NASA MarsXR Challenge

Upgrades proposed for the martian
virtual training environment XOSS

Team: Overheat

Members:
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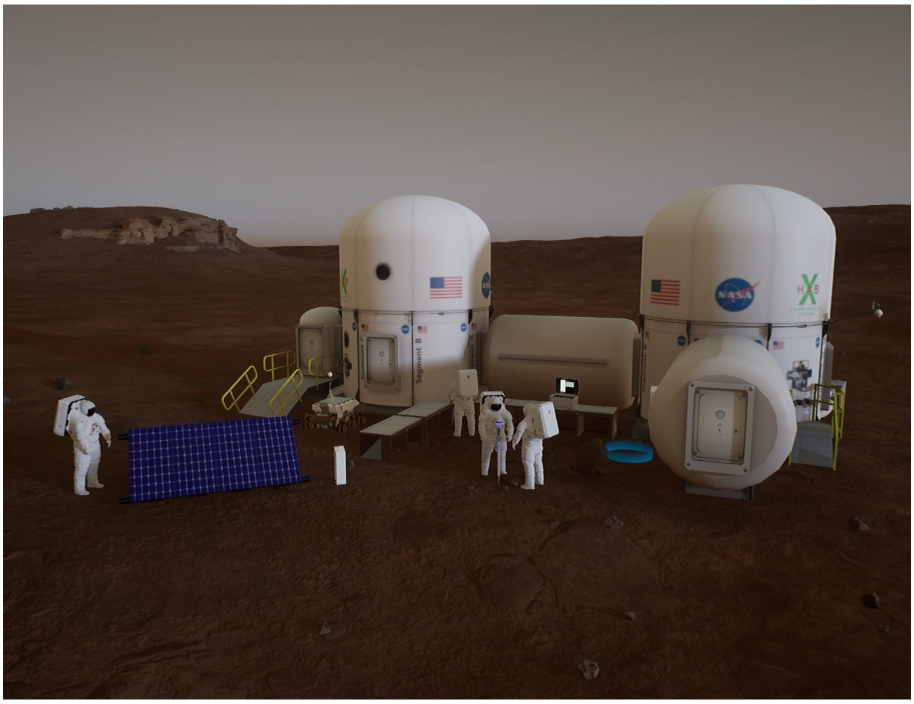


Contents

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: Satellite recovery

This storyboard is focused on recovering parts from a fallen satellite. A satellite has fallen in the martian surface, and the astronauts need to find where it has fallen (using the drone's camera), go there, recover the satellite's black box, and head back to the habitat.

Additionally, the astronauts can also salvage additional parts that are in good shape, or that they think that will be useful. Resources in Mars are limited, so any resource that they can get might be helpful.

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 recovered parts:** Another metric could be how many parts have the astronauts recovered.
- **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:

- **Suit damage:** If the astronauts are not careful when salvaging the satellite, any loose metal piece could create an scratch on the suit, which would be potentially dangerous. This event will then activate when an astronaut is too close to dangerous metals, and they will need to repair the suit, and depending on the damage, cancel the mission and leave it for another time.
- **Malfunctioning 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, Satellite Recovery

Storyboard Title, Sequence, & Description

1

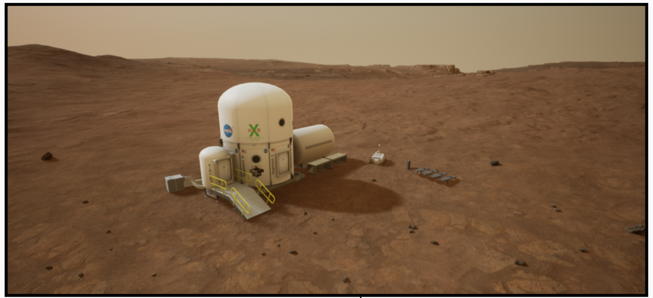
Find the satellite location.

First of all, astronauts will need to know where the fallen satellite landed, for that, they are gonna use the drone to explore the area faster and obtain the coordinates of the satellite.

Assets Available in this Storyboard

- Drone
- Drone remote controller

5



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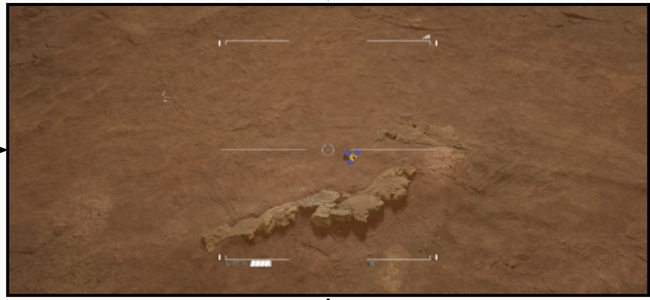
Location Marker Textures

1



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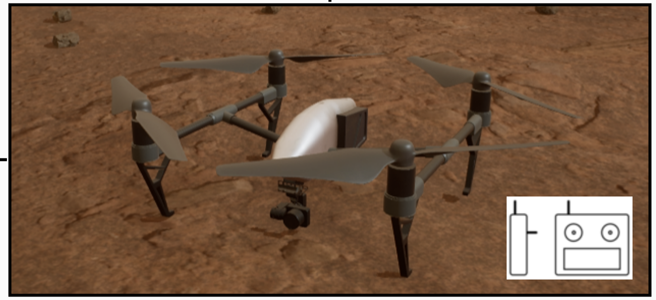

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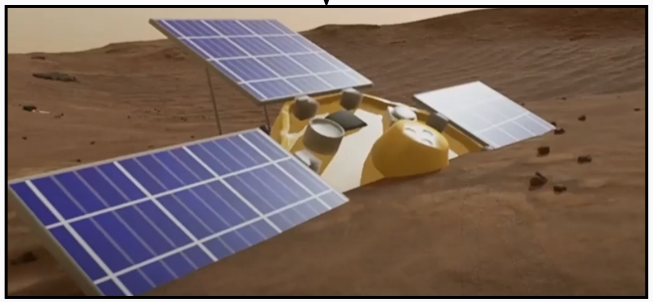


Actions Executable in this Storyboard

1. Turn ON the drone
2. Grab the drone controller
3. Fly and discover the satellite location
4. Mark the location
5. Return the drone to the base
6. Turn OFF the drone
7. Store the drone controller

Frame Descriptions

1 Drone View

2 Drone + Remote Controller

3 Location Maker Textures

4 Fallen Satellite Located

5 Drone Start/End Location - Main Base

Overheat, Satellite Recovery

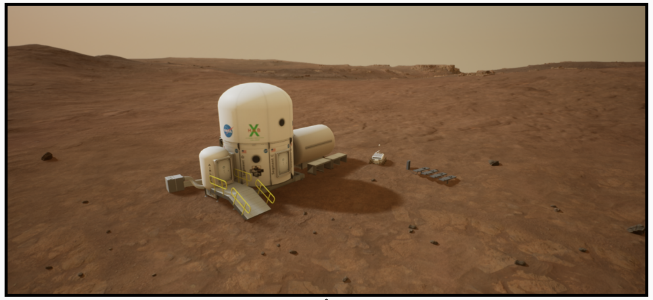
Storyboard Title, Sequence, & Description

2

Go to the fallen satellite

The astronauts know the location of the satellite. Currently, they need to grab some tools and the Centaur rover to recover the satellite's usable parts.
Using the Centaur's controller, astronauts need to navigate for the surface to the satellite location.

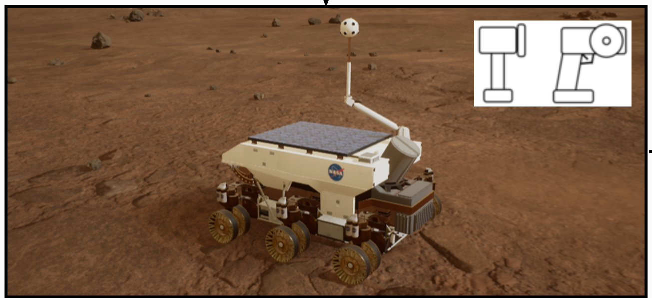
5



Assets Available in this Storyboard

- CENTAUR rover
- CENTAUR remote controller
- Toolbox

3



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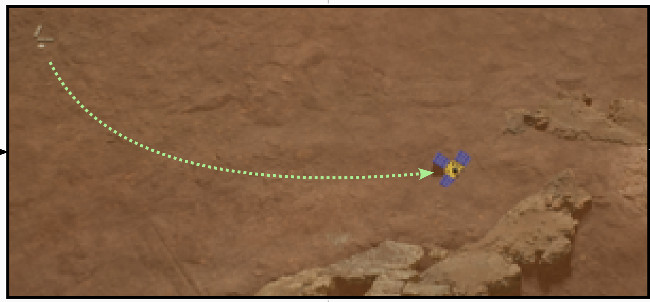

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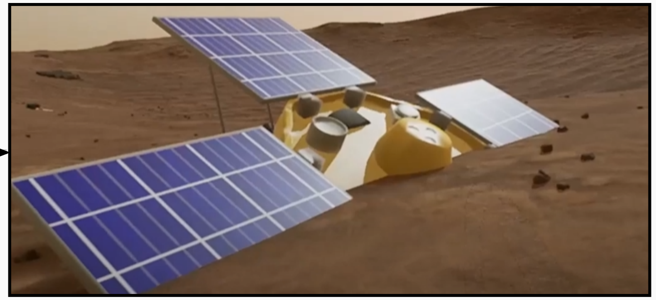
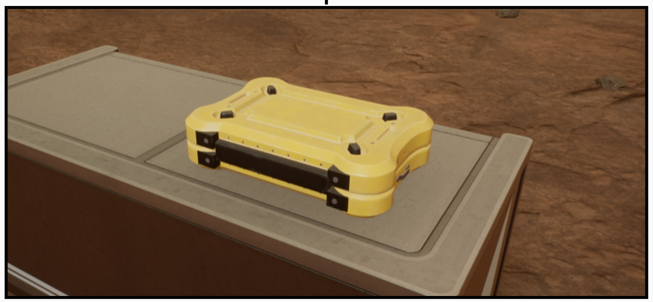


Actions Executable in this Storyboard

1. Grab the toolbox
2. Leave the toolbox in the CENTAUR
3. Turn ON CENTAUR rover
4. Grab the CENTAUR controller
5. Walk to the satellite location with the CENTAUR
6. Park the CENTAUR near the satellite
7. Turn OFF CENTAUR

4



Frame Descriptions

1 CENTAUR Route

2 Fallen Satellite Location

3 CENTAUR Rover + Remote Controller

4 Toolbox

5 Start Loation - Main Base

Overheat, Satellite Recovery

3

Storyboard Title, Sequence, & Description

Recover Satellite Parts

The fallen satellite has multiple broken plates that the astronauts must remove with the appropriate tools to find the black box and some parts to recover.

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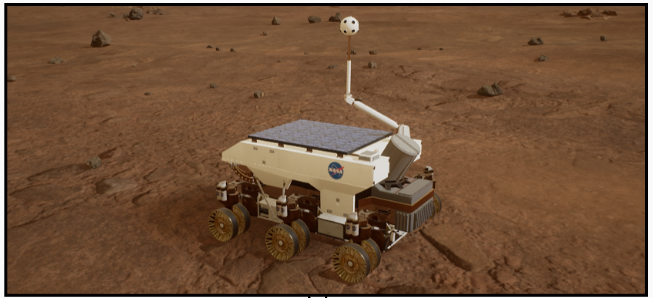
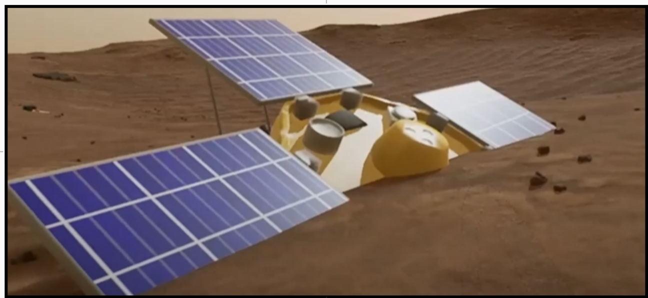


Assets Available in this Storyboard

- Fallen Satellite
- Satellite's Black Box
- Satellite's Broken Panels
- Satellite's Electrical Plate
- Screwdriver
- Screwdriver bits box
- Crowbar

3

1



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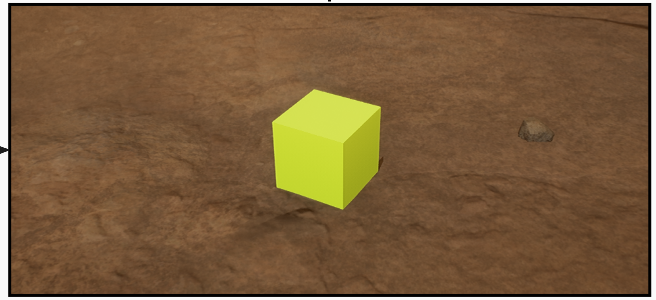

Actions Executable in this Storyboard

1. Open the toolbox
2. Grab the Crowbar, Screwdriver and bits box
3. Check the Satellite and look for the broken panels
4. Use the Screwdriver and the crowbar to remove the broken panels
5. Find the Satellite's Black Box
6. (Optional) Find useful parts
7. Leave the Satellite's Black Box in the CENTAUR
8. (Optional)Store the parts in the CENTAUR
9. Store the tools in the toolbox

4

Frame Descriptions

1 Fallen Satellite Location

2 Satellite's Black Box

3 Toolbox

4 Screwdriver + Bits box

5 CENTAUR Rover

Overheat, Satellite Recovery

Storyboard Title, Sequence, & Description

4

Return to the base

Once the recovery is finished, the astronauts can return to the base and save the black box and the satellite parts. Finally, they have to store the tools and leave the CENTAUR in his bay.

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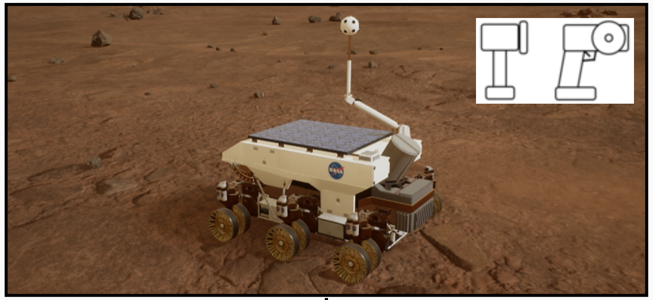
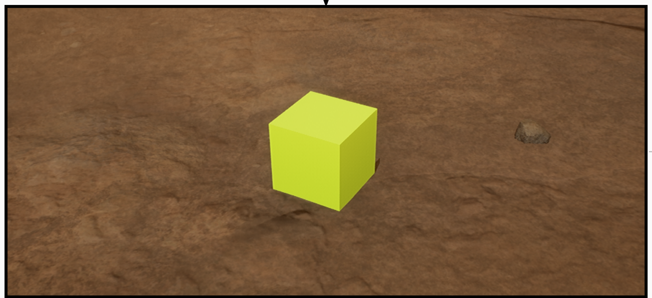


Assets Available in this Storyboard

- CENTAUR Rover
- CENTAUR Remote Controller
- Toolbox
- Satellite's Black Box

3



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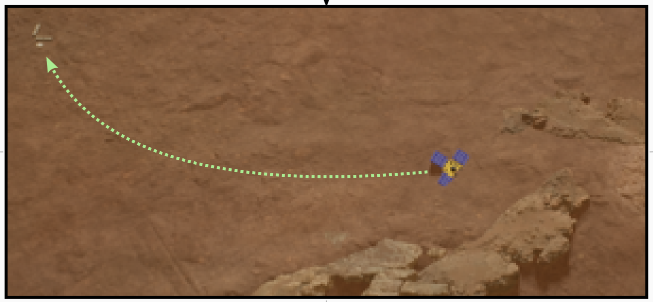
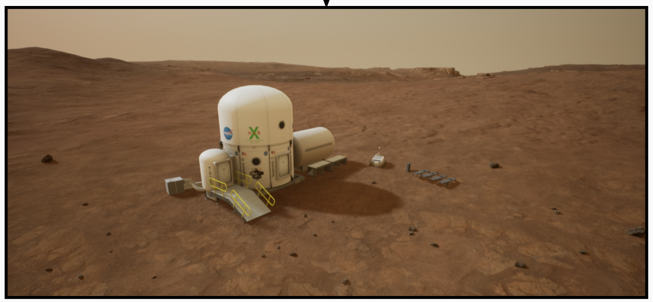


2

Actions Executable in this Storyboard

1. Use the CENTAUR remote controller to navigate back to the base
2. Store the Black Box
3. (Optional)Store the useful parts
4. Store the toolbox
5. Park the CENTAUR rover in his bay
6. Turn OFF the CENTAUR
7. Store the CENTAUR remote controller

4



Frame Descriptions

1 CENTAUR back Route

2 Toolbox

3 Satellite's Black Box

4 End Mission Location - Main Base

5 CENTAUR Rover + Remote Controller

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 Screwdriver

A useful tool that might be needed in Mars is an electric screwdriver. The screwdriver should be able to perform the following operations:

- Screw
- Unscrew
- Change power applied
- Change the bit

The different bits that can be applied to the screwdriver are related with the screws that are used, and they are both described in section 3.3.

The screwdriver should also be stored together with the bits and screws in a toolbox like the one in section 3.1.

Figure 3: Early version of the screwdriver model.

NOTE: when in the storyboards we talk about the action of "screwing", we actually mean the whole process of choosing the right bit, get the correct screw, place it in the whole, choose the correct power and mode for the screwdriver, and screw the screw in place. The "unscrewing" action is analogous, but removing the screw and storing it.

3.3 Screws and screwdriver bits

For the screwdriver described in section 3.2 to work, it's needed to have some bits and some screws. To make it more realistic, there should exist different types of screws and their corresponding bits.

Also, for this iteration of the contest, it could be more engaging if the screws are not automatically set in place or they despawn after the use, but rather that the astronaut needs to manually put it in place or remove it and store it in the box.

Both the bits and the screws could be stored in the same toolbox as the screwdriver, to have an easy access to the entire tool set.

3.4 Crowbar

This tool is mainly used for recovering damaged parts from machinery. There might be parts that are damaged enough that the astronauts won't be able to easily detach it, so the crowbar might help in those situations.

3.5 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 4 you can see a version of the actual model from the XOSS editor divided by pieces and fully mounted.

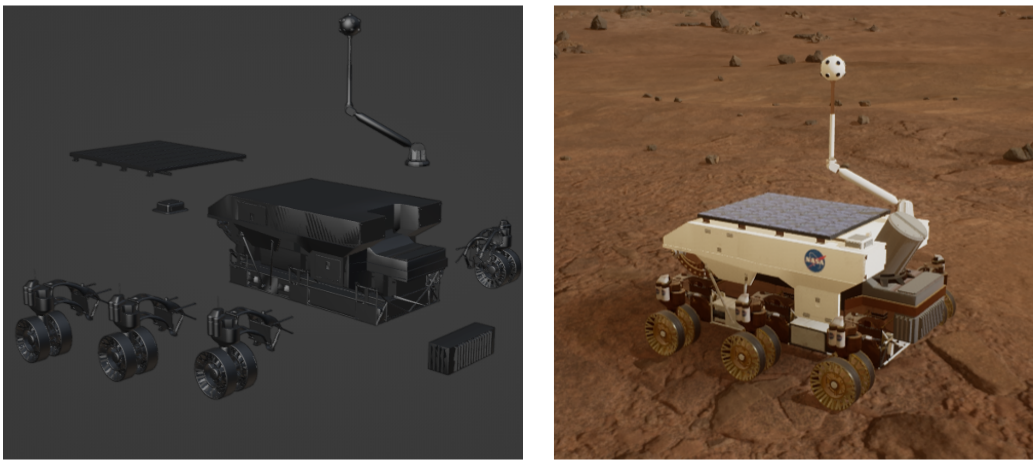


Figure 4: CENTAUR models. From left to right they are the model divided by parts and the model fully mounted and texturized in the XOSS editor.

The remote controller that will be used to move the CENTAUR rover is described in section 3.6.

3.6 CENTAUR controller

This prop is the remote controller of the CENTAUR rover (described in section 3.5). The idea is that it's able to control the rover's movement and other functionalities that it might have. In figure 5 you can see an sketch of the controller.

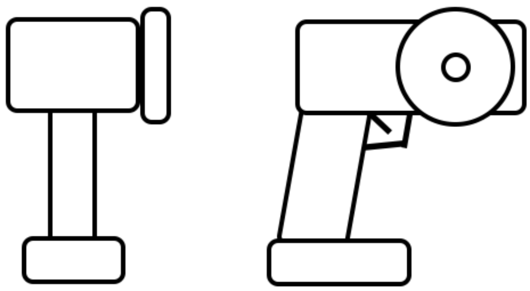


Figure 5: Sketch of the CENTAUR's controller. The image on the left is the rear view and the one on the right is the lateral view.

3.7 Drone

The drone is an asset that is already implemented in the XOSS editor, but it needs some modifications to work with our scenarios.

The drone needs to be remotelly controlled by the astronaut (using a remote controller that is explained in section 3.8). Also, it needs to have a camera to explore the surroundings of Mars and help the astronaut controlling it in farther places.

For the purpose of the scenarios, it should also be divided by parts, having the main frame of the drone, the propellers, and the camera as detachable parts. This will allow the astronaut repair it in case of malfunction, or mount it from scratch if it's the first time of use. In figure 6 you can see the drone divided by parts and fully mounted.

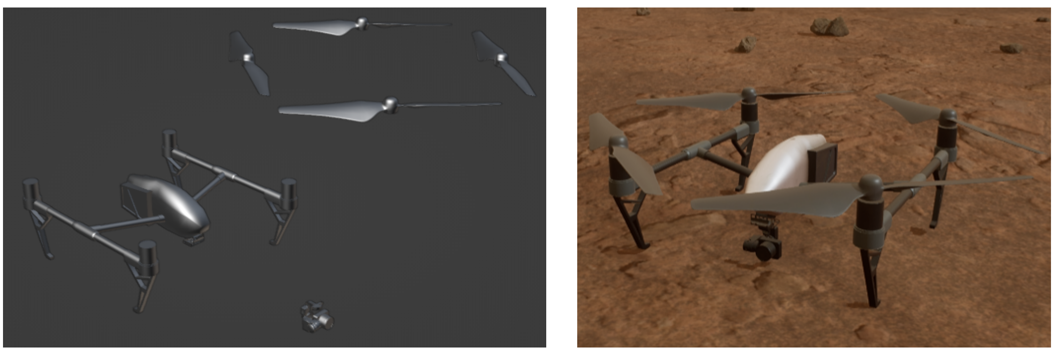


Figure 6: Drone models. From left to right they are the model divided by parts and the model fully mounted and texturized in the XOSS editor.

The drone could also have a LIDAR under it, to be able to scan the terrain more precisely than the scans made using the MRO.

3.8 Drone controller

This prop is the remote controller of the drone (described in section 3.7). The idea is that it's able to control the drone's movement and other functionalities loke the camera or the LIDAR. In figure 7 you can see an sketch of the controller.

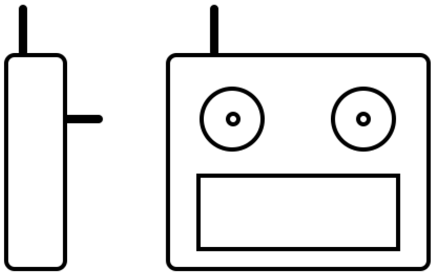


Figure 7: Sketch of the Drone's controller. The image on the left is the lateral view and the one on the right is the front view.

3.9 Fallen satellite and black box

The fallen satellite is a prop that should be placed a but far from the habitat. It needs to include some detachable parts that could be rescued.

For the scenario that we propose, inside the satellite there should also be a black box that the astronaut has to recover.

The black box (flight recorder) should have some connector sockets in it, in order to recover the contents that there are inside. Also, contrary to the flight recorders on Earth (that are usually painted in orange, to aid in its rescue), the box should be painted with a color that is highly contrasting to the Martian's orange color (like glossy lime) so that it stands out in the surface of Mars.

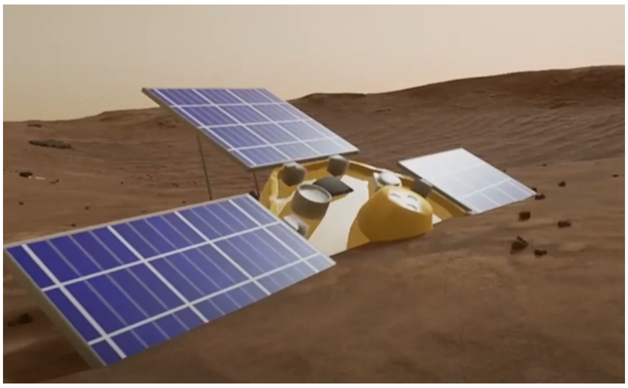


Figure 8: Image of a fallen satellite in the XOSS editor. The model was extracted from [3].

4 References

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