Part 3: Automated Planning problem description

Heriot-Watt Underwater has decided to continue its exploration activities in the sea. Mission operations will be controlled by plans generated using an automated planner that will direct the activities of personnel and underwater vehicles. The area of operation is divided into a series of grid-based **locations** involving land and water. A command centre, which acts as a base of operations, is in one of the water locations near the land. Several types of **personnel** serve at the command centre, including engineers, scientists, and pilots. The main activities are performed by advanced **subs**, which can travel underwater and perform various types of exploration and construction tasks. All personnel and subs initially begin at the command centre. Some of the operations of the underwater mission are described in the following list (which isn't exhaustive):

1. Each location in the area of operation can be either land, shallow water, or deep water.
2. A sub can only move in shallow or deep water and must have a pilot on board in order to move. A sub can only move to an adjacent location from its current location (i.e., it may take multiple moves to reach distant locations).
3. Subs are big enough to carry two people at a time.
4. Subs can carry at most one construction kit at a time: a structure kit or an energy cable kit. Kits can be loaded or unloaded to/from subs by engineers at the command centre.
5. A sub can perform two types of underwater scans. A sub can perform a subsea survey of a location, to make sure the location is safe for construction. A sub can also perform a more intensive research scan of a location, to gather data for further analysis. A scientist must be on board the sub to perform a scan and only one type of scan can be performed at a time.
6. A tidal power generator can be constructed by a sub provided the location has been surveyed and an engineer is on the sub. A tidal power generator can only be built in shallow water in a location adjacent to land. The sub must be carrying a structure kit which is used up by constructing the power generator.
7. An offshore energy cable can be installed by a sub in a water location (deep or shallow) provided the location has been surveyed and an engineer is on the sub. An energy cable can only be installed in a location provided the location is adjacent to a tidal power generator or another energy cable. The sub must also be carrying an energy cable kit, but the kit can be reused any number of times.
8. An underwater research base can be constructed by two subs operating in the same deep water location. The location must have been surveyed and both subs must have engineers on board. An offshore energy cable must also be in the location before the research base can be built. Each sub must also be carrying a structure kit which is used up by constructing the research base.
9. Some locations of shallow and deep water are marine protected areas. Subs are permitted to travel through marine protected areas, but no construction or installation of offshore energy cables is permitted in a marine protected area.
10. Personnel can move between the command centre and a sub, or an underwater research base and a sub, provided the command centre/research base and sub are in the same location.
11. The results of a research scan can be transferred from a sub into the computer system of an underwater research base if the sub is at the same location as the base. The results of a research scan can be analysed by a scientist at an underwater research base if the results have been transferred to the base computers.
12. A sub has a protective energy shield that can be turn on or off by the pilot.
13. Several locations are home to a kraken. If a sub passes through a location with a kraken without having its energy shield on, then the sub will be destroyed by the kraken.
14. If two underwater research bases are operational then a special sonar array can be turned on by an engineer at one of the bases. The sonar array confuses any kraken, allowing subs to pass through a location with a kraken, even if their energy shield is turned off.
15. All personnel, subs, and kits start at the command centre. The command centre must be situated in a water location adjacent to a land location. There are a finite number of personnel, subs, and kits. No tidal power generators, offshore energy cables, or underwater research bases are initially built/installed. At least one location must contain a kraken and at least one location must be a marine protected area.

At the start of operations, the command centre is given a series of missions to complete that involve setting up structures and analysing particular locations in the area of operation.

What to do: all students

1. **PDDL implementation:** You must model the underwater exploration domain in PDDL by defining the properties, objects, and actions that are needed to describe the domain. Note that the planning domain is described at an abstract level and is somewhat incomplete, with certain pieces of information missing. You must make design decisions as to how you will represent the knowledge and actions necessary to encode this scenario as a planning problem. Some requirements are more difficult than others. It is strongly recommended that you try to implement the domain incrementally, ensuring that some parts of the domain work correctly before moving on to others. Use the example domains from the PDDL lectures as a starting point for your solutions. You may also find that the planning time increases as you add more complexity. You may have to consider whether an alternative knowledge representation leads to a better solution. You may use the planning tools available at http://editor.planning.domains/, the Fast Forward (FF) planner, or the Fast Downward planner. You should ensure that your solution works with one of these planners. Note that the performance of certain planners may outperform that of the web-based planner. **Do not use any features of PDDL that we have not covered in the course**. Make sure you test your solution on a series of different problem scenarios. Include comments in your PDDL files to describe important sections of your code. **You do not need PDDL features that we have not covered in the course.**

2. **PDDL report:** Write a short report (maximum 2 pages) briefly discussing how you structured your domain. Show the different types of locations in your domain and the location of the command centre. Also list in your report the particular problem instances you have included in your code and what planner you have used to test your domain/problems. The report will be used by the markers to help understand your code.

What to do: 1-year Edinburgh postgraduate students and all Dubai postgraduate students (full time and part time)

In addition to the above instructions for all students, 1-year Edinburgh postgraduate students and all Dubai postgraduate students (full time and part time) should design an additional feature in PDDL to add to the domain (e.g., new personnel that can perform some task, a new activity, etc.) that isn't included in the above domain description. Add this feature to your domain and test it. Your new features should not simplify or remove any of the existing requirements. Include a description of the additional feature in your report (maximum 1 extra page).

What to hand in: all students

- **PDDL source files:** Submit your PDDL source files consisting of **a single domain file and at least 4 different problem files**. Make sure your source files have comments describing the properties and actions you've defined. Your solution should illustrate the different scenarios that are supported by your domain. You should aim for comprehensive scenarios that support multiple missions in each problem file. Your source files will be checked for plagiarism and tested to see if they are operational. For 1-year Edinburgh postgraduate students and all Dubai postgraduate students (full time and part time): one of the problem files must test your additional feature.

- **PDDL report:** Submit your report as a PDF file. Your report will be checked for plagiarism.

Declaration of Authorship: Students are also required to sign and include a standard declaration of authorship with each submission. This is a mandatory part of the assessment submission. Links to the standard declaration can be found on the Canvas site for F29AI.