NASA MarsXR Challenge

Upgrades proposed for the martian
virtual training environment XOSS

Team: Overheat

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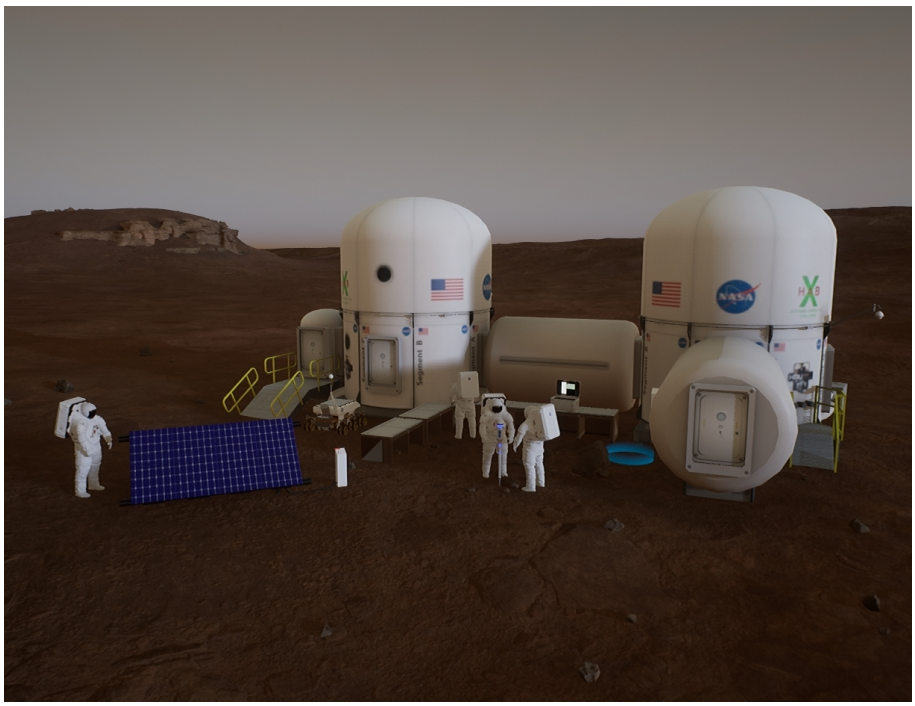

Contents

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: Maintenance

This storyboard is focused on doing maintenance tasks in the habitat. The three tasks that have been planned are:

- **Habitat maintenance:** The astronauts will have to check that all the systems of the habitat are correctly working, and will have to replace the filters from the oxygen generator to continue with an optimal production. Also, it will have to search for leaks in the pipe, and fix them.
- **CENTAUR rover maintenance:** The astronauts will need to check that the CENTAUR rover is working properly, and repair it in case that it's not. In this case, one of the wheels will be damaged, and will need to be replaced.
- **Solar panels maintenance:** The third thing to take care of are the solar panels. The habitat will have detected a decrease in the electricity production. To increase the effectivity, the astronauts will need to clean the solar panels using the compressed air cleaning tool and the mop. When they have finished, they will see an increase in the performance, but not the one that they expected. To ensure that everything is working, they will then need to check that the cables are in good condition (using visual inspection and other electrical tools, like detecting if there's current in the cable using a hall sensor). A wire will turn out to be damaged, and the astronauts will have to replace it.

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.
- **Percentage of cleaning:** Another metric that could be useful is how clean are the solar panels.
- **Effectivity of the solar panels:** As the solar panels had 2 problems, the effectivity of the electrical production is affected from both. This metric tries to make sure that the panels have been correctly cleaned and repaired.
- **Number of leaks fixed:** The number of pipe wholes that that the astronauts have covered.
- **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:

- **Calibration error:** One thing that could randomly happen is that the rover is not well calibrated. When the power up sequence is completed, the astronaut will have to test the robot. If this event happens, then the controls won't do as expected (for example, the go strait action will make the rover rotate). The astronaut will then have to follow some sequence of recalibration to make it work.

- **Malfunctioning part:** It might be possible that another part was malfunctioning, so the astronaut will need to replace it for a new one.
- **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, Maintenance

Storyboard Title, Sequence, & Description

1

Habitat maintenance

It's mandatory to perform maintenance to check all systems and confirm that everything is OK. For the habitat, the astronauts must ensure the O2 production is stable and the habitat is well pressurized.

Assets Available in this Storyboard

- Habitat
- O2 Generation Module
- Pressurization Console
- O2 Filters
- Toolbox
- Screwdriver
- Screwdriver bits box
- Tape

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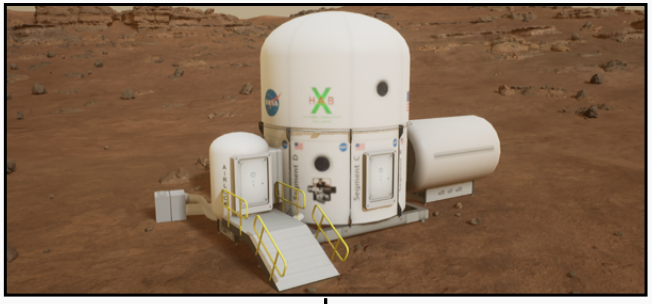

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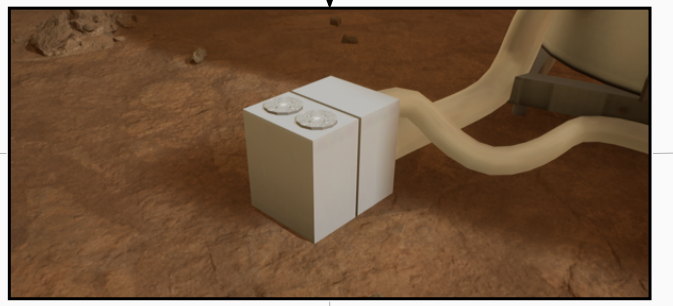

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Actions Executable in this Storyboard

1. Open the toolbox
2. Pick up the screwdriver and the bits box
3. Pickup the O2 filters
4. Pick up the tape
5. Change the O2 filter from the Oxygen generation modules
6. Check the O2 transport pipes looking up for leaks
7. Use the tape to stop the leaks
8. Check the habitat presurization console
9. Store the tape and the used filters

4

Frame Descriptions

1 O2 Generation Module

2 Habitat Pressurization Console

3 Toolbox

4 Screwdrivet + Bits Box

5 Mission Location - Main Base

Overheat, Maintenance

2

Storyboard Title, Sequence, & Description

CENTAUR Rover Maintenance

The astronauts should check all vehicles to make sure all are ready for the next mission. In this case, one of the wheels of the CENTAUR rover is broken and needs a replacement. The CENTAUR filter needs to be changed as well.

Assets Available in this Storyboard

- Screwdriver
- Screwdriver bits box
- CENTAUR Rover
- CENTAUR Repair Box
- CENTAUR Rover wheel
- CENTAUR Rover Filter

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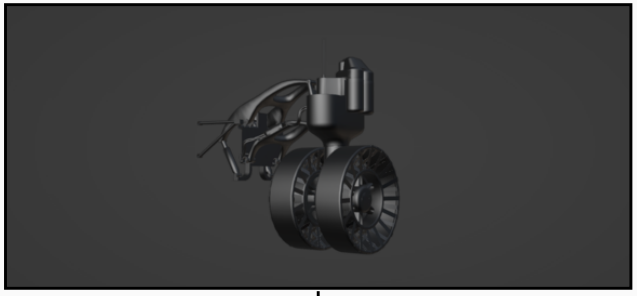

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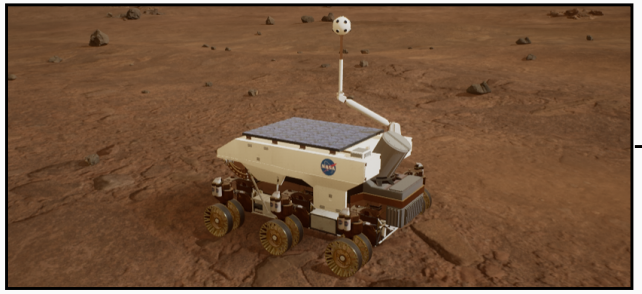

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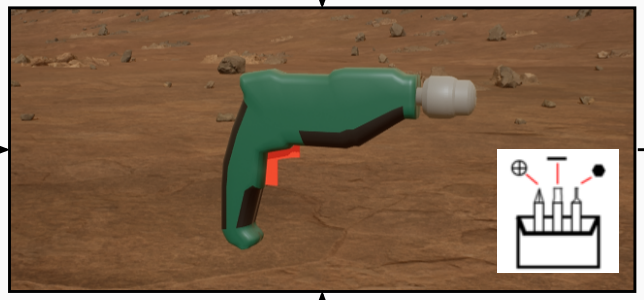

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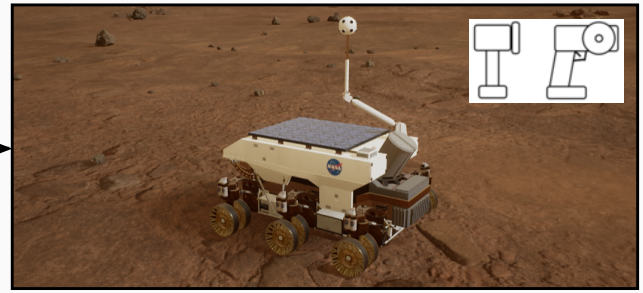

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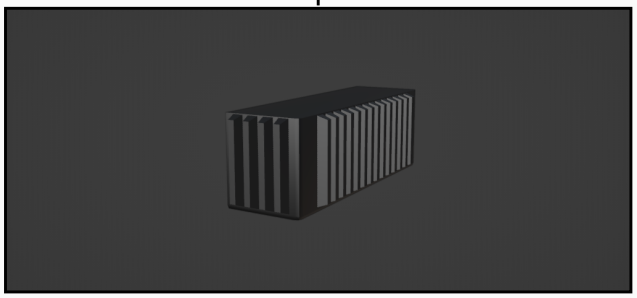

Actions Executable in this Storyboard

1. Turn ON the CENTAUR and check the main status
2. Turn OFF CENTAUR
3. Remove the CENTAUR filter
4. Use the screwdriver to remove the broken wheel
5. Open the CENTAUR repair box
6. Grab the new filter
7. Attach the filter in the CENTAUR
8. Grab the new wheel
9. Install the wheel using the screwdriver
10. Turn ON the CENTAUR and check the main status
11. Turn OFF CENTAUR
12. Store CENTAUR Controller and Screwdriver

Frame Descriptions

1 Screwdriver + Bits Box

2 CENTAUR Rover + Remote Controller

3 Malfunctioning CENTAUR Rover

4 CENTAUR Rover Filter

5 CENTAUR Rover Wheel

Overheat, Maintenance

3

Storyboard Title, Sequence, & Description

Solar Panels Manitenance

In the long term, solar panels lose effectivity because the sand accumulated from storms and time. The astronauts must do the proper cleanup to maintain the effectiveness of the solar panels and produce enough electricity.
It is also required check the electrical installation looking for malfunctions or bad connections.

Assets Available in this Storyboard

- Solar Panels
- Solar Panels Console
- Cleaning Machine
- Mop
- Cables
- Electrical failure detection tool

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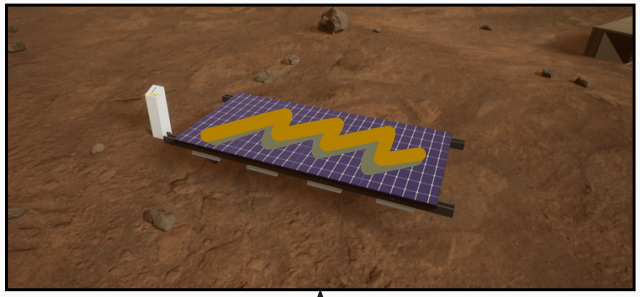

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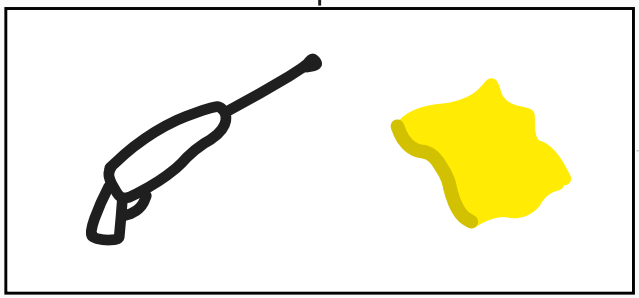

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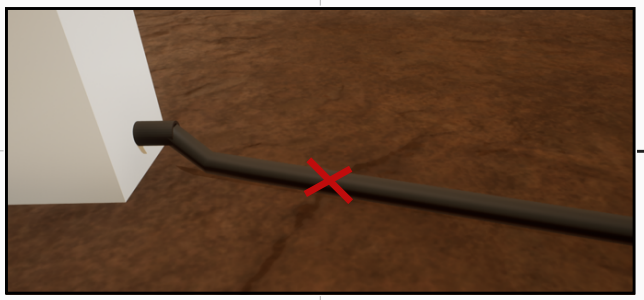

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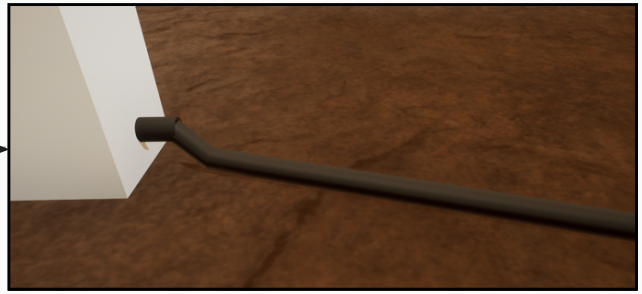

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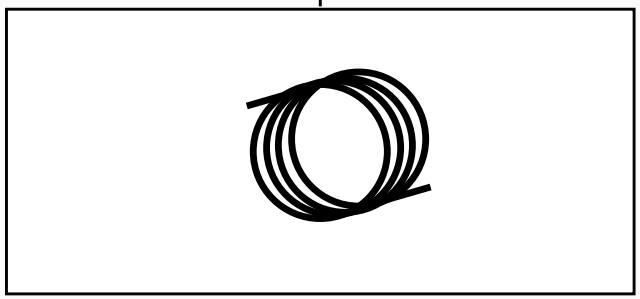

Actions Executable in this Storyboard

1. Grab the Cleaning Machine and the mop
2. Use high pressured air to clean up the solar panels
3. Use the mop to end the cleaning
4. Store the Cleaning Machine and the mop
5. Go to the console and check the current input/output
6. Look for any bad-looking cable (visual + technical inspection)
7. Turn OFF the electricity
8. Remove the cable
9. Grab a new cable
10. Install the new cable
11. Turn ON the electricity
12. Go back to the console and check the current input/output

Frame Descriptions

1 Broken Cable

2 Repaired Cable

3 Cleaning Machine + Mop

4 New Cable

5 Dirty Solar Panels

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.

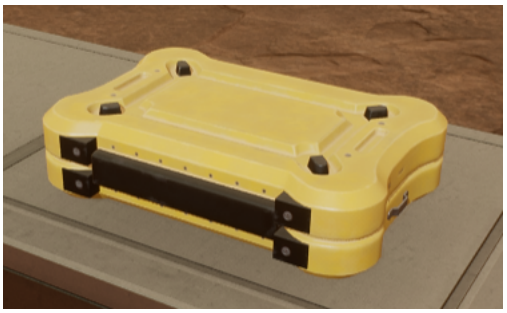

Figure 2: A model of a toolbox from the XOSS editor.

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 Tape

Just tape. Nothing else to add.

3.5 Electrical failure detection tool

This tool will enable the astronaut inspect the electrical wires and detect if a wire is conducting electricity or not (using for example the hall effect).

3.6 Dust cleaning machine

This tool is a gun shaped tool that gets air from the environment, compress it, and throws the air steam through the pipe, to remove the dust from different surfaces, such as the solar panels.

3.7 Mop

This prop is another tool for cleaning surfaces (like the solar panels). It is a regular mop that can be used to eliminate particles that weren't detached after cleaning with the dust cleaning machine explained in section 3.6.

If someone wants a more complex mop, an alternative could be a tool that cleans the dust particles using electrostatic charges. Look at the reference [7] for more information.

3.8 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.

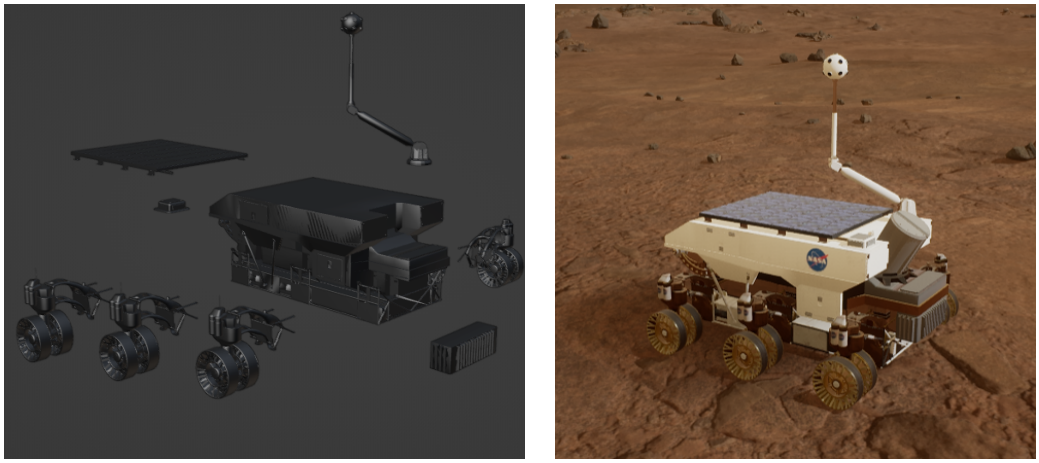

Figure 4: CENTAUR models. From left to right they are the model divided by parts and the model fully mounted and texturized in the XOSS editor.

The remote controller that will be used to move the CENTAUR rover is described in section 3.9.

3.9 CENTAUR controller

This prop is the remote controller of the CENTAUR rover (described in section 3.8). 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.

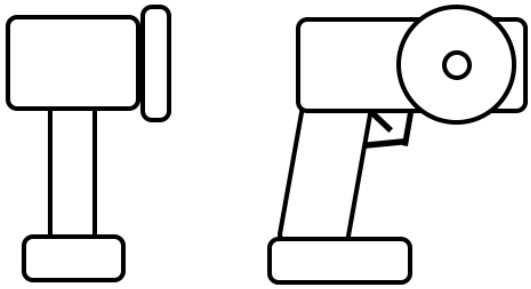

Figure 5: Sketch of the CENTAUR's controller. The image on the left is the rear view and the one on the right is the lateral view.

3.10 O_2 generation module

This prop is a machine attached to the habitat that collects air from the martian atmosphere and pumps the oxygen into the habitat's oxygen deposit.

The prop has some filters inside (which will be further described in section 3.11) and some tubes connecting it with the habitat. The filters should be removable after taking off the screws, and the tube should have some parts that can break, so the astronauts can train the reparation of pipe leaks.

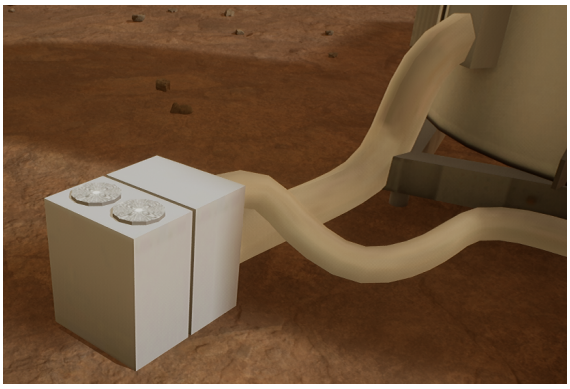

Figure 6: Image of the O_2 generator module and air tubes in the XOSS editor. The model was extracted from [3].

3.11 O_2 filters

The oxygen filters are a prop that fit inside the oxygen generator module explained in section 3.10.

They should be detachable from the generator after all the screws have been removed, or completely fixed once they are in place and tightly secured with the screws. These filters are used to stop particles from entering the oxygen generator module, so they should be changed and cleaned periodically.

3.12 Pressurization console

This prop is a console attached to the habitat which controls the pressure inside. It has a display that shows the pressure, and some buttons to receive input in case that the astronauts want to change the pressure inside.

3.13 Cable

This prop is an electric wire that is mainly used for the solar panels connection, but it can also be used in other electrical systems. It should be attachable to the habitat and the extension sockets (which are explained in section 3.14).

3.14 Extension sockets

To connect the solar panels with the habitat, instead of using 1 long cable, we propose to use some electrical extension sockets. These sockets should be attached to the ground, to avoid having the cables floating away when there is a bit of wind.

This also helps the astronauts in the reparation, as if a cable is damaged, it will be easier to change a small cable rather than a long one.

3.15 Solar panels array

This prop is one of the props that we assume that are already on the scene (except if the mission is to mount them from scratch). They produce energy to the habitat, but the amount of energy depends on how clean they are.

So, these solar panels need get dirty over time, so that the astronauts need to go on an EVA mission to clean them.

Also, it might be possible that during the martian mission some wires get damaged, which would also cause the amount of electricity produced to be lower. The astronaut then would need to locate the damaged cable and replace it.

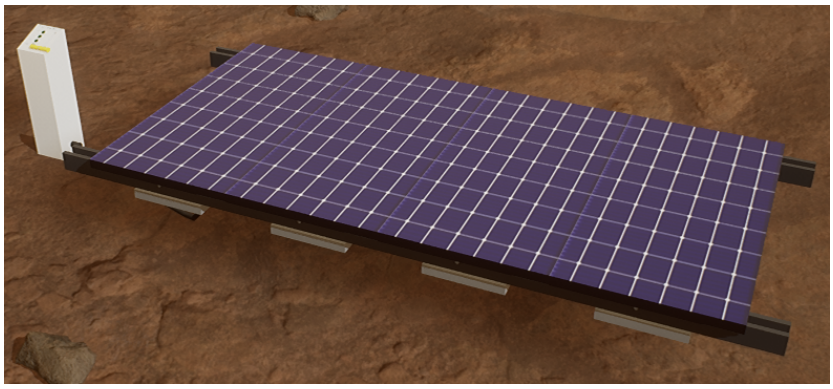

Figure 7: Image of the solar panel array already mounted in the XOSS editor. The white console will be explained in section 3.16.

Apart from the cleaning and damaging properties of this prop, the asset should also be designed by parts, so it can be assembled or disassembled (for repair, for example). Our vision of the asset is that there will be a main support structure connecting the array to the power, and with some mobile parts to follow the trajectory of the sun (to get more sunlight, and there fore, more energy). There will also be a frame to easily mount the panels. And finally there will be the solar cells, which can be attached to the frame, and connected to the base structure via some cables.

3.16 Solar panels console

This console is an important part of the solar panels system. The solar panel array gets connected to this console, and it is the one in charge of orienting the panels in the correct position, and also enable the current flow to the base. In case that an astronaut want to pause the electrical supply to the habitat (due to a reparation for example), it should be controlled from this console.

A model of the console can be seen in figure 7.

4 References

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