

# Assignment for the course

## Automated Planning Theory and Practice

### Academic Year 2025-2026

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## 1 Introduction

The aim of this assignment is twofold. First to model planning problems in PDDL/HDDL to then invoke a state of the art planner as those provided by `planutils` [5] or manually compiled (e.g., `fast` downward [2], or `optic` [1]). Second, to see how a temporal planning model could be integrated within a robotic setting leveraging the `PlanSys2` [4] infrastructure discussed in the lectures and available at [https://github.com/PlanSys2/ros2\\_planning\\_system](https://github.com/PlanSys2/ros2_planning_system).

This assignment can be performed alone or in group of *at most two* students.

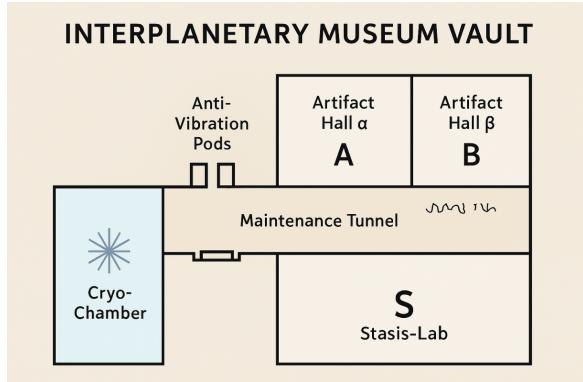


Figure 1: Automated Planning and Scheduling - Assignment 2025-2026

This year, I propose two scenarios. The first is inspired by the *space* domain. The second is *free choice*, namely the student is asked to propose a scenario that is not related to the space domain. The student is free to choose the scenario, and she/he must provide a brief description of the scenario, the initial state, the goal, and the actions that can be performed. The student must also provide a brief justification of the choice of the scenario.

## 2 Autonomous Preservation Robots in an Interplanetary Museum Vault scenario

On Mars' largest research outpost, a subterranean structure — The Interplanetary Museum Vault (IMV) — stores frag-

ile artifacts from various space missions, asteroid excavations, and ancient Martian geology samples.

Due to a sudden micro-quakes streak, pressure fluctuations threaten several high-value items. The autonomous robotic curators must execute a series of stabilization and relocation tasks while avoiding unstable corridors and using limited cryogenic and anti-vibration resources.

The vault is divided into zones:

- **Cryo-Chamber:** Maintains sub-zero temperatures for temperature-sensitive artifacts.
- **Anti-Vibration Pods:** Specialized zones that dampen vibrations, crucial for transporting delicate items (only 2 pods available).
- **Artifact Halls:** Two main halls ( $\alpha$  and  $\beta$ ) where artifacts are displayed. Hall  $\beta$  is unstable during certain periods due to seismic activity, while Hall  $\alpha$  remains stable.
- **Maintenance Tunnel:** A low-pressure area requiring the robotic curators to activate their sealing mode for safe passage.
- **Stasis-Lab:** The final safe destination for all artifacts, equipped with advanced preservation technology.

The robotic curators have the following goals:

- Retrieve Artifacts from Artifact Hall  $\beta$  (only accessible outside seismic windows).
- Place retrieved artifacts into an Anti-Vibration Pod before transporting them.
- Transfer artifacts Artifact Hall  $\alpha$  to the Cryo-Chamber, ensuring their temperature never rises above a threshold (requires cooling them).
- Relocate the Martian Core Samples from the Cryo-Chamber to the Stasis-Lab.

The robotic curators must navigate the vault, managing their resources and ensuring the safety of all artifacts while adapting to the dynamic environment caused by seismic activity.

### 2.1 The Problems

The assignment is structured in 5 sub problems to be solved in sequence where the second builds on the first, both the third and the fourth build on the second, the fifth builds on the fourth.

#### 2.1.1 Problem 1

##### Initial condition

- Initially all the artifacts are positioned in the rooms as discussed above.
- There is a single robotic curator to move artifacts, initially located at the entrance of the vault.
- The robotic curator can move between the different locations (rooms) of the vault, and can carry one artifact at a time.

There are no particular restrictions on the number of artifacts available, and constraints. The problem considers several design modeling choices left unspecified and that each student shall consider and specify in her/his solution.

**Goal** The goal should be that the artifacts are moved to their respective destinations, following the constraints discussed above.

### 2.1.2 Problem 2

We leverage the scenario in Section 2.1.1 with the following extensions, where we will have to consider an alternative way of moving artifacts (e.g., robotic curators with different capabilities or drones), and the fact that the robotic agents are allowed to have maximum capacity.

It might be the case additional actions, or modifications of the previously defined actions are needed to model loading/unloading/moving of the artifacts on the robotic curator (one can either keep previous actions and add new ones to e.g., consider the capacity of the robotic curator, and the kind of robotic curator).

The initial condition and the goal are the same as the problem discussed in Section 2.1.1.

### 2.1.3 Problem 3

We leverage the scenario in Section 2.1.2, but in this case we need to address the problem with hierarchical task networks (HTN). To this extent, it is suggested to keep the same actions as per the solution proposed for Problem 2.1.2, the same initial condition and the same goal (encoded as an HTN). However, here the candidate shall introduce :tasks and :methods following approaches similar to those discussed in the Lab session on HTN.

### 2.1.4 Problem 4

We leverage the scenario in Section 2.1.2 with the following extensions.

- Convert the domain defined in Section 2.1.2 to use durative actions. Choose arbitrary (but reasonable durations) for the different actions.
- Consider the possibility to have actions to be executed in parallel when this would be possible in reality. For example, a robotic curator cannot pick up several artifacts at the same time, or pick up an artifact and if it is a drone fly to a destination at the same time.

The initial condition and the goal are the same as the problem discussed in Section 2.1.2.

### 2.1.5 Problem 5

The final problem consists in implementing within the PlanSys2 the last problem resulting as outcome of Section 2.1.4 using fake actions as discussed in the tutorials of PlanSys2 available at [3]. To facilitate the executions, if needed the candidate can enforce that no actions execute in parallel.

## 3 Free choice scenario

For the free choice scenario, the student is asked to propose a scenario different from the one proposed in the space domain. The student is free to choose the scenario, and she/he must provide a brief description of the scenario, the initial state, the goal, and the actions that can be performed. The student must also provide a brief justification of the choice of the scenario. The scenario must be complex enough to require the use of HTN, and must follow the same structure of the space scenario (i.e. it must be composed of steps that build on each other), and in the last step it must be shown a simple deployment in PlanSys2.

## 4 Deliverables

The deliverable shall consist of a unique archive containing at least the following contents:

- The PDDL/HDDL files (domain and problems) for each of the problems discussed in Sections 2.1.1, 2.1.2, 2.1.3, and 2.1.4 and similar contents for the free choice scenario, possibly organized in folders. All the PDDL/HDDL files shall be valid ones, and shall be parsable correctly by at least one planner (it shall be specified which one, and discussed why the planner has been chosen). The options used to run the chosen planner shall be specified.
- A folder containing all the code to execute the PlanSys2 problem as discussed in Section 2.1.5 or of the equivalent for the free choice scenario.
- A professional report in PDF describing: (i) a brief description summarizing the understanding of the problems for the health care scenario, or for the free choice scenario a description of the scenario, the initial state, the goal, and the actions that can be performed, and a brief justification of the choice of the scenario with assumptions if any; (ii) the approach followed, justifying and documenting all the design choices (e.g., predicates, actions, ...); (iii) possible additional assumptions (for the part left under-specified), and in case of deviation from the specification in this document a clear justification. Finally, the document shall include evidence of the attempts to solve the PDDL problems formulated, and running the final version within PlanSys2 (in form of screenshots and/or output generated by the planner).
  - The report shall also discuss the content of the archive and how it has been organized.
  - The report shall also contain a critical discussion of the results obtained.

- It would be appreciated experimenting with different solvers and/or options (e.g., different heuristics), discuss possible differences in the generated solutions, and also some scalability analysis (e.g., considering different initial states, size of the problem, number of agents, number of locations).

The submission shall be performed only through the web form available at the following URL:

## Submission Form

<https://forms.gle/u94MEuBblwiBqdke7>

## References

- [1] J. Benton, Amanda Jane Coles, and Andrew Coles. Temporal planning with preferences and time-dependent continuous costs. In Lee McCluskey, Brian Charles Williams, José Reinaldo Silva, and Blai Bonet, editors, *Proceedings of the Twenty-Second International Conference on Automated Planning and Scheduling, ICAPS 2012, Atibaia, São Paulo, Brazil, June 25-19, 2012*. AAAI, 2012. URL <http://www.aaai.org/ocs/index.php/ICAPS/ICAPS12/paper/view/4699>. (page 1)
- [2] Malte Helmert. The fast downward planning system. *J. Artif. Intell. Res.*, 26:191–246, 2006. (page 1)
- [3] Francisco Martín and colleagues. PlanSys2 Tutorials, 2022. <https://plansys2.github.io/tutorials/index.html>. (page 2)
- [4] Francisco Martín, Jonatan Ginés, Francisco J. Rodríguez, and Vicente Matellán. PlanSys2: A Planning System Framework for ROS2. In *IEEE/RSJ International Conference on Intelligent Robots and Systems, IROS 2021, Prague, Czech Republic, September 27 - October 1, 2021*. IEEE, 2021. (page 1)
- [5] Cristian Muise and other contributors. PLANUTILS, 2021. General library for setting up linux-based environments for developing, running, and evaluating planners. <https://github.com/AI-Planning/planutils>. (page 1)