_berth3	Command_no	wait	
wait	wh drop	Command_wh_drop_berth3	LowSA_MediumWL_drop_berth3	10-2=8
LowSA_MediumWL_blocked_berth3	Yes/no_drop_berth1	Command_no	wait	
wait	wh drop	Command_wh_drop_berth1	LowSA_MediumWL_drop_berth1	10
LowSA_MediumWL_blocked_berth3	Yes/no_drop_berth2	Command_no	wait	
wait	wh drop	Command_wh_drop_berth2	LowSA_MediumWL_drop_berth2	10-2=8
LowSA_MediumWL_blocked_berth3	Yes/no_drop_berth3	Command_no	wait	
wait	wh drop	Command_wh_drop_berth3	invalid	-100
LowSA_HighWL_blocked_berth1	Yes/no_drop_berth1	Command_no	wait	
wait	wh drop	Command_wh_drop_berth1	invalid	-100
LowSA_HighWL_blocked_berth1	Yes/no_drop_berth2	Command_no	wait	
wait	wh drop	Command_wh_drop_berth2	LowSA_HighWL_drop_berth2	10
LowSA_HighWL_blocked_berth1	Yes/no_drop_berth3	Command_no	wait	
wait	wh drop	Command_wh_drop_berth3	LowSA_HighWL_drop_berth3	10-2=8
LowSA_HighWL_blocked_berth2	Yes/no_drop_berth1	Command_no	wait	
wait	wh drop	Command_wh_drop_berth1	LowSA_HighWL_drop_berth1	10
LowSA_HighWL_blocked_berth2	Yes/no_drop_berth2	Command_no	wait	
wait	wh drop	Command_wh_drop_berth2	invalid	-100
LowSA_HighWL_blocked_berth2	Yes/no_drop_berth3	Command_no	wait	
wait	wh drop	Command_wh_drop_berth3	LowSA_HighWL_drop_berth3	10-2=8
LowSA_HighWL_blocked_berth3	Yes/no_drop_berth1	Command_no	wait	
wait	wh drop	Command_wh_drop_berth1	LowSA_HighWL_drop_berth1	10
LowSA_HighWL_blocked_berth3	Yes/no_drop_berth2	Command_no	wait	
wait	wh drop	Command_wh_drop_berth2	LowSA_HighWL_drop_berth2	10-2=8
LowSA_HighWL_blocked_berth3	Yes/no_drop_berth3	Command_no	wait	
wait	wh drop	Command_wh_drop_berth3	invalid	-100

Adding the POMDP below :

```
STATES = (
   ("wl", (0, 1, 2)),  # workload: low, medium, high
   ("berth1", ("blocked")), # to be combined with W and SA
   ("berth2", ("blocked")),  # to be combined with W and SA
   ("berth3", ("blocked")),  # to be combined with W and SA
  ("drop_berth1")),  # to be combined with W and SA
  ( "drop_berth2")),  # to be combined with W and SA
  ( "drop_berth3" )),  # to be combined with W and SA
  ("invalid"),
  ("SA", (0,1)), # high, low
  (wait))
PHYSICAL_ACTIONS = ( //silence strategy
     "silent_drop_berth1",
    "silent_drop_berth3",
     "silent_drop_berth2")
COMM_ACTIONS = (
    "comm_yesNoQuestion_drop_berth1", // if no ask wh
     "comm_yesNoQuestion_drop_berth2", // if no ask wh
     "comm_yesNoQuestion_drop_berth3", // if no ask wh
     "comm_whQuestion)

ACTIONS =  PHYSICAL_ACTIONS + COMM_ACTIONS

OPERATOR_COMMAND_OBSERVATIONS = (
      "No_ob_comm", // asking questions
     "command none", // silent
     "Command_drop_berth1", //yes_wh
     "Command_drop_berth2", //yes_wh
     "Command_drop_berth3", //yes_wh)
```

REWARD_based on correctness of communication = (

"Success", // robot no malfunction in communication +10

"Failure", // robot malfunction in communication - 100

“Cost”, → asking for help, not using the nearest berth)