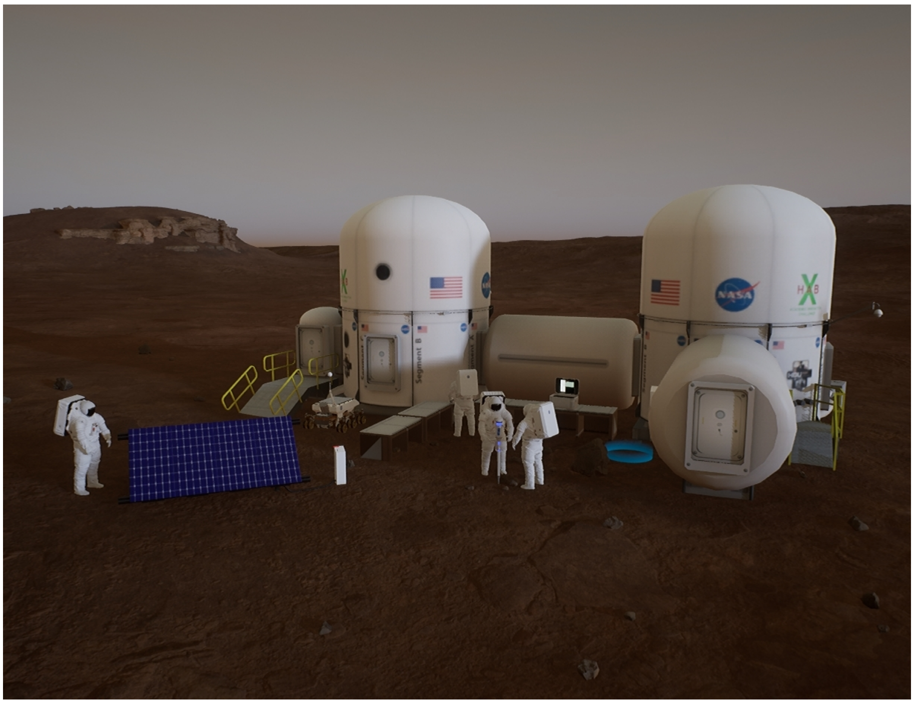
NASA MarsXR Challenge

Upgrades proposed for the martian
virtual training environment XOSS

Team: Overheat

Members:
Omar Gil Sturlese
Pol Sturlese Ruiz



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: Extended solar panel installation

This storyboard is focused on installing a solar panel array to produce electricity to the habitat. This time, the astronauts will need to first find a suitable place to mount the panels, then transport all the materials there, unbox them (with boxes that won't magically disappear, but that they will have to clean after the installation), mount them, connect them to the base and clean everything.

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 screws screwed:** Another metric that could be useful is how tight are the screws (globally). Every screw can have a percentage of how screwed it is (0% being completely outside, 100% being completely inside and tightly fixed). The astronauts can decide when to stop screwing, but if the screws are not well fixed, it could have some bad repercussions during the mission. The metric would be then the average of percentage of every screw.
- **Number of extensors placed:** Another metric could be how many electric externsor sockets have been placed. It is important to minimize the material that is sued, so a large number might indicate an inefficient placement.
- **Meters of wire used:** Related to the metric above, this will track the total length of cable used. As before, the more cable is used, the worse it will be.
- **Array's angle:** The solar panel array that we have designed can rotate on 1 axis, to follow the Sun's trajectory. If the array is placed perpendicular too the sun's trajectory, the rotation will match the trajectory path, and the panels will be more efficient. So the angle of placement will directly affect on the solar panel's effectivity.
- **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 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

Storyboard Title, Sequence, & Description

1

Mission preparation: place finding

The first thing to do before mounting the solar panels is to find the right place to do so. The idea is then to find a place near the habitat, take some photographs of the place chosen for documenting the process, mark the zone with some flags and visualize and correctly decide where to place the solar panels using the suit's AR capabilities, projecting the finalresult into the martian ground.

Overheat, Extended solar panel installation

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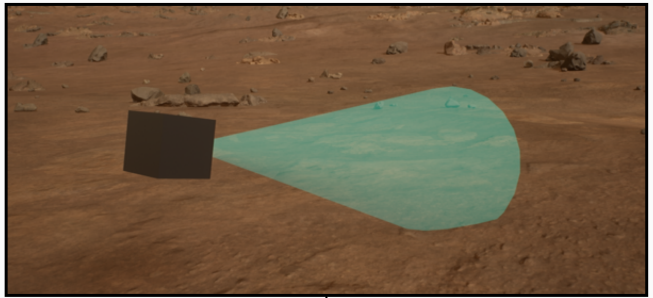
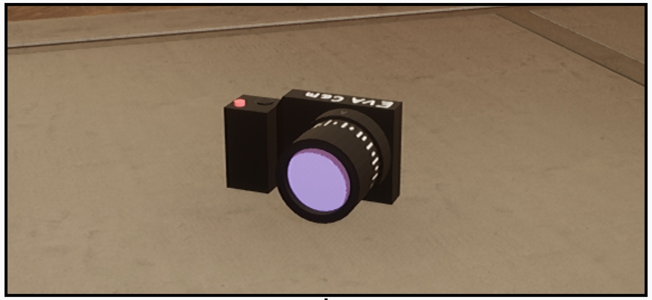


Assets Available in this Storyboard

- Toolbox
- Camera
- Flag markers
- AR tool set

3



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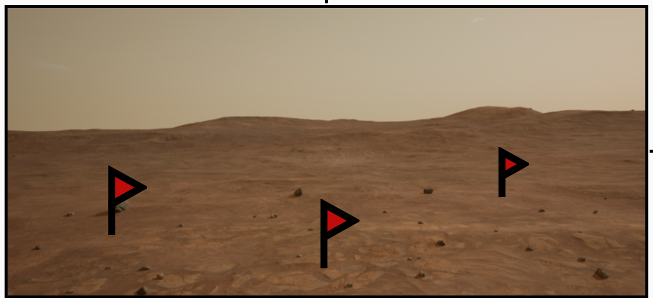

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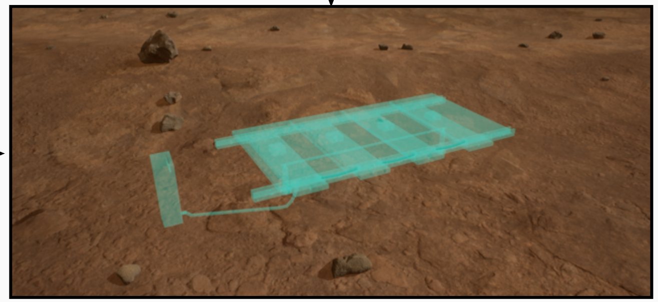
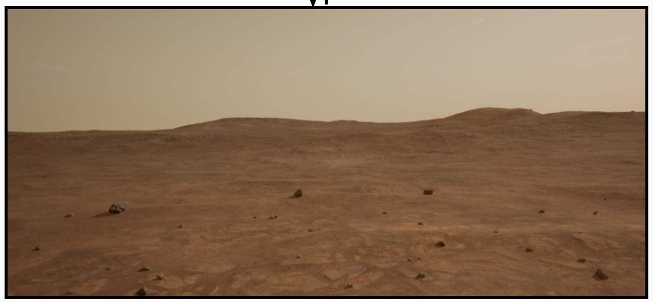


Actions Executable in this Storyboard

1. Open the toolbox
2. Grab the camera, the flags, and the AR tracking tool set
3. Search for the right place to mount the solar panels (they should be near the habitat, to minimize the length of the power cables, but far enought to not be affectetd by the shadows). A recomended place could be marked in AR
4. Take some pictures of the empty zone
5. Put some flags on the zone
6. Deploy the AR tracking set
7. Choose where the solar panels will be mounted
8. Store the tools

4



Frame Descriptions

1 Flags in the marked zone

2 Solar Panels Holographic View

3 Camera

4 Possible Mount Area

5 AR Tool Set

Overheat, Extended solar panel installation

Storyboard Title, Sequence, & Description

2

Tool and material gathering

The idea is to go to the tool's shed and grab all the tools that will be needed to mount the solar panels.
In the shed there will also be the "CENTAUR", a rover operated by remote control that will be used to transport the tools and materials

Assets Available in this Storyboard

- CENTAUR Rover
- CENTAUR Remote Controller
- Toolbox
- Screwdriver
- Screws
- Screwdriver bits box
- Box
- Panel structure set
- Solar panel cell
- Frame beam
- Cable extensor set

5

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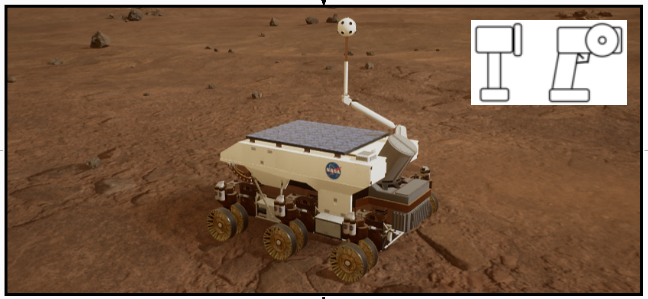

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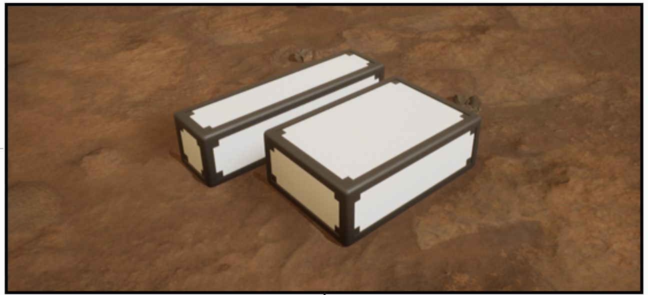
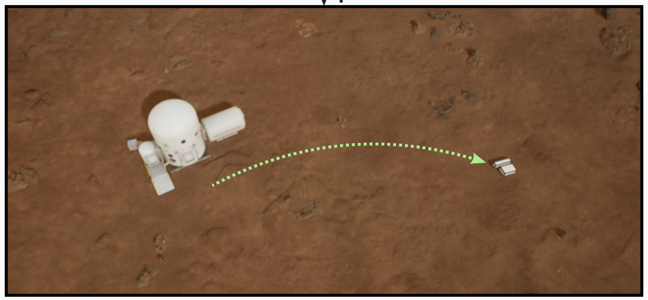


Actions Executable in this Storyboard

1. Get CENTAUR's remote controller
2. Turn ON CENTAUR and check that it boots correctly
3. Open the toolbox and get all the necessary tools (you might place the tools on CENTAUR's transportation space)
4. Locate the boxes with the solar panel parts and load them onto the CENTAUR.
5. Exit the shed with the tools, materials and the CENTAUR (remotelly controlled)
6. Go to the installation site

NOTE: Maybe more than one trip is needed to bring all the material

4



Frame Descriptions

1 CENTAUR Rover + Remote Controller

2 Boxes

3 Screwdriver + Bits Box

4 CENTAUR Route

5 Toolbox

Overheat, Extended solar panel installation

Storyboard Title, Sequence, & Description

3

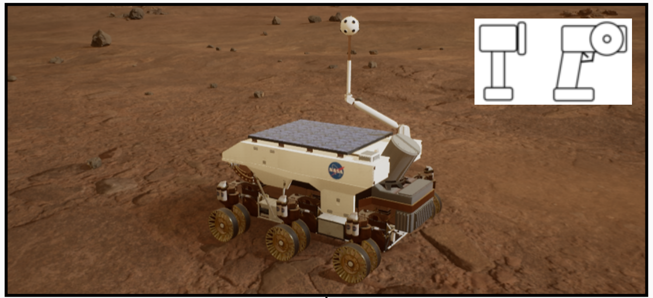
Unboxing

Once the astronauts are in the installation site, they will have to unbox all the different components and prepare the tools to mount them all

Assets Available in this Storyboard

- CENTAUR Rover
- Screwdriver
- Screwdriver bits box
- Screws
- Box (entire and parts)
- Panel structure set
- Solar panel cell
- Frame beam
- Cable extensor set

5



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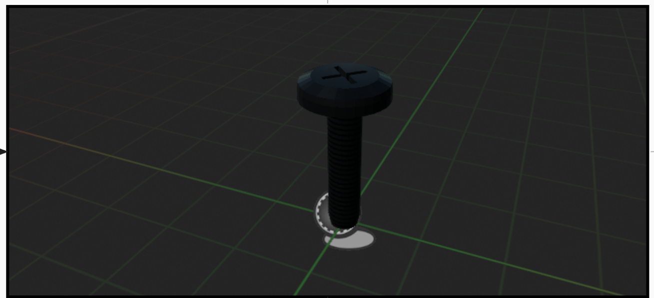

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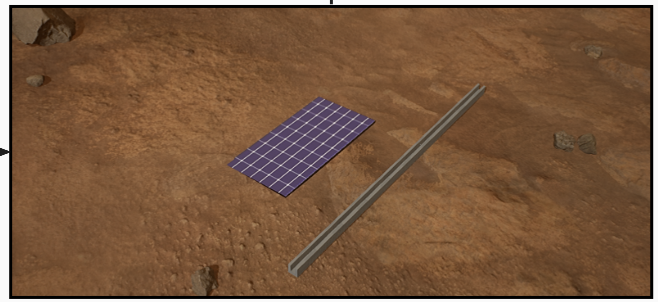

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Actions Executable in this Storyboard

1. Unload all the boxes with the components
2. Plug the correct bit to the screwdriver
3. Open all the material boxes (by unscreweing the fixing bolts and storing them).
4. Put the opened parts from the boxes on the rover's storage (to maintain a clean work space)

Frame Descriptions

1 Screw (+)

2 Solar Panel Cell + Structure Beam

3 Screwdriver + Bits Box

4 Boxes

5 CENTAUR Rover + Remote Controller

Overheat, Extended solar panel installation

Storyboard Title, Sequence, & Description

4

Mounting the solar panels

Once everything is prepared, the astronauts will need to mount the solar panels. For this, they will have to fix the base into the ground, mount the structure frame for the cell, connect the cells to the electrical sockets and finally place the cells in the corresponding frame (fixing everything tight and secure in all these steps)

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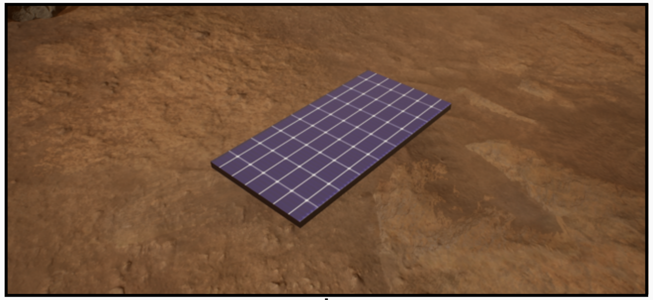
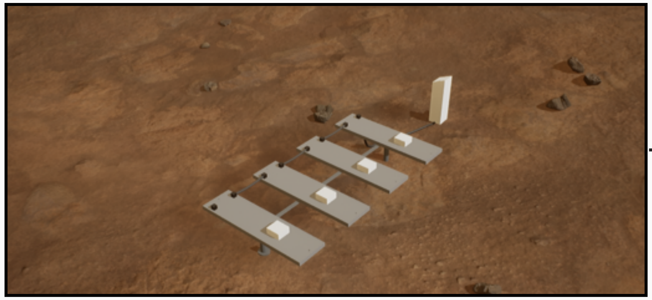


Assets Available in this Storyboard

- Screwdriver
- Screwdriver bits x3
- Screws (x3 types)
- Panel structure set
- Solar panel cell
- Frame beam

3



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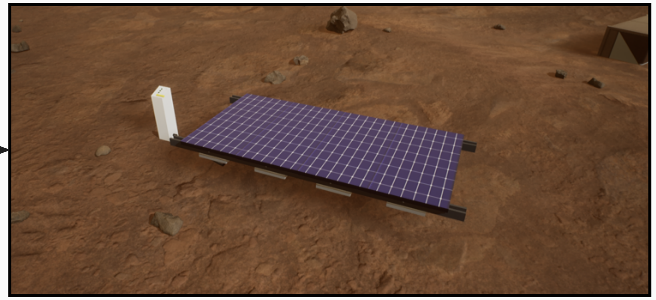
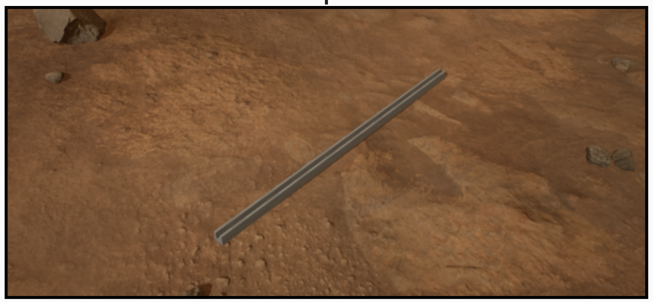


Actions Executable in this Storyboard

1. Change the tip of the drill/screwdriver to an appropiate one.
2. Place the structural base and fix it into the ground using the drillable screws (they will be drilled into the soil to stay fixed).
3. Change the bit again, now for the frame's screws.
4. Place the frame parts into place and screw them tight.
5. Change the bit again, nor for the cells' screws.
6. For every cell that will fo in the frame:
   a. Connect the cell's cable to the socket in the frame
   b. Place the cell in its corresponding place and fix it
7. Repeat this as many times as solar panels arrays you want to build

4



Frame Descriptions

1 Screwdriver + Bits Box

2 Mounted Solar Panel Array

3 Panels Structure Set

4 Beam

5 Solar Panel Cell

Overheat, Extended solar panel installation

Storyboard Title, Sequence, & Description

5

Electrical connections and activation

After having the solar array mounted, it´s needed to connect it to the habitat. For that, the astronauts will need to use the cable extensions, and connect each array with the habitat's power panel. From there, they can activate the panels, boot the system, and check that everything is working.

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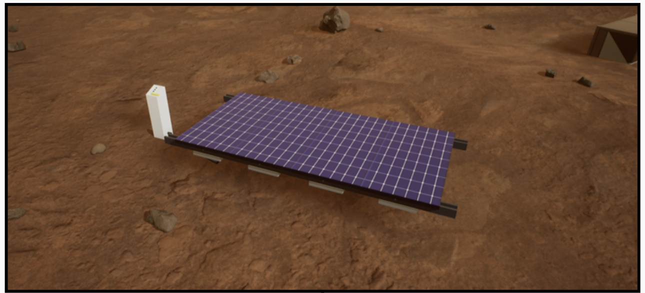

Assets Available in this Storyboard

- Cable extensor set (cable + sockets)
- Screwdriver
- Screws
- Screwdriver bits box
- Panels power control computer
- Solar panel array (already mounted)

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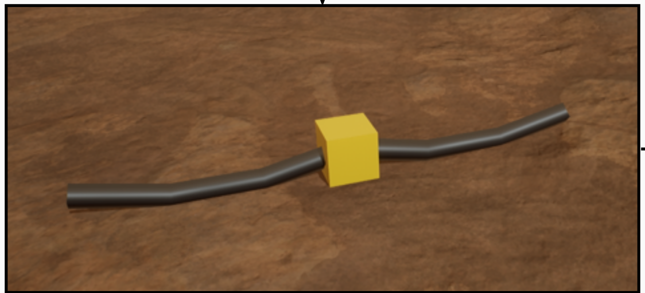

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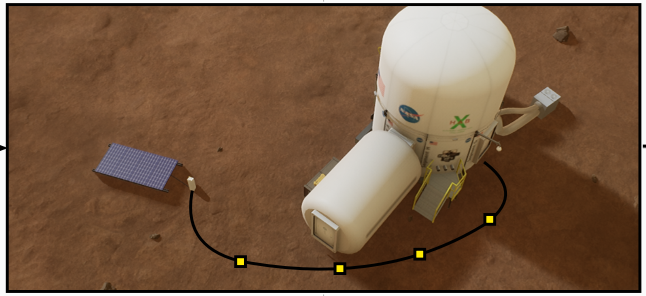

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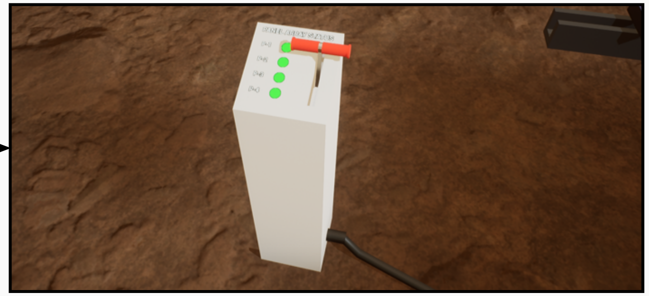

Actions Executable in this Storyboard

1. Placce some extension sockets in the ground making a path from the solar panels until the habitat, and fix them.
2. Connect the solar panel array with the habitat, making use of different cables and following the path created by the extension sockets.
3. Activate the solar panel arrays
4. Check that everything is correctly working.

4

Frame Descriptions

1 Extensors Path

2 Panels Power Control Computer

3 Extensor

4 Screwdriver + Bits Box

5 Mounted Solar Panel Array

6

Storyboard Title, Sequence, & Description

Tidy the work space and store the tools

Once everything is working, the astronauts need to tidy the workspace, pick up the flags, the AR tracker, and the remaining box parts, and store it all

Overheat, Extended solar panel installation

5

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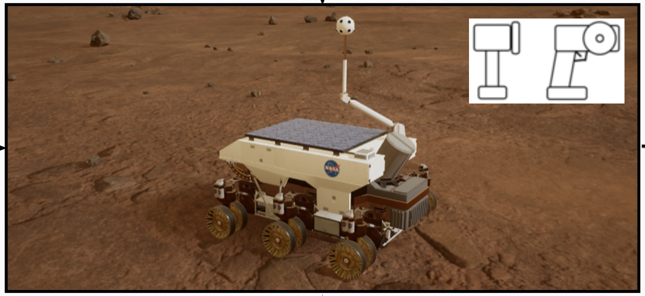

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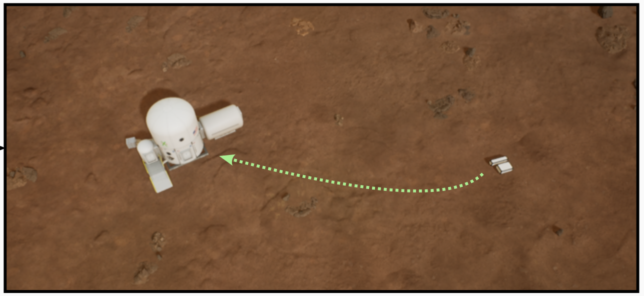

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Assets Available in this Storyboard

- Flag markers
- AR tool set
- Box parts
- CENTAUR Rover
- CENTAUR Remote Controller
- Toolbox
- Screwdriver
- Screws
- Screwdriver bits box

Actions Executable in this Storyboard

1. Store all the tools in the CENTAUR
2. Pick up the flags and the AR tracker
3. Pick up any box part left on the ground, and put it on the CENTAUR with the other box parts
4. Return to the base with the CENTAUR
5. Unload everything from the CENTAUR and store it in the right place
6. Park the CENTAUR in its spot, power it off and return the remote controller

Frame Descriptions

1 CENTAUR Rover + Remote Controller

2 CENTAUR Back Route

3 Toolbox

4 Screwdriver + Bits Box

5 Empty Boxes

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 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 4: A model of the camera from the XOSS editor.

3.5 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.

3.6 AR tool set

One of the uses of the AR technology is to visualize virtual objects in real scale. For this reason, we propose to add this prop.

We don't know how the AR on the helmet will work. However, AR needs to do tracking, and depending on the time and conditions, it might be difficult to do a correct tracking in the martian surface. However, by adding this tool set, we could add some points that the helmet can track, and therefore correctly display the buildings that will be constructed in the desired place and with the correct scale.

3.7 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 5 you can see a version of the actual model from the XOSS editor divided by pieces and fully mounted.

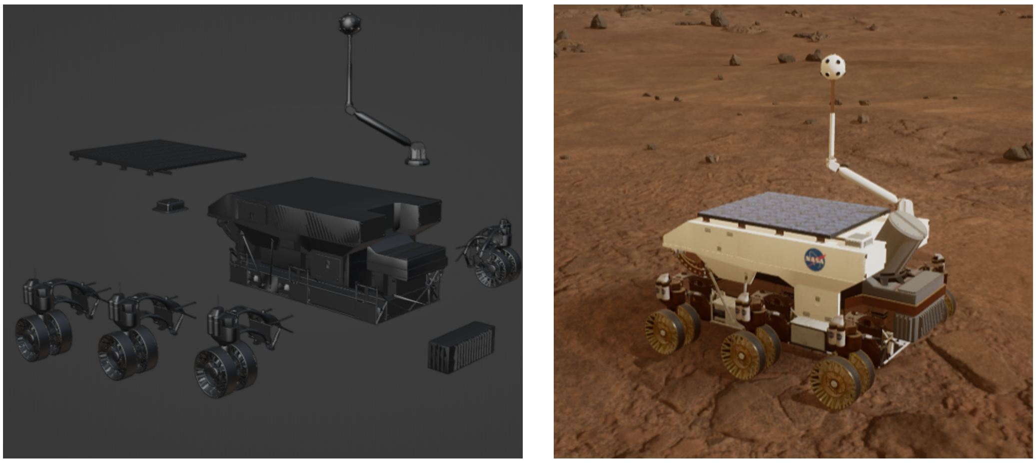

Figure 5: CENTAUR models. From left to right they are the model divided by parts and the model fully mounted and texturized in the XOSS editor.

The remote controller that will be used to move the CENTAUR rover is described in section 3.8.

3.8 CENTAUR controller

This prop is the remote controller of the CENTAUR rover (described in section 3.7). The idea is that it's able to control the rover's movement and other functionalities that it might have. In figure 6 you can see an sketch of the controller.

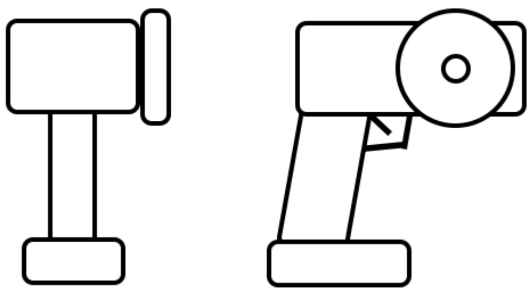

Figure 6: Sketch of the CENTAUR's controller. The image on the left is the rear view and the one on the right is the lateral view.

3.9 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 3.10).

3.10 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.

3.11 Box

This prop is a modular box that contains different materials or samples. The astronauts should be able to disassemble it and take each part individually, so they can recycle the box once the materials are outside of it.

To assemble it or disassemble it, it could be programmed to work with the screws and the screwdriver, so it makes sense that the box can hold sensible materials.

The box should be able to be instantiated in different sizes, as not every object has the same dimensions. In figure 7 you can find some examples of the boxes.

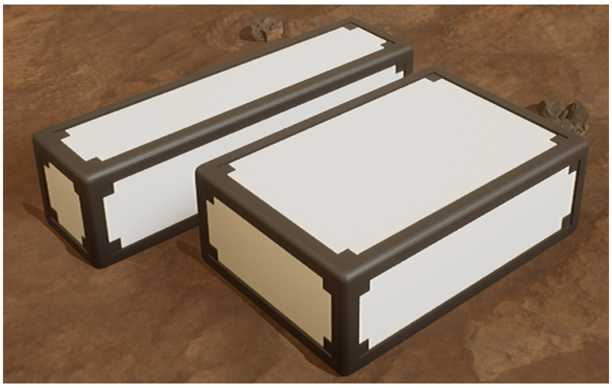

Figure 7: Two boxes of different sizes in the XOSS editor.

3.12 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.

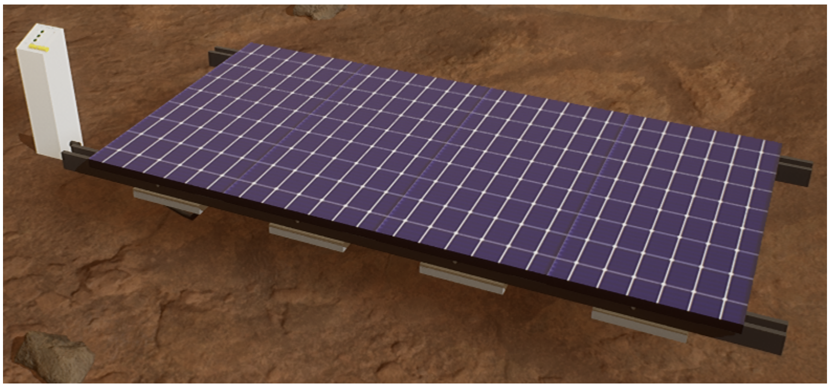

Figure 8: Image of the solar panel array already mounted in the XOSS editor. The white console will be explained in section 3.13.

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.

3.13 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 8.

4 References

[1] Exploration eva system concept of operations. https://www.nasa.gov/sites/default/files/atoms/files/eva-exp-0042_xeva_system_con_ops_rev_b_final_dtd_10192020_ref_doc.pdf.

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