NASA MarsXR Challenge

Upgrades proposed for the martian
virtual training environment XOSS

Team: Overheat

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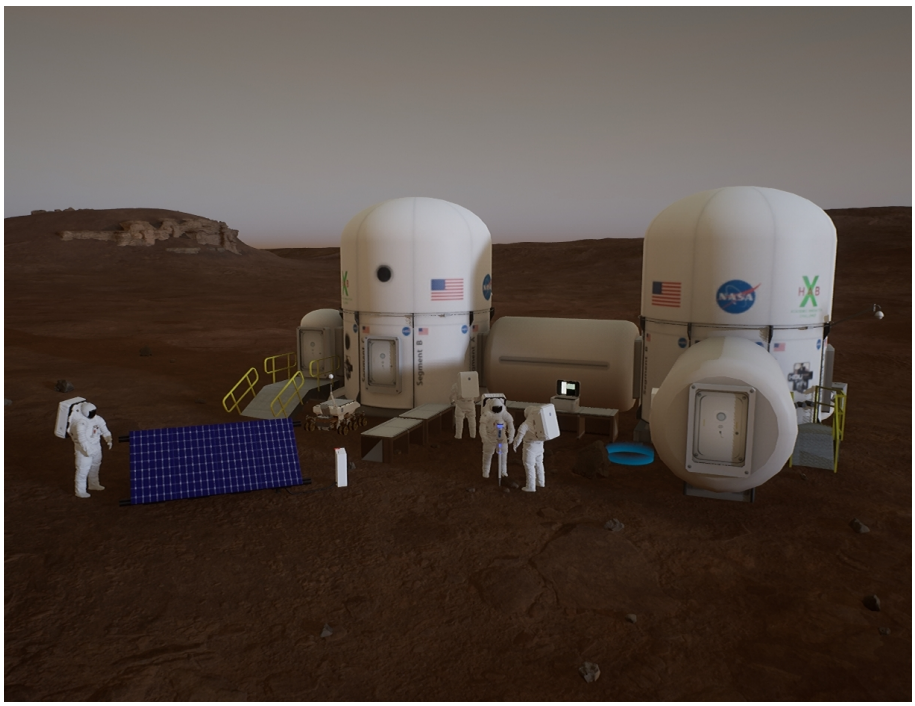

Contents

1 Introducction

Space exploration has been an interest for humanity for a long time. So many missions have been completed, and there are yet many more to come.

For one of these missions, which will take place on the red planet, NASA, Buendea and Epic Games have initiated the second iteration of the NASA MarsXR challenge, and are requesting people to create new scenarios and assets for the new Mars XR Operations Support System (XOSS) environment, using Epic Games' Unreal Engine 5.

For the first part of the challenge, competitors are asked to design scenarios as storyboards. In our case, we have decided to also add this LaTeX documentation, to add some explanations to our ideas. The storyboards could be followed without having to read the full document, but it will give more detailed explanations about the idea of the storyboards and the different assets that are presented. It also has the reference to the information that we have used to justify our ideas.

Figure 1: Overheat's team logo

1.1 Assumptions

For our storyboards, we are assuming that there are some facilities already built and working (except if specified otherwise in a specific scenario):

- **Habitat:** A place with the necessary facilities where the astronauts will live.
- **Energy production system:** A system to produce electricity. We are assuming that there are at least solar panels. There might also be other sources of power.
- **Greenhouse:** A place for the astronauts to plant different crops.
- **CENTAUR rover:** A rover that can be used to transport materials and tools, or mount certain tools.
- **Drone:** A remote controlled drone with a camera and other systems.

2 Storyboard: Soil sampling

This storyboard is focused on research. The astronauts will need to gather different types of samples: small stones, rock samples, regolith samples. Each type of sample has a different way of being obtained, so the astronauts will need to make use of a variety of tools to success.

During the mission, there could be some events that break the flow of the storyboard, and that the astronaut will need to deal with before completing the mission. Also, we have designed some metrics to assess in the correct execution of the scenario. Both things are explained in the following sections.

2.1 Metrics

For this mission, the metrics that we propose are the following ones:

- **Time:** The most basic metric that could be implemented is tracking the time that the astronauts take to complete the mission. It could be tracked in both ways: as a global time, and an individual time for each step. This way, scientists can measure which tasks are more complicated.
- **Number of samples gathered:** The number of samples that have been correctly analyzed and stored.
- **Number of samples analyzed:** It's also important to measure the number of samples that have been analyzed. If few samples have been needed for completing the mission, it could be beneficial to investigate a little bit more, as other interesting samples might appear.
- **Drilling angle:** The angle that was used to drill the wholes. A perpendicular angle would be preferable, as it can then penetrate deeper in the Martian surface / rock.
- **Depth of the wholes:** The depth of the wholes made could also be tracked, as a longer whole implies that more sample has been gathered.
- **Tool's battery usage:** For the electrical tools that are used, if they are used with batteries, checking the amount of battery that has been used will help the astronauts make a better use of them.
- **Overheat:** This metric counts the time that a tool has been working without stopping. The idea is to track if the astronaut reaches a high level of overheat, which could damage the tool or the products that is being worked with.

2.2 Events

For this mission, the events that we have designed that break the flow of the storyboard are the following ones:

- **Malfunctioning rover:** It might be possible that a part of the rover breaks (like a wheel), so the astronaut will need to replace it for a new one.
- **Analysis tool malfunction:** If the analysis tool breaks (because it has fallen to the ground, for example), the astronauts won't have any mean to detect which samples are the correct ones. They can then proceed in 2 following ways: go back to the base to get a new one or collect more samples (for example, at least 3 times more samples), and then decide in the base which are the valid ones.
- **Malfunctioning sampling tool:** The tool might stop working for different reasons, like having a broken part. The astronaut needs then to go back to the base and get a new one.
- **Tool's battery drained:** The battery of the tool has been completely drained. The astronauts need to grab a new battery and replace it before continuing with the task.
- **Tool overheat:** The tool has been used for too long without a pause, and it has stopped working. The astronaut needs to wait for the tool to cool down. (The event will be triggered when the overheat metric reaches the maximum).

2.3 Storyboard

Overheat, Soil sampling

1

Storyboard Title, Sequence, & Description

Tool gathering

This scenario is focused on getting different soil samples. To do that, first the astronaut needs to go to the shed and gather the different sampling tools and the CENTAUR rover.

Assets Available in this Storyboard

- Toolbox (x2)
- Camera
- Flag markers
- CENTAUR Rover
- CENTAUR Remote Controller
- Analysis tool set
- Sampling tool set
- Sample box

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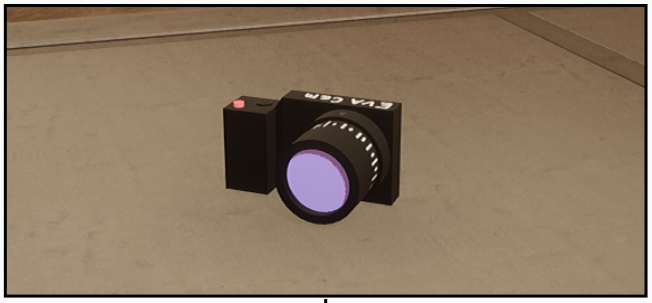

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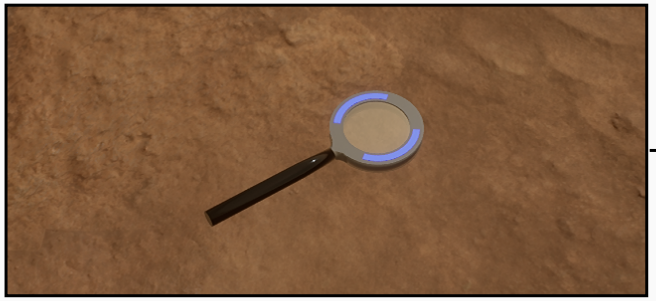

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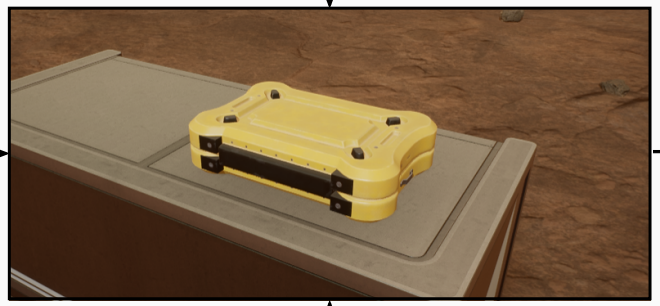

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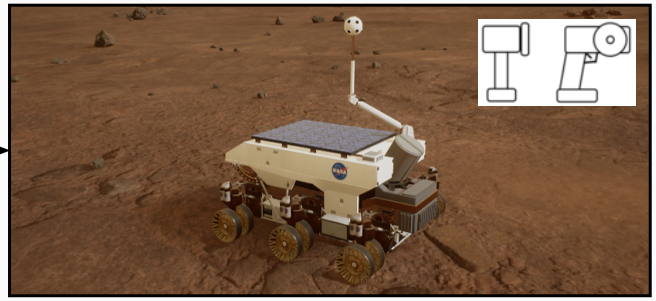

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Actions Executable in this Storyboard

1. Load the toolboxes on the CENTAUR
2. Get CENTAUR's remote controller
3. Start CENTAUR and check that it boots correctly
4. Move with the CENTAUR and the tools to the designated exploration place.

Frame Descriptions

1 Toolbox

2 CENTAUR Rover + Remote Controller

3 Analysys Tool - Analysing

4 Pliers

5 Camera

Overheat, Soil sampling

2

Storyboard Title, Sequence, & Description

Small rock sampling

Some of the sampling that will be done is about small stones from the martian surface. To do that, the astronauts need to detect which rocks could be good candidates, pick them up with some pliers and store them inside some bags.

Assets Available in this Storyboard

- Analysis tool
- Stone sample
- Pliers
- Zip bag
- Sample box
- CENTAUR Rover

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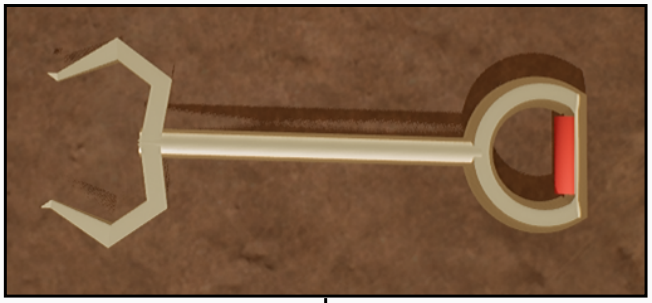

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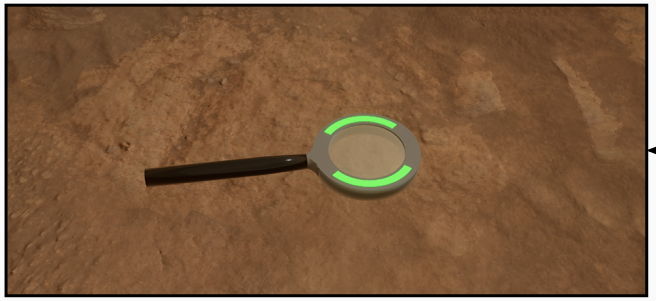

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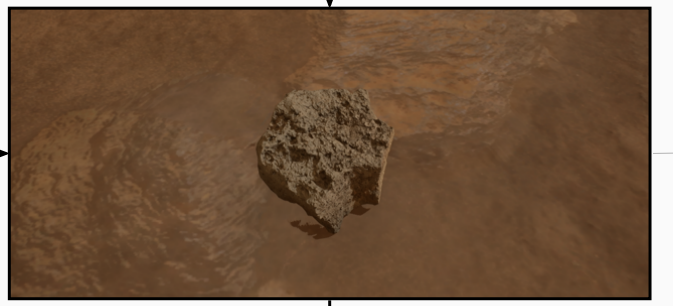

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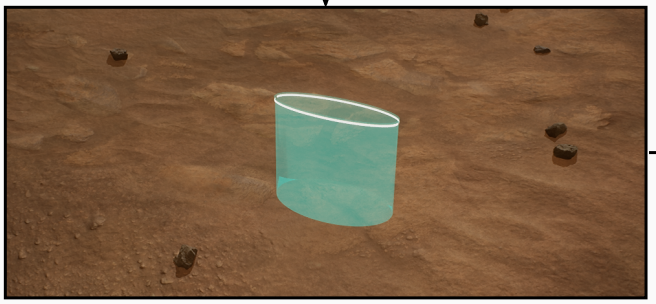

Actions Executable in this Storyboard

1. Pick up the stone analysis tool
2. Analyze some stones to find some that could be suitable samples
3. Leave the analysis tool back into its box
4. Get the pliers
5. For each stone that the astronaut wants to store:
   a. Get a clean zip bag
   b. Pick up the stone using the pliers, store it inside the bag, close it, and store the bag in the samples' box.
6. Store the pliers in its place

Frame Descriptions

1 Small Rock Sample

2 Samples Box

3 Analysys Tool - Viable Sample

4 Sample Zip Bag

5 Pliers

Overheat, Soil sampling

3

Storyboard Title, Sequence, & Description

Deep rock sampling

Another type of samples that might be needed are bigger rock samples. To extract them, the astronaut will need to drill a whole in the rocks, and extract the sample in the vial.

Assets Available in this Storyboard

- Analysis tool
- Vial (empty and full)
- Deep core drill
- Flag markers
- Sample box
- CENTAUR

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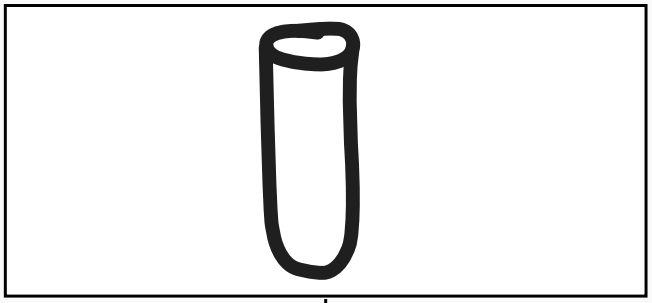

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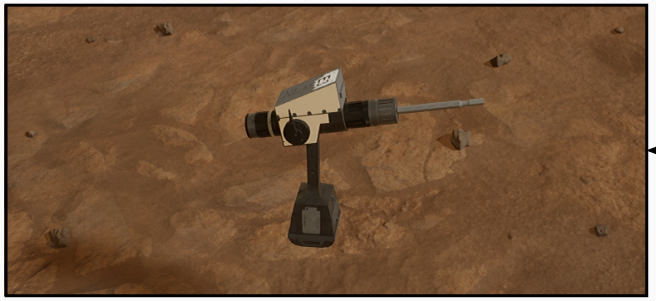

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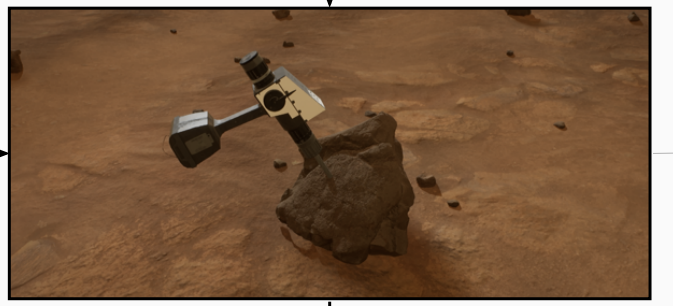

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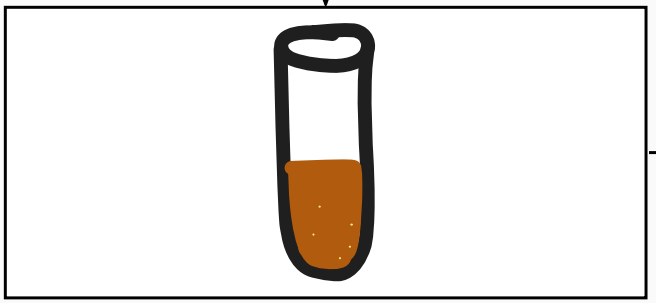


Actions Executable in this Storyboard

1. Get the soil analysis tool and some flags
2. Analyze different rocks and mark the interesting ones with the flag markers
3. Store the analysis tool and the remaining flags
4. Pick up the rock core drill and some vials
5. For each of the samples that the astronaut will take:
   a. Load the vial in the drill
   b. Drill the rock and get the sample
   c. Unload the vial and store it in the sample box
6. Store the rock core drill

Frame Descriptions

1 Collecting the sample

2 Samples Box

3 Analysys Tool

4 Filled Vial

5 Empty Vial

Overheat, Soil sampling

4

Storyboard Title, Sequence, & Description

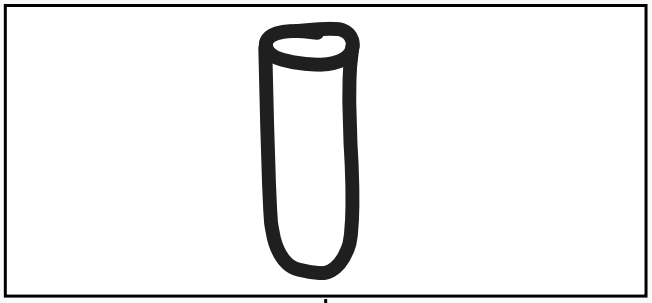
Regolith sampling

The third type of samples that the astronauts can collect are martian surface regolith. To do that, the astronaut will need to analyze some parts of the terrain and use the regolith collector to get some samples.

Assets Available in this Storyboard

- Analysis tool
- Vial (empty and full)
- Regolith collector
- Flag markers
- Sample box
- CENTAUR

5



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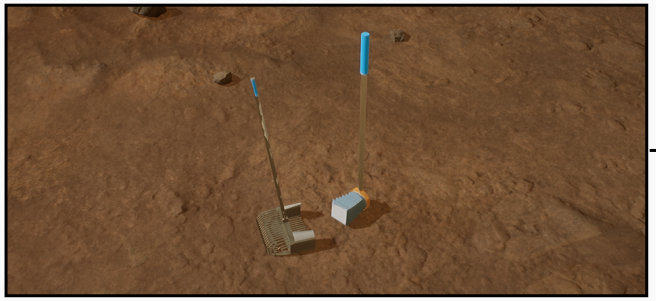

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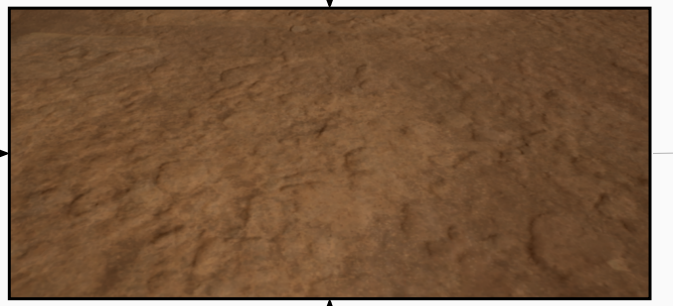

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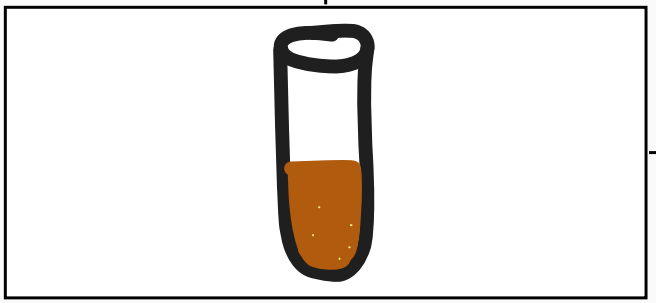


Actions Executable in this Storyboard

1. Get the soil analysis tool and some flags
2. Analyze different parts of the terrain and mark the interesting ones with the flag markers
3. Store the analysis tool and the remaining flags
4. Pick up the regolith collector and some vials
5. For each of the samples that the astronaut will take:
   a. Load the vial in the tool
   b. Collect the regolith
   c. Unload the vial and store it in the sample box
6. Store the regolith collector

Frame Descriptions

1 Soil Dust

2 Samples Box

3 Sampling Tool Set

4 Filled Vial

5 Empty Vial

Overheat, Soil sampling

5

Storyboard Title, Sequence, & Description

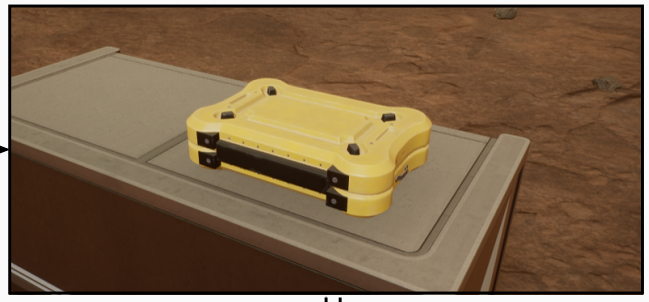
Return to the base and store the samples

Once all the samples have been gathered, the astronauts will need to return to the habitat. They will deposit the sample box in the lab, so they can fully analyze the samples without the EVA suit. After that, they can return everything to storage and head to the habitat.

Assets Available in this Storyboard

- Camera
- Flag markers
- CENTAUR Rover
- CENTAUR Remote Controller
- Analysis tool set
- Sampling tool set

5



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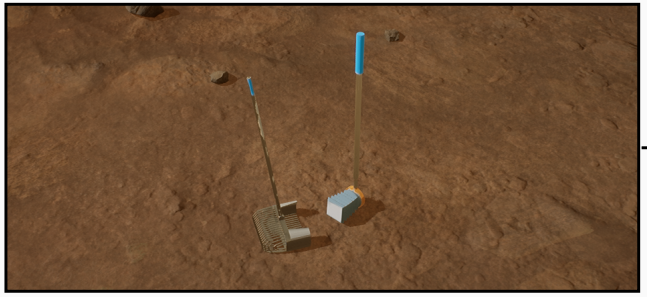

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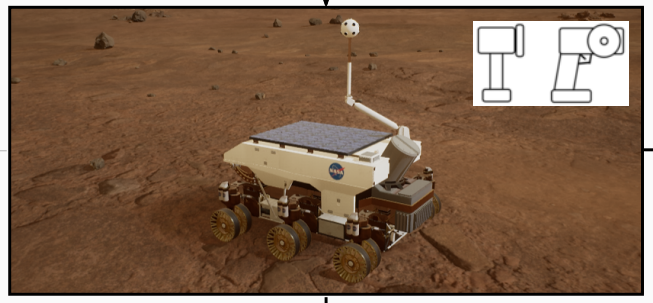

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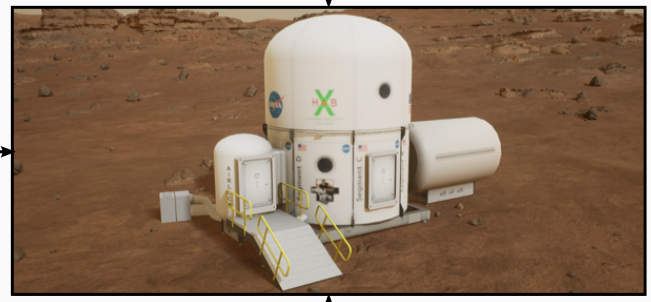

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Actions Executable in this Storyboard

1. Store the tools in the toolboxes
2. Put the toolboxes on the CENTAUR
3. Return to the Main Base
4. Unload the sample box and leave it in the lab.
5. Unload the toolboxes and store it
6. Park the CENTAUR in its spot
7. Power off CENTAUR
8. Store the CENTAUR remote controller

Frame Descriptions

1 CENTAUR Rover + Remote Controller

2 Main Base

3 Sampling Tool Set

4 Samples Box

5 Toolbox

3 Props

In this section we describe a little further all the props that have been mentioned in the storyboards. Our goal is to include a little description of the prop that we have in mind, to make it more clear for the people who wants to develop our scenarios.

We also want to add some reasoning on why the asset would be useful, and what makes us think that it's possible to create it, so people can get a better understanding of the prop and their role in the different scenarios.

3.1 Toolbox

To maintain order during the mission, and avoid losing the tools, it will be necessary to have a toolbox. It might be needed different instances of this prop with different sizes, as not every tool might perfectly fit in a generic toolbox.

Figure 2: A model of a toolbox from the XOSS editor.

3.2 Camera

This prop is already built in the XOSS editor. The idea is to use it to take pictures to document the missions and keep record of the places visited by the astronauts and the actions that they do.

Figure 3: A model of the camera from the XOSS editor.

3.3 Flag marker

This prop serves the purpose of marking specific points in a small area. It is not thought to be used to mark a place in the distance. For that, we have the waypoints that are already in the XOSS editor.

This flag could be use, for example, to mark certain features for future investigation, or to delimit a certain area.

3.4 Analysis tools

As stated in the documentation that was given for the challenge, a task that the astronauts will need to do is pick-up some rocks for later scientific research. However, it's better if this process in not random. For this reason, we propose to use some tool to do a preliminary analysis of the

potential sample. If the analysis results in a good sample, then the astronauts can pick it up. Otherwise they can search for other samples.

We have envisioned different types of analysis tools:

- For small rocks or regolith, we think of a tool that uses different sensors to detect if the sample is a good one, and that also displays a close up view. As an idea, it could be like a magnifying glass, with some sensors and indicators on whether the sample is a valid one. You can see it in the left image of figure 4.
- For big rocks, we think of a tool that makes a small whole in the rock, and analyze it from the inside. You can see it in the right image of figure 4.

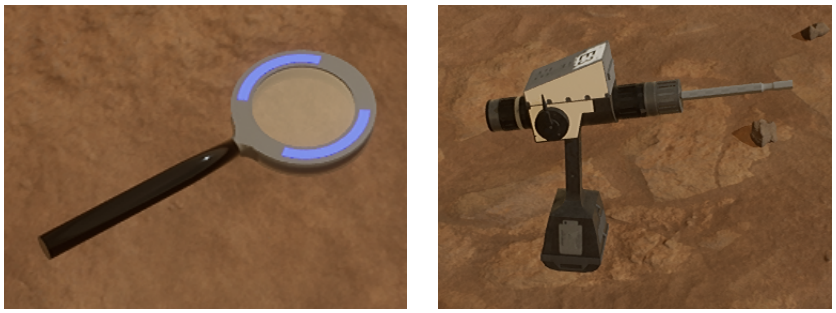

Figure 4: Examples of analysis tools in the XOSS editor. The left one is for small rocks and regolith, the right one is for big rocks. (NOTE: the right one is actually a different asset from the XOSS editor, but the tool we envision has a similar shape.)

3.5 Pliers

For our scenario, a task that the astronauts will need to do is pick-up some rocks for later scientific research. However, before picking them up, it is better if they can take a closer look at them, and do it avoiding the direct contact with the suit (as it might contaminate it with minerals that should not be there). Also, if they are good samples, they will need to grab them to store them, also avoiding direct contact.

For this purpose, we have designed a pair of pliers. They can help the astronaut pick the desired rocks and do a preliminary evaluation, in order to determine if the sample is good enough or not, and also help in the process of storing the good samples.

Figure 5: A model of the pliers in the XOSS editor.

3.6 Sample zip bag

During the martian missions, samples will be gathered, (from rocks to regolith or soil). Maybe not only samples, but also bigger quantities of soil. To store them and avoid them getting contaminated by things that were brought from Earth, we have designed this prop: a zip bag.

It should be able to be opened and closed by the astronaut, and different things should fit inside. There could be multiple instances of the prop with different sizes, if you are planning to store very different objects inside.

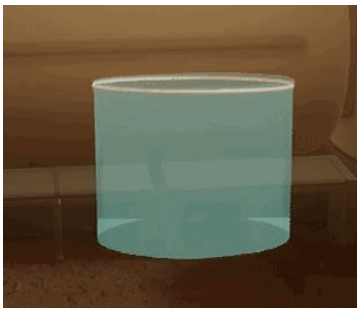

Figure 6: A model of the opened zip bag in the XOSS editor.

3.7 Deep core sampling drill

This prop is a small drill that has a whole in the bit, to capture samples of the rocks and store it in some vials (which are explained in section 3.8).

The idea of the drill is very similar to the method that is used by the Perseverance rover [5].

3.8 Sample vial

This prop is used to store samples of small particles. It's a tube-shaped vial with one end opened when it's empty, and that should be closed once the particles are inside the vial.

3.9 Regolith collector

This tool is used to collect regolith from the martian surface. For the storyboard, we have represented it using two of the assets in the XOSS editor, but it could also be a new asset that (for example) absorbs the regolith.

3.10 CENTAUR rover

For martian missions it will be very helpful to have a rover accompanying the astronauts during the missions. It would also be very useful if the rover could carry some items around, because some material might be heavy or uncomfortable to carry. For that reason, we have designed a prop that it's a remote-controlled rover with some extra capabilities:

- **Carrying objects:** One of the main reasons for the use of the rover is to carry objects of big dimensions or to carry items for long walking distances.
- **Tool mounting points:** Another advantage of having a rover helping in the missions is that it can transport large tools and use them remotely using the controller. For that, the rover should have some places where the astronauts can attach specific tools that require some space to be operated. For example, if the astronauts are going to use a drill of great dimensions, instead of mounting it on every place, they could mount it on the rover, and move the rover from one place to another, which would save them time and energy.

The rover should also be divided in sections that can be disassembled, to be able to do some reparations in case they are needed. And also some interaction interface should be added to it, like a power button, a display or a connector socket (to connect it to other devices).

For this prop, we plan to use the CENTAUR rover that already exists in the XOSS editor, and modify it a bit to meet our ideas. For this reason, we have decided to keep it with the same name. In figure 7 you can see a version of the actual model from the XOSS editor divided by pieces and fully mounted.

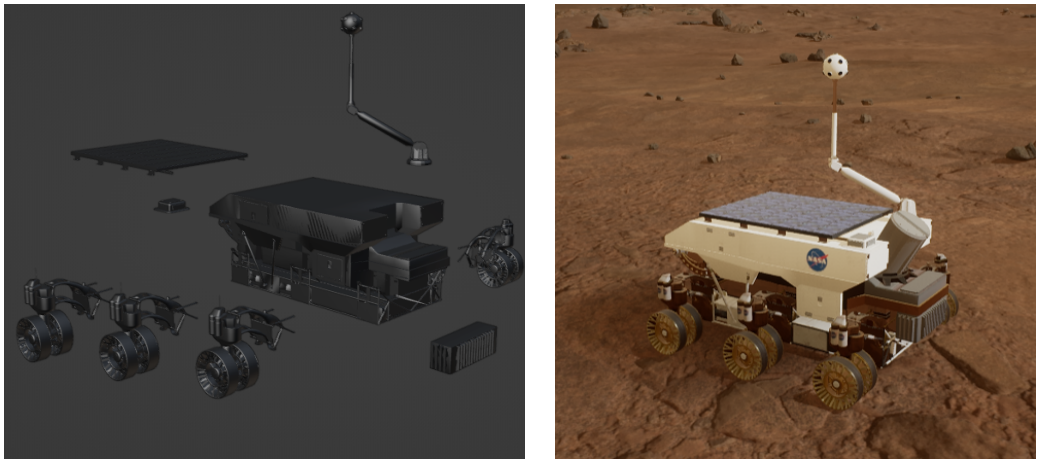

Figure 7: CENTAUR models. From left to right they are the model divided by parts and the model fully mounted and texturized in the XOSS editor.

The remote controller that will be used to move the CENTAUR rover is described in section 3.11.

3.11 CENTAUR controller

This prop is the remote controller of the CENTAUR rover (described in section 3.10). The idea is that it's able to control the rover's movement and other functionalities that it might have. In figure 8 you can see an sketch of the controller.

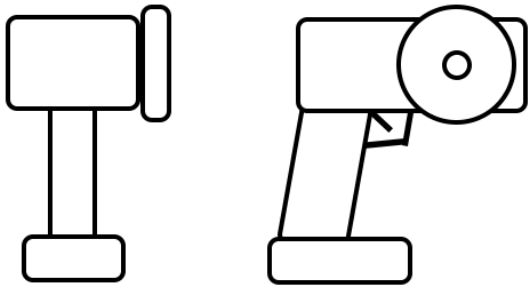

Figure 8: Sketch of the CENTAUR's controller. The image on the left is the rear view and the one on the right is the lateral view.

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