Systems Design Exercise

May 2015

This is a design exercise for a Systems Designer role. Please spend no more than the time suggested. Present your design in whatever form you feel is best. Feel free to identify your assumptions and discuss the constraints you chose.

Suggested Work Time:	12 hours
Calendar Time:	3 days

Design Scenario

NASA is sending a new rover to search the surface of Ganymede. The goal of the mission is to collect data on a radioactive volcanic rock that was spotted from orbit. The robot landed somewhere near this object.

You need to design the control and interaction systems for this robot. The robot can navigate the moon's surface and is equipped with a camera, a depth sensor, and an arm that can deploy a Geiger counter. The remote driver of the robot will use a virtual reality headset that will recreate the environment that the robot sees. The driver will be able to walk freely anywhere in the virtual space and see any data that the robot's sensors can see. Assume the virtual reality headset can track the driver's position, the target they are looking at, and gestures they make with their hands. The headset can also understand discreet voice commands. At no time will the driver be able to use a keyboard, mouse, or any hand-held controller.

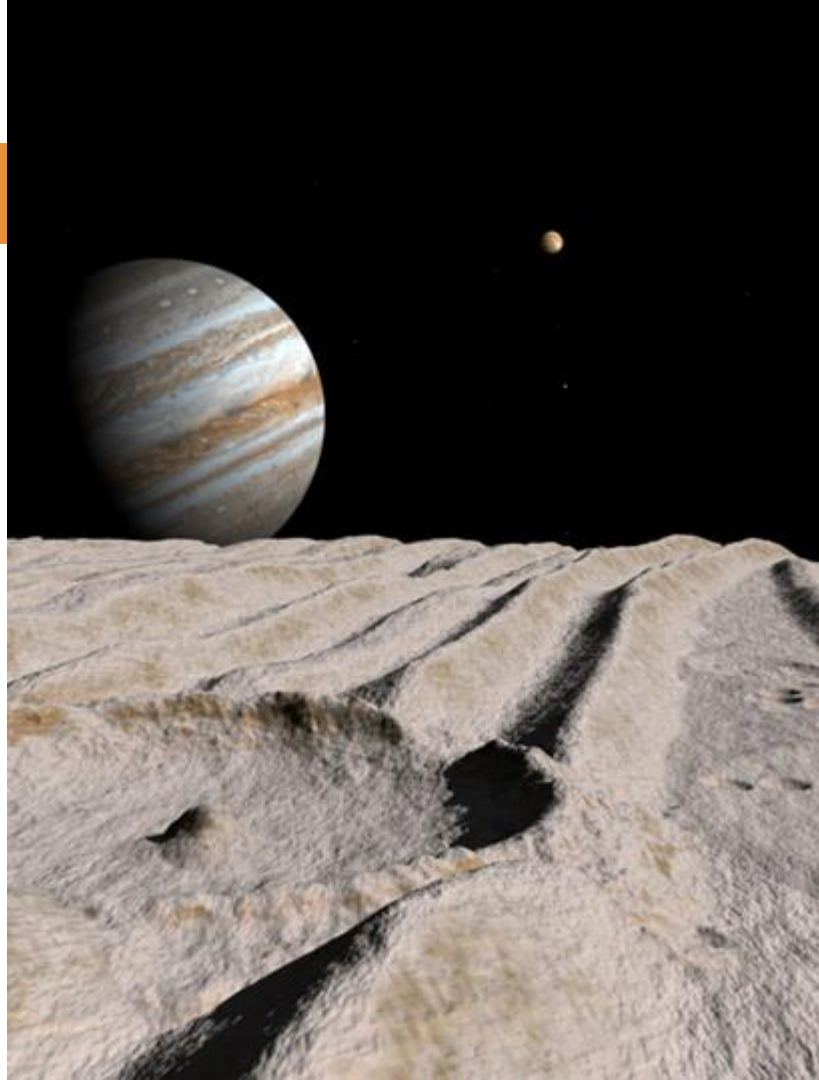
Ganymede Explorer

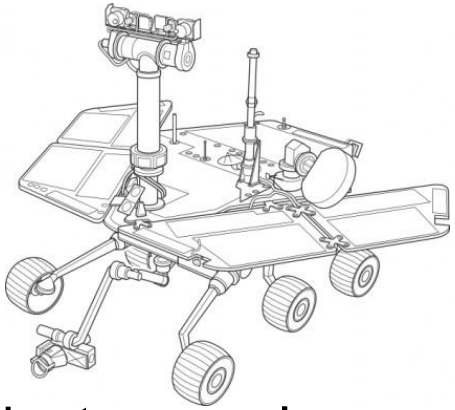
Remote Driver Training Overview

Laura Lantz | Systems Designer | 5.28.2015

Mission:

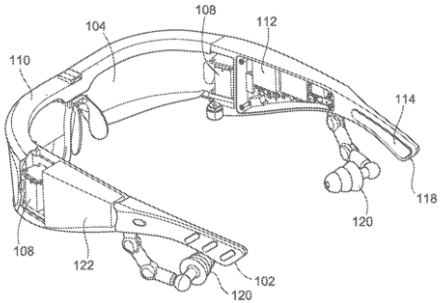
Collect data on a **radioactive volcanic rock** on the surface of Ganymede.





Robot

- can navigate moon’s surface
- has camera
- has depth sensor
- has arm that can deploy Geiger counter

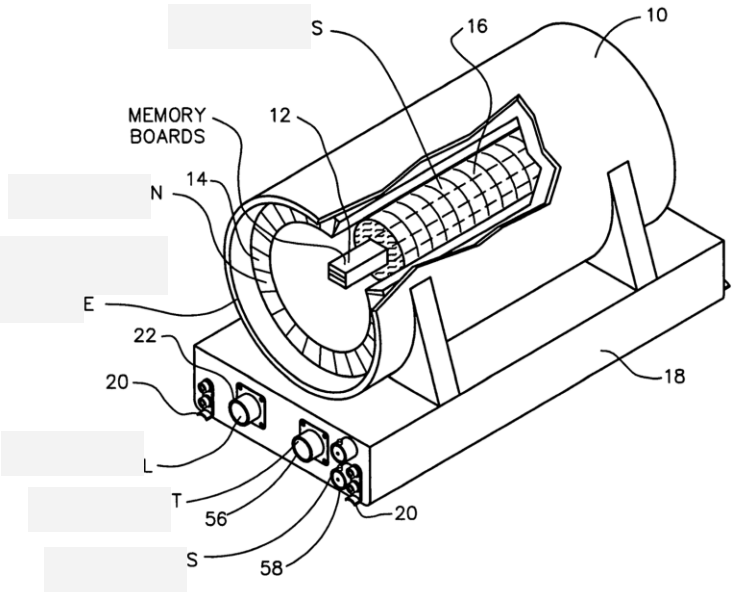


VR headset

- can recreate environment robot sees
- can display data from robot sensors
- can track your:
  - position
  - visual target
  - hand gestures
  - voice commands

Ansible

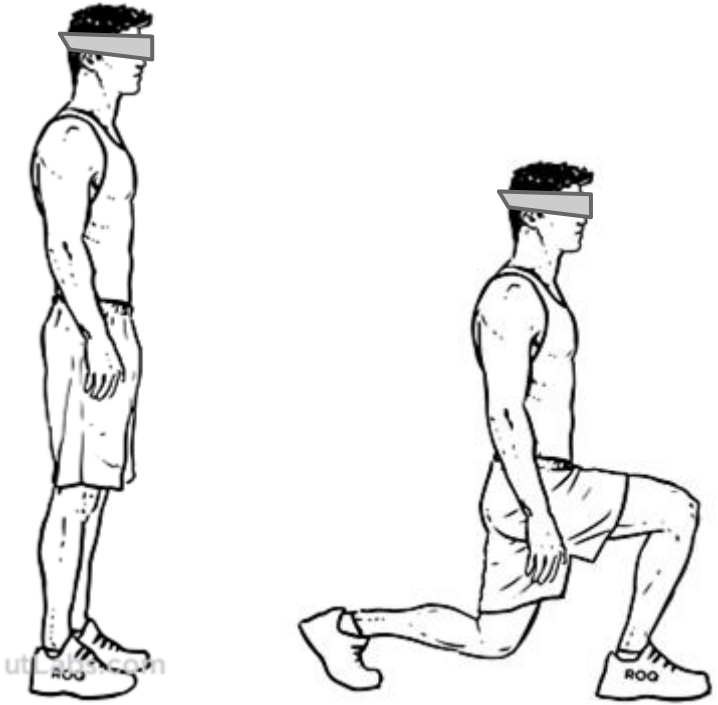
- nullifies the ~45-minute time delay it would otherwise take for signals to travel between you and the robot on Ganymede



Interface Basics

When you initially put on the headset you will see the robot’s camera’s current view of Ganymede.

You can move through space to change the camera direction, zoom level, and height.



Interface Basics

To reset your position and return to the standard view, use voice command **“Reset”** or move your hand upward in a straight line from the bottom center of your field of vision to the top.

Interface Basics

Your most common actions will be

taking photos

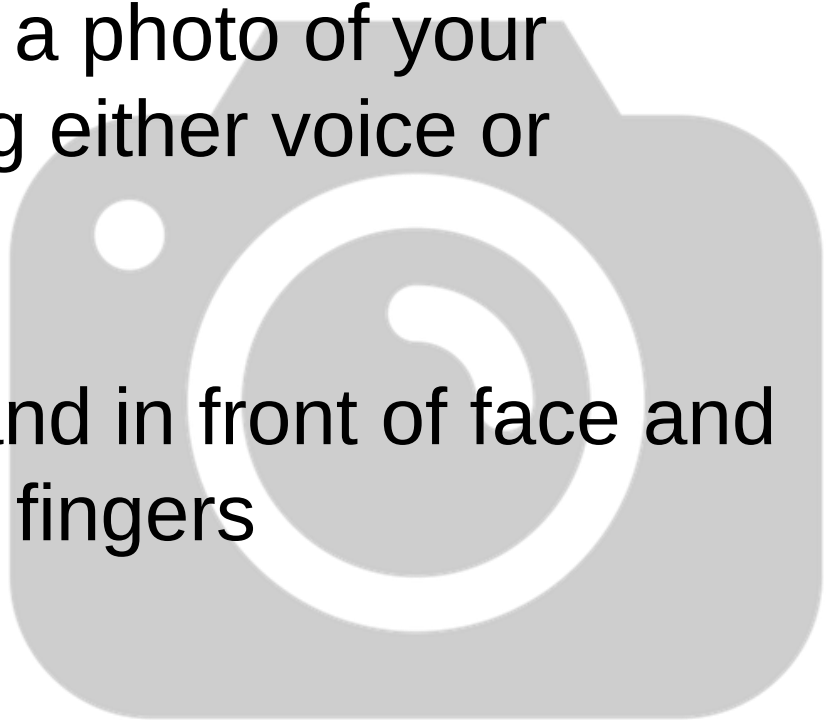
navigating the environment

taking Geiger counter readings

Taking a Photo

At any time, you can take a photo of your current camera view using either voice or gesture command.

- Voice: **“Photo”**
- Gesture: hold either hand in front of face and pinch thumb and index fingers



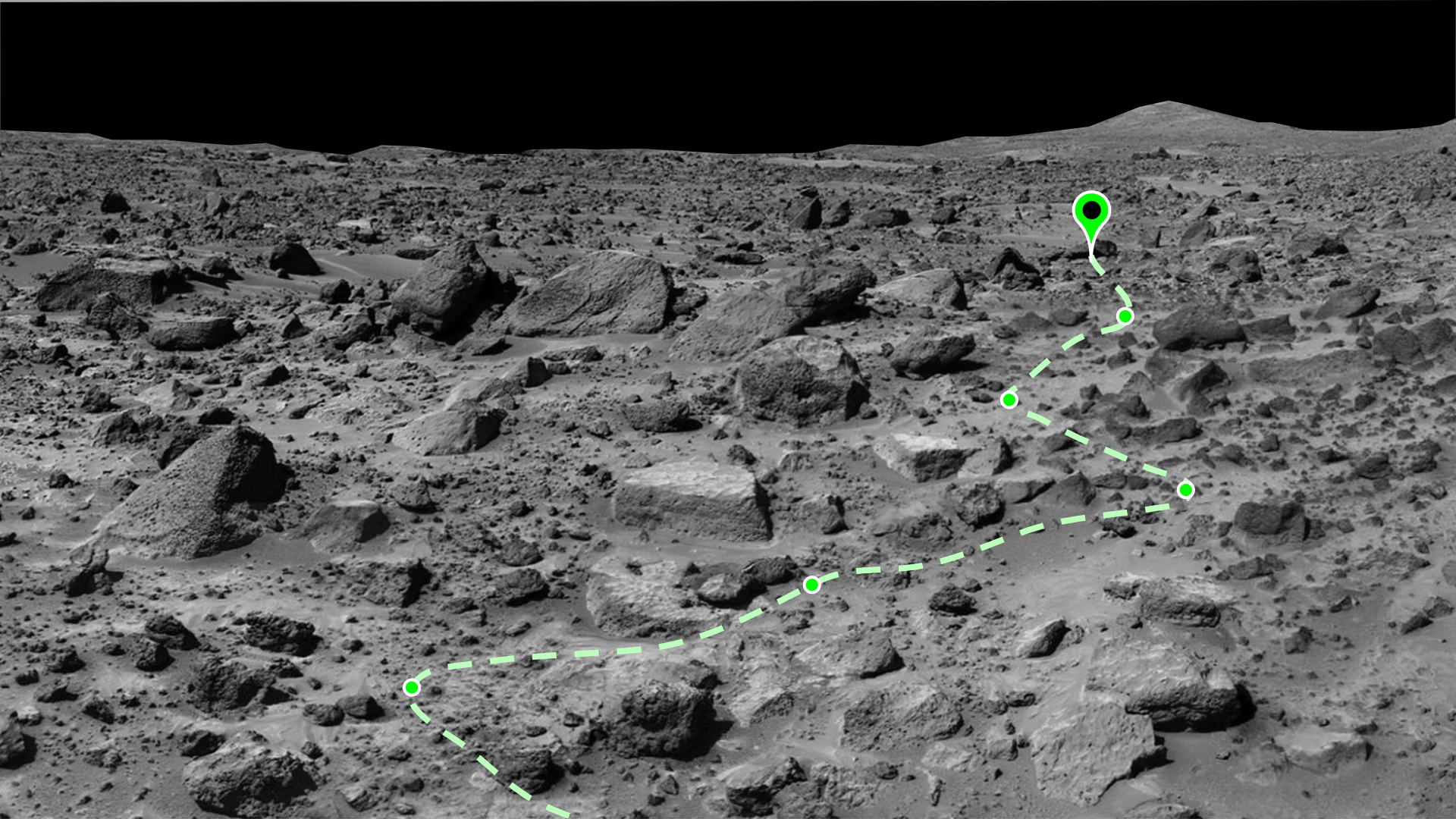
Navigation: 3 Methods

- Remotely placed targets
- Physically placed targets
- Embodied navigation

Target-based navigation

Target-based navigation makes use of the robot’s programmed pathfinding abilities and is most useful for covering large distances.

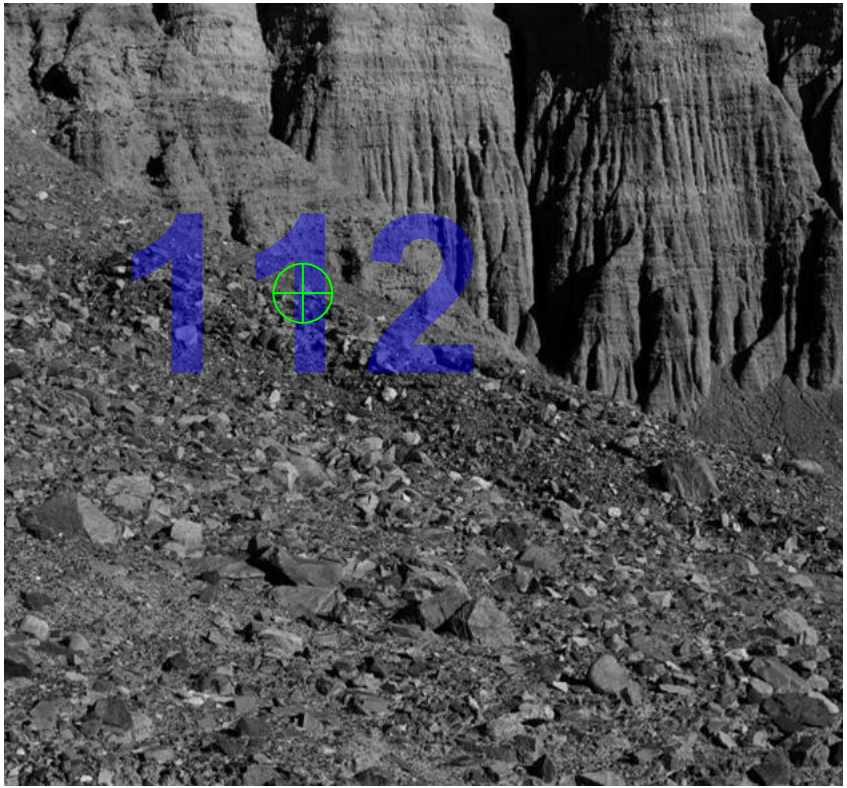
As the driver, you place targets (and, if desired, intermediate waypoints) to direct the robot’s movement.



Remotely Placing a Target

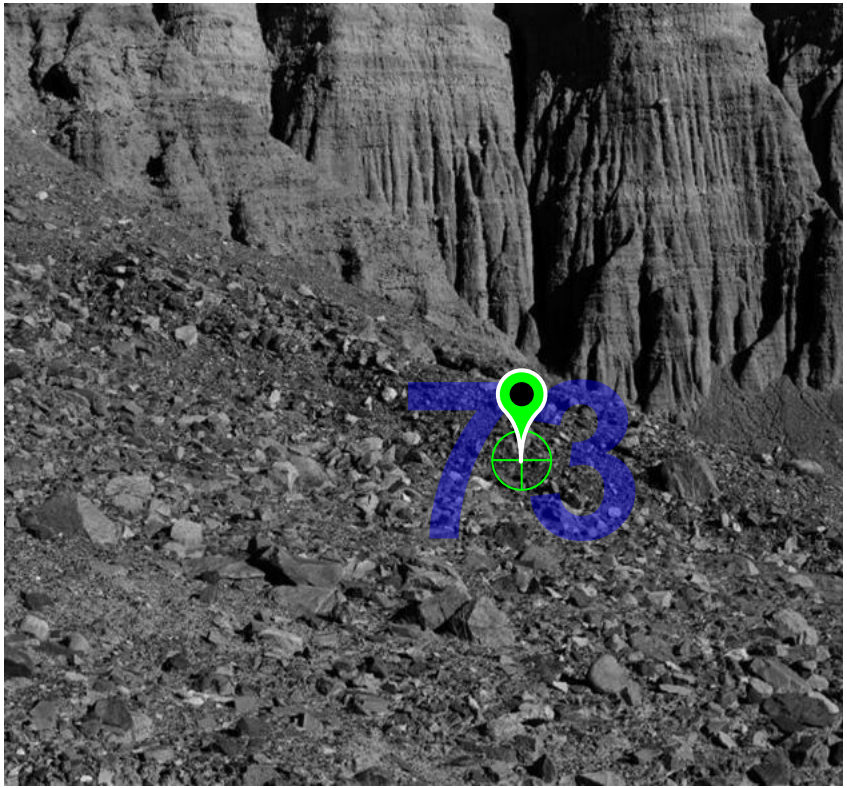
To remotely place a target, use the voice command **“Target mode**.”

Your view will change to show a gaze-tracked reticle with superimposed distance reading.



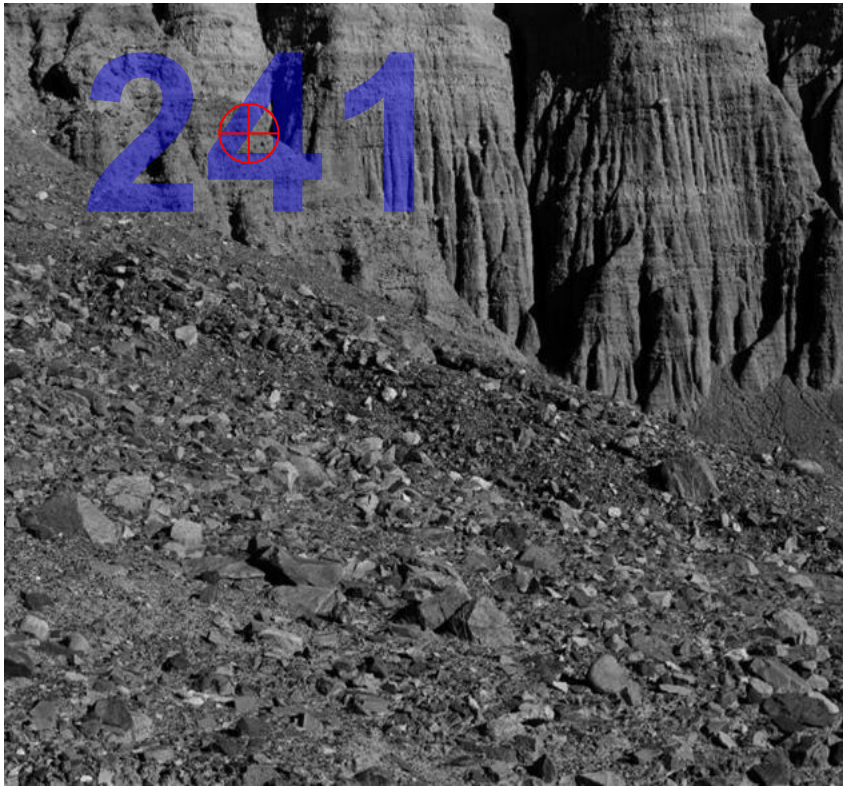
Remotely Placing a Target

Use your eyes to position the reticle and then use voice command **“Set target”** to set target or **“Set waypoint”** to set an intermediate waypoint.



Remotely Placing a Target

The reticle will display in red to indicate when you are looking at an area that cannot be set as a target or waypoint (such as a vertical wall).



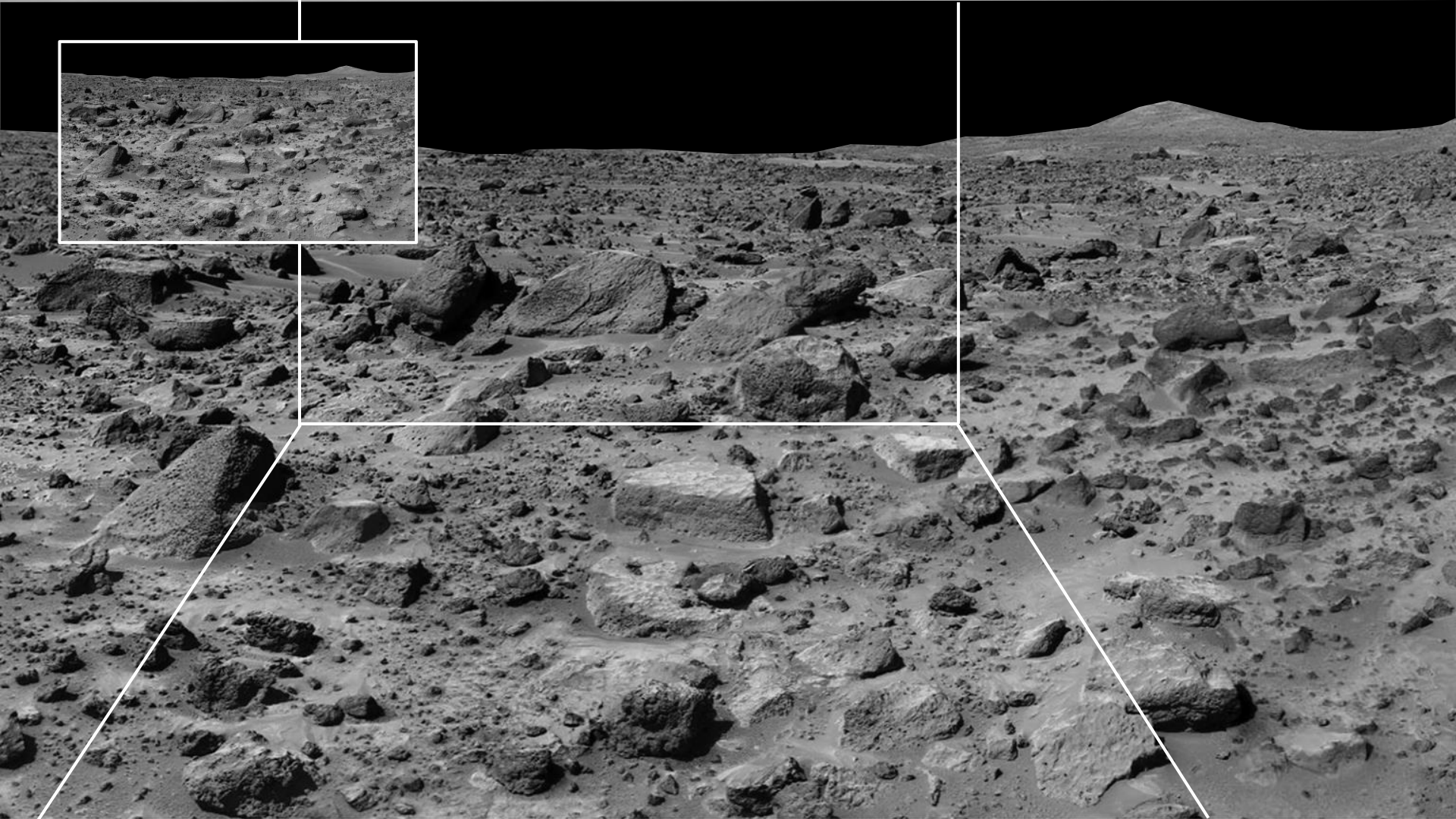
Remotely Placing a Target

After you place your target the robot will calculate a path to the target, which you can adjust, approve or cancel.

- To adjust path, either add waypoints or look at any existing point on the path and use voice command **“Move”**—you can now reposition the point using your eyes and finalize the new placement by saying **“Set**.”
- To approve path and set robot in motion, use voice command **“Go**.”
- To cancel path, use voice command **“Cancel**.”
- To exit target placement mode, use voice command **“Exit”** or move your hand downward in a straight line from the top center of your field of vision to the bottom.

Physically Placing a Target

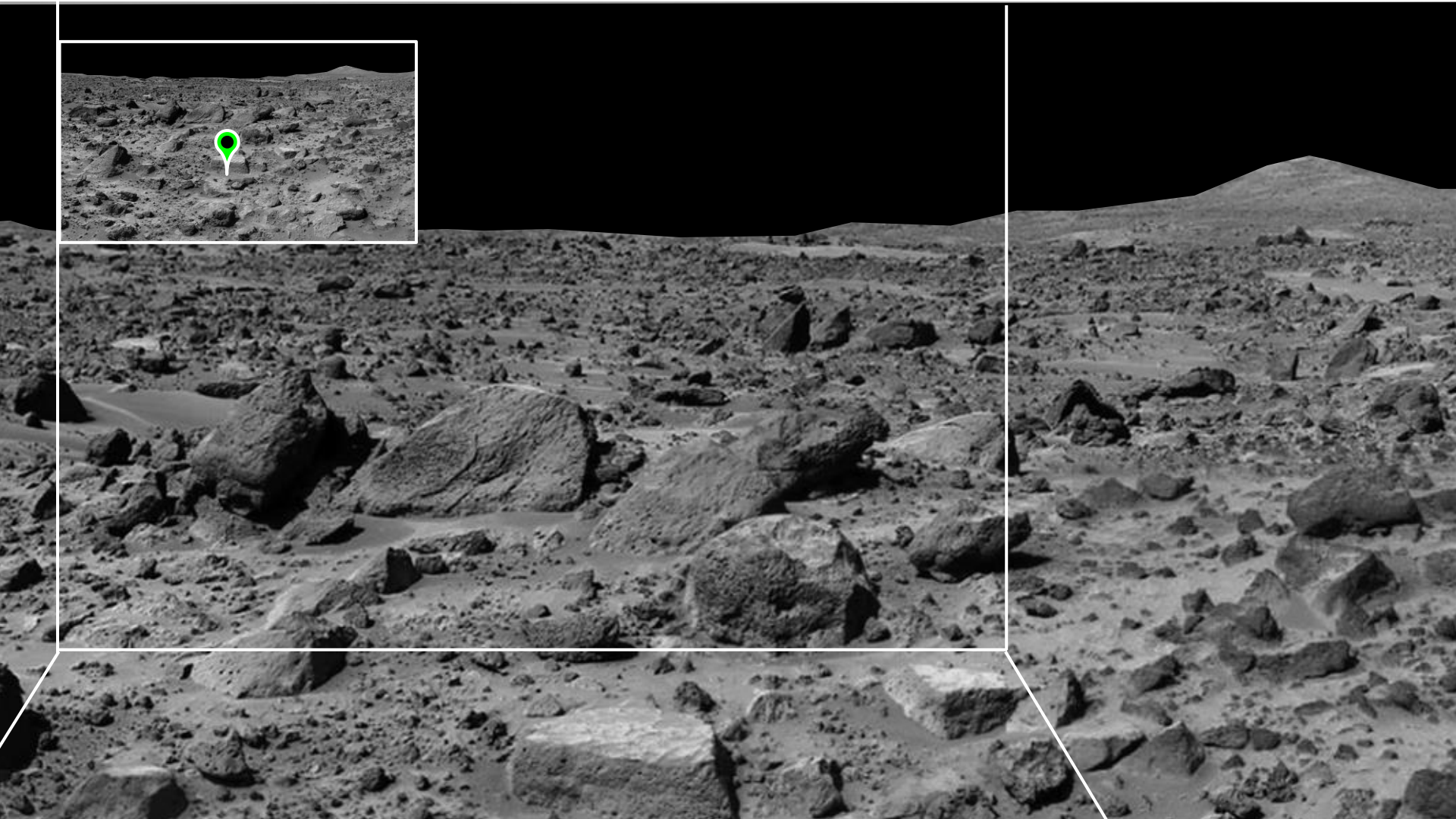
To physically place a target, use the voice command **“Out-of-body”** to change your VR display. The display will now superimpose the boundaries of the room you are in onto your view of the Ganymedian terrain, with a copy of the robot’s unchanged view still visible as a picture-in-picture.



Physically Placing a Target

Now, as you move through the physical space of the room, your viewpoint is not longer that of the robot’s. Because of this, the terrain on your display must be approximated based on previously-recorded data (from the robot and satellite), and may have distorted or blank areas.

As you walk around the room, the target you are placing (visually displayed as a pushpin) moves relative to the robot and can be viewed on the picture-in-picture.



Physically Placing a Target

When you are in the desired position, use voice command **“Set target”** to set target or **“Set waypoint”** to set an intermediate waypoint.

If you need to move beyond the boundaries of the room in order to set a point, use voice command **“Freeze”** to stop the tracking of your movement, move to a position in the room that provides more space in the desired direction, and use command **“Unfreeze”** to resume physically placing the point.

Physically Placing a Target

After you place your target the robot will calculate a path to the target, which you can approve or cancel.

- To approve path and set robot in motion, use voice command **“Go.”**
- To cancel path, use voice command **“Cancel.”**
- To reset your position to the robot’s current position, use voice command **“Reset”** or move either hand upward in a straight line from the bottom center of your field of vision to the top.
- To exit out-of-body mode, use voice command **“Exit”** or move your hand downward in a straight line from the top center of your field of vision to the bottom.

Embodied Navigation

Embodied navigation is the most direct way to control the robot’s navigation and is most useful for movements within a small area.

Using Embodied Navigation

To enter embodied navigation mode, use voice command **“Embodied**.” Your view will change to incorporate hazcam (hazard avoidance camera) views, with superimposed lines indicating the boundaries of the robot body (similar to a car’s backup camera display). Superimposed lines will also show the boundaries of the room you are in.

You can now move around the VR space with the robot’s movement yoked to yours. This works best if you move slowly and avoid hazards in the robot’s environment.

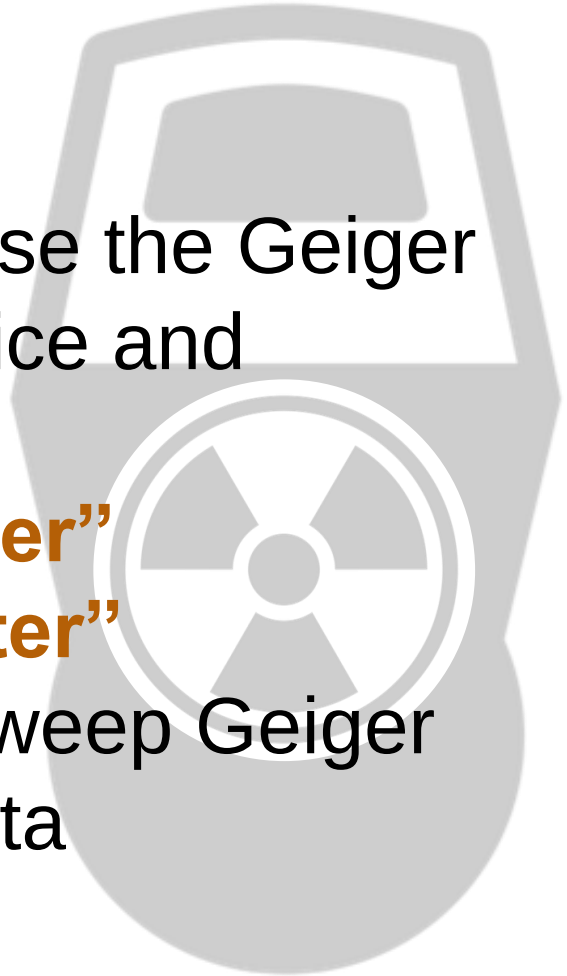
Using Embodied Navigation

If movement becomes desynced (either you or the robot changes position faster or slower than the other) your display will take on a red tint. If you see this tint, either stop moving and wait for the tint to go away before you resume, reset to the robot’s current view, or exit embodied mode.

Using the Geiger Counter

At any time, you can deploy and use the Geiger counter using a combination of voice and gesture command.

- Voice: **“Deploy Geiger counter”**
  “Retract Geiger counter”
- Gesture: point finger to direct/sweep Geiger counter and collect radiation data



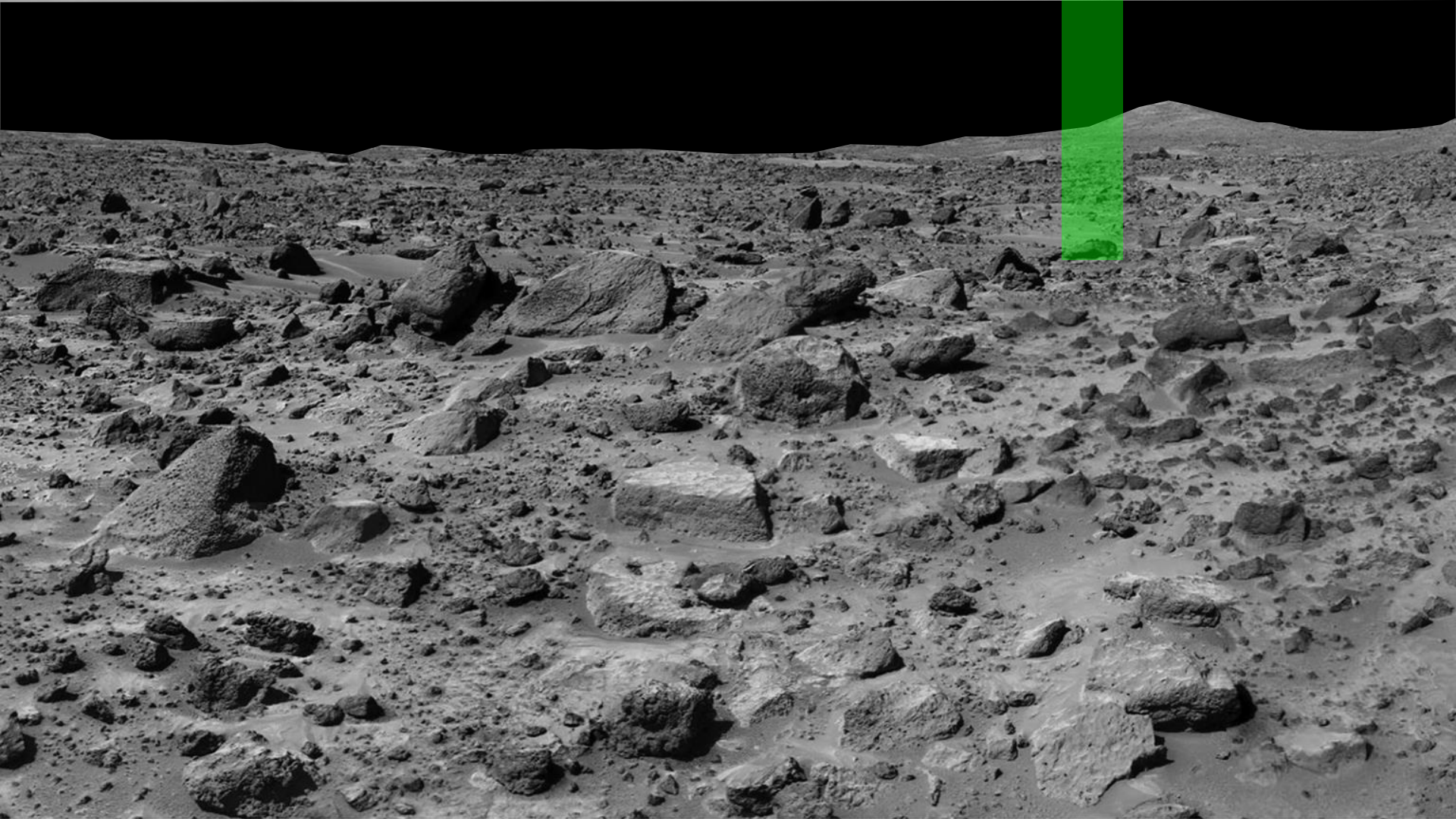
Driver Mission Overview

Driver assumes control after robot lands and stabilizes.

1. Orient to rock’s location using orbital data.
   (may require preliminary maneuvering)
2. Navigate to rock.
3. Collect data.
   (i.e. photographs and radiation readings)

Driver Mission Overview

When the robot is oriented, the radioactive rock’s location will be highlighed by a column of light.



Good luck with your mission!