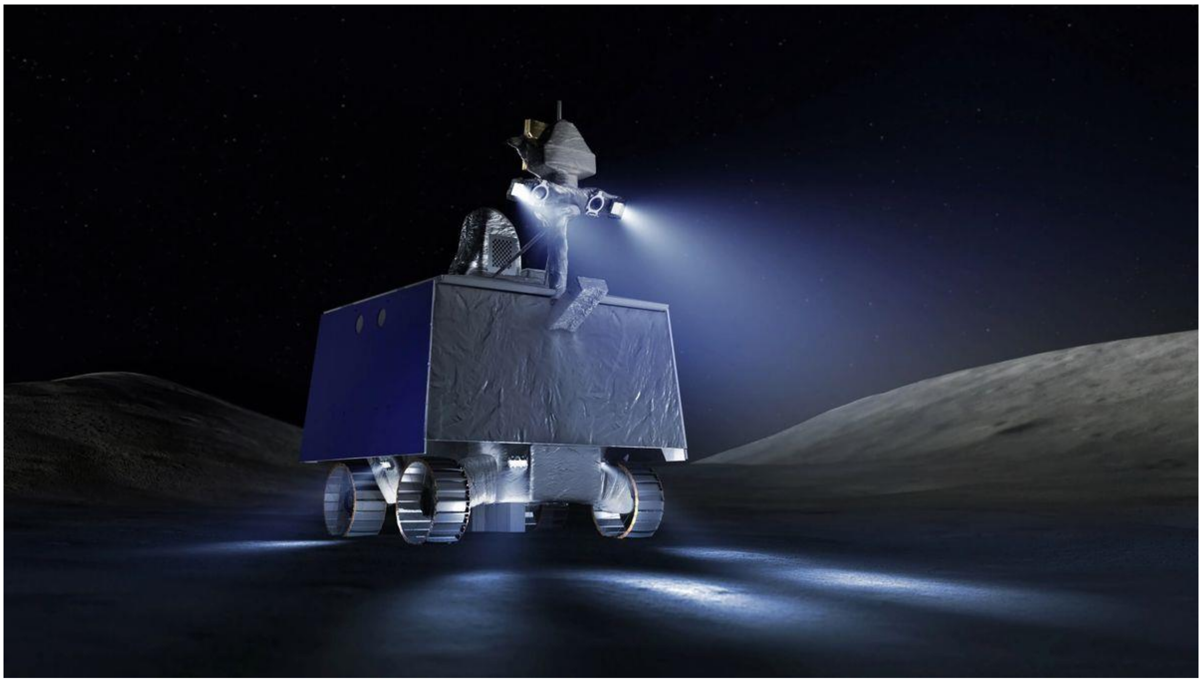
COMPLEX CYBER-PHYSICAL SYSTEMS DESIGN

DESIGN A TELEROBOTIC EXPLORATION ROVER

CONTEXT



Future moon rovers could be teleoperated from Earth. (Image credit: NASA/Daniel Rutter)

"Teleoperated rovers could soon be working on the moon, with human controllers on Earth manipulating the rovers' tools virtually, allowing for greater dexterity when taking samples, digging or assembling.."[1]

We will design a small demonstrator inspired by the needs of a real robot as described above. The system consists of the following components:

- A controller running a real-time OS.
- A light Sensor distinguishes between light and dark, as well as determine the light intensity in a room or the light intensity of different colors.
- An ultrasonic sensor able to detect an object and measure its proximity in centimeters.
- Three servomotors: the motor has a built-in rotation sensor measuring speed and distance. Several motors can be aligned to drive at the same speed. The actuator can rotate forward and backward

[1] https://www.space.com/moon-mars-robots-remote-control-technology

Case study description and objectives

On-orbit Remote Operated Vehicles (ROVs) appear as a very promising solution to space exploration. Indeed, remote control of rovers from Earth hampers real-time or reactive control due to the latency.

However, ROVs cannot be repaired or assisted physically because they are not accessible after deployment. Therefore, they must have a reliable operation. ROVs are complex systems that must operate at real-time with a safe operation, in a complex environment.

Model-driven engineering proposes modern approaches to software and system design that helps engineers to build complex systems with more reliable and efficient techniques than traditional techniques.

We propose to evaluate model-driven engineering development techniques for the design and analysis of ROVs. The objective is to prototype a ROV to evaluate the benefits and limitations of model-based techniques.

Prototype

Since the point is to evaluate the model-driven engineering techniques, the prototype will be built with already existing well-known components. The system is a cyber-physical system (combination of hardware and software).

Preliminary requirements

Following are a few preliminary requirements:

- Rovers can be either directly operated by in-orbit astronauts or commanded by a program from an orbit station for routine tasks.
- Analysis of the ground shows that it is mostly sand and rocks: the rovers could bog down in the sand or bump rocks. Whatever the commands from the program or the astronaut, the rover must have a “smart and reliable motion”.
- The rover should be built on a generic platform that can be programmed for specific exploration tasks.
- The system is a four wheels rover, two of them are powered by a servomotor
- The rover must be able to steer left and right (servomotor)
- The rover must be able to go forward and backward.
- The rover sends operation errors to the remote base.
- Operations and errors must be logged and accessible at any time.
- The minimal and maximal power consumption (stored in an attribute of a constraint definition) must be greater than 0.
- The actual power consumption shall be less than or equal to the maximal power consumption.
- The actual power consumption shall be greater than or equal to the minimal power consumption.
- Power consumption for the steering of the Rover must be 60W +/- 5%.
- Left steering angle must be between -1/3pi and 1/3pi.

Your Tasks

- Create a requirements diagram in SysML v2. Take into account calculations with respect to power consumption and steering angle
- Create a hierarchical decomposition of the system using part definitions and part usages.
- Include a behavior specification including actions and state-machine