

**3D ANIMATION AND ENVIRONMENT MODELING FOR VISUALIZING
HUMAN SURVIVAL SCENARIOS ON MARS: A RESEARCH-DRIVEN
VISUALIZATION FRAMEWORK, MARS100**

BY

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This Report Presented in Partial Fulfillment of the Requirements for the
Degree of Bachelor of Science in Multimedia and Creative Technology

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APPROVAL

This Project titled "3D Animation and Environment Modeling for Visualizing Human Survival Scenarios on Mars: A Research-Driven Visualization Framework, MARS100", submitted by Md. Tuhin Islam to the Department of Multimedia and Creative Technology, Daffodil International University, has been accepted as satisfactory for the partial fulfillment of the requirements for the degree of B.Sc. in Multimedia and Creative Technology and approved as to its style and contents. The presentation has been held on 27th December 2025.

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I hereby declare that, this project has been done by me under the supervision of **Mr. Arif Ahmed, Professor of Practice, Department of MCT** Daffodil International University. I also declare that neither this project nor any part of this project has been submitted elsewhere for award of any degree or diploma.

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ABSTRACT

MARS100 is a research driven 3D simulation and animation project for simulating viewable realistic human survival situations on Mars by blending new scientific research and cinematic storytelling. As a student currently working on this framework, I consider this to be another way to represent how future Martian habitats and life support systems may function based on the data from current aerospace investigations, engineering proposals, and tech demos from the National Aeronautics and Space Administration. The simulation is based heavily on the JEANNE Habitat Design (2022), the MOXIE Oxygen ISRU experiment (2021) as well as ice mining and water extraction research, and hybrid solar - nuclear power research. Those sources provide an environment for modelling important elements of survival, such as the production of oxygen, recovery of water, greenhouse-based food systems, recycling of waste, mobility, and power generation. The project goes down a complete 3D production pipeline towards pre-production research, scriptwriting, concept development, modeling, texturing, simulation, environment design, lighting and real-time rendering. Even though the foundation consists of sound science, the end result is delivered as cinematic storytelling, with well-heeled voice over, as well as storytelling per scene to make complex processes accessible and visually interesting for the viewer. By combining the scientific accuracy with an artistic form, MARS100 creates a holistic visualization framework that not only emulates critical survival systems for Mars habitation, it enhances a greater understanding of future off-world habitation in the public domain as well. We do this through 3D environments and narrative driven design and give people a good visual idea of what life might actually look like on Mars.

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CHAPTER 1

INTRODUCTION

1.1 Background Study

3D animation has become a pretty huge tool for telling stories in the visual world, particularly in the realm of science, architecture and tech demos. It's not only for cool movies but studies also show it helps to break down hard science issues, the guts of buildings and of technology in the future in a way that's easy to understand. Big space players like the spaceflight agencies are using it more for things like showing how a mission's layout looks, designing habitats, planning in-situ resource use (ISRU) tech and sharing planetary data from all over the world to keep everyone in the loop [1]. NASA's Scientific Visualization Studio, and the Eyes on the Solar System site are perfect examples of how taking real scientific data and visualizing it into interactive, animated stuff can make it an engaging lesson in and of itself [2].

The global appetite for 3D animation has been shooting upwards thanks to tech that drives real-time rendering, virtual production and simulation into new territory. A 2024 report by MarketsandMarkets claims that the 3D animation industry was valued at about USD 22.3 billion in 2023; it is poised to reach around USD 44.8 billion by 2028; all thanks to the breakthroughs of VR/AR, the mandatory use of AI to assist and execute workflows as well as its application in aerospace, research and education [3]. Statista's 2024 data backs up and more and more use of animation to report science news, space news blogs, and digital learning, as it can help make complex tech simple for non-tech [4].

Mars is still the star of all "future of humanity" talk. With earth's climate problems escalating along with people's interest in off-world life, the whole world is watching very intently as to how we plan a mission to Mars and build habitats there. NASA, ESA and SpaceX are all pushing on with mission blueprints, crewed habitat designs, rover-style mobility systems and ISRU tech to support humans for months or years on Mars [5]. Recent research programmes like that of the JEANNE Habitat Design at the Space Station or the MOXIE oxygen generating experiment and PRIME-1's ice mining gear provides people with concrete ideas on what we might do with stuff we might find on Mars to keep people alive [6][7][8].

In this entire context MARS100 becomes an outstanding research-centric visual project that transforms vetted science into a 3-D simulation and animation of human survival on Mars. It combines sound bits of information with storytelling leading narrative scenes to lead the viewer through core survival systems - oxygen, water, food grown by plants, waste, shape of habitats and power plants. And, We are blending our animation and simulation knowledge to develop a visualization of mars and also illustrating the possible habitation of human in mars.

1.2 Rational and Motivation

The Main Motivation behind the creation of MARS 100 is purely personal interest and career enhancement and the rising significance of 3D animation in science communication and space representation. Increasing Public Interest and Investment by Space Agencies. The interest of people in exploring Mars has never been greater, due to the Hollywood blockbusters *The Martian* and *Interstellar*, or series on Netflix such as *For All Mankind* and *Away*. These two shows, amongst others, are desperate in their desire to have stories that would be a combination of real science and a good drama. Simultaneously the aerospace related organizations like NASA and ESA but also companies like SpaceX and others rely on 3D animation and simulations to depict a mission blueprint, spacecraft layout or future home.

The system NASA has used in this instance in the form of its animation which is the system of the NASA Eyes on the Solar system and Scientific visualization studio in this case is an animation digital media solution and application that transforms complex scientific data into simple visual contents that are easily understandable by all members of the society. There is a booming market of 3D animation, and its market size today stands at USD 22.67 billion in 2023, with a subsequent growth to USD 40-44 billion in 2029, with a CAGR of 11.8-13.7 per annum. The entertainment, gaming, education, architecture and scientific visualization demand is there, and new technologies, which also offer virtual reality and augmented reality, enhance the role of animation, which consists of complex communication.

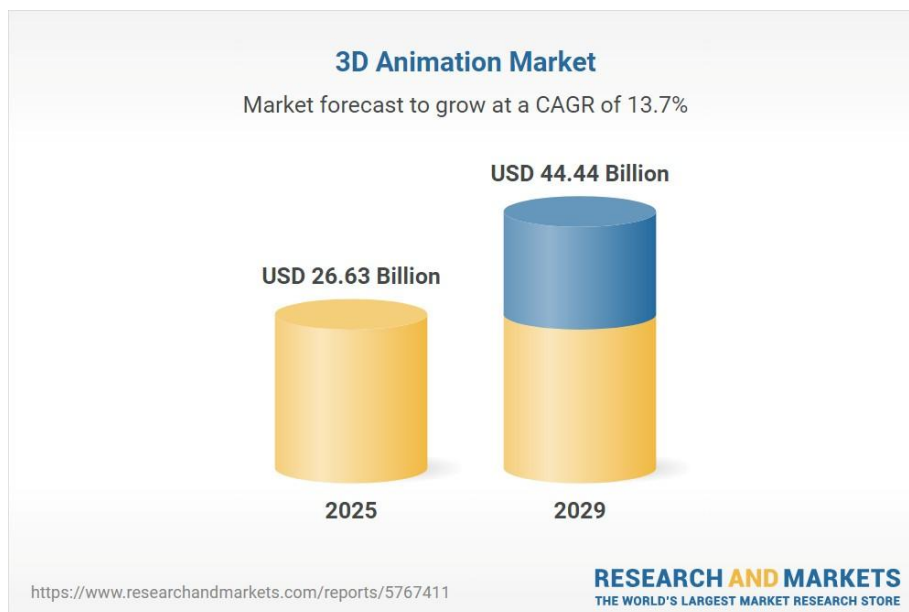


Figure 1.2.1: 3d Animation future market demand

Skills-so far as students-of Multimedia and Creative Technology (we have been developing our high-level technical skills regarding the 3D modeling, animation, texturing, lighting, and rendering etc.). In MARS 2100, we are using these skills to synthesize a high bar scientific-fiction approach to research with epic cinematic narrative presentation to showcase our future of exploration into space. The program will entail allowing multimedia producers in Bangladesh to catapult into a global scale of space visualization and science communication regarding the contents production.

1.3 Objectives of the Project

The main objective of “MARS100” Project is to create a research-driven 3D simulation and animation framework that visualizes realistic human survival scenarios on Mars. Through the project, we will bring scientific studies - from the JEANNE Habitat Design and the MOXIE oxygen generation experiment to ice mining technology, Martian greenhouse agriculture and hybrid solar nuclear power systems to life as a visual story accessible to all using cinematic techniques. We have also some supportive objectives on it and they are.

1. To communicate with science in the form of a cinematic voice over and scene-based storytelling approach to educate & engage a broad audience.
2. Establishing the viability of 3D animation and research as a visualization tool for future concepts of habitation in the Martian environment.
3. Creating an internationally competitive example of research-based 3D animation in Bangladesh.

1.4 Scope and Limitations

Within the framework of my present research project, we are working on a design paper of a habitation module, which will be named the JEANNE concept, and will deploy an early crew habitat during October 2033. Internal and external spatial planning, the major life-support subsystems, such as the MOXIE oxygen production, the water repossessing units, and the greenhouse/recycling modules power production facilitated by photovoltaic arrays in relation to a compact nuclear power solution and supply of surface mobility in the form of rovers are all projected in the manuscript. The story is devoted to a strict scientific approach of describing interdependence of these components which all guarantee human viability.

However, the documentary is not a live mission to Mars, but a visual simulation based on the latest, most innovative ideas and designs ever. Constrains also present problems with team dimension, software ability and rendering time of in-depth simulation, and the general time of production. Even though the work will be scientifically based, the artistic interpretation will be included and well defined in the final report.

CHAPTER 2

PREVIOUS RELATED WORKS

As we know, for a creative work, inspiration is necessary to establish the visual and narrative axis of a 3D animated film. There have been many films and animation industry produced works which consider the problems and potential for life on Mars. When examining examples like these two we come to notice how the filmmakers not only turn to scientific expertise but also to imagistic beliefs on the red planet in visual narration. The highlights of the central Mars-centered movies, series, and 3D short films that have interacted with the international discourse on the universe and the actual space settlement.

2.1 The Martian (2015)

The Martian, directed by Ridley Scott, is a film which is literally the go-to of everyone discussing how astronauts might survive on Mars. It follows Mark Watney - and chances are it's about as good as a book on how to grow food, recycle water and get creative with life-support on a planet with zip resources as they get any better. That's why it's gone down in history as a classic reference of anyone who is studying survival situations on Mars. The accuracy of the film is on the up as the team did scout out the engineering crews of the Nasa and even gained design input from the mission planners [9].

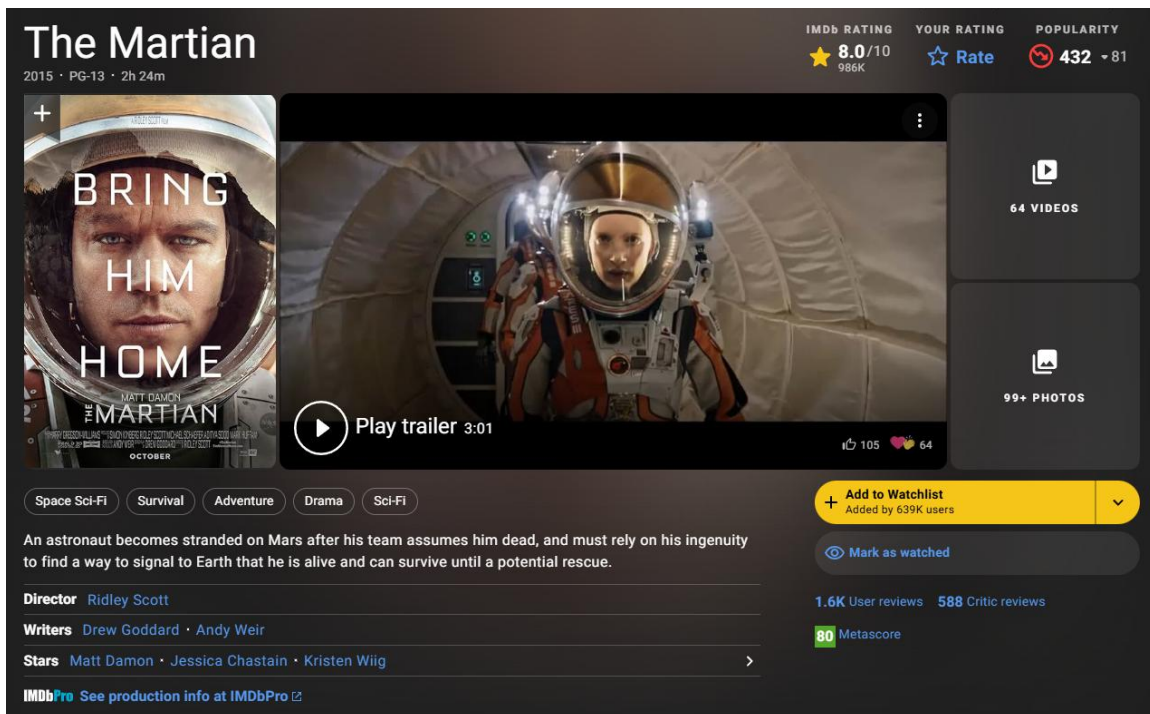


Figure 2.1.1: The Martin Movie Poster and Details

2.2 Mars (National Geographic, 2016–2018)

Mars is this hybrid docu - drama series from National Geographic which combine actual interviews of experts with dramatized scenes of a future Col. James Walt. It breaks down mission planning, how you build habitat, ISRU tech, mental stresses that go along with long duration crews, etc. For coursework that deals with survival visualization frameworks, it strikes all the right notes for relevance and detail [10].

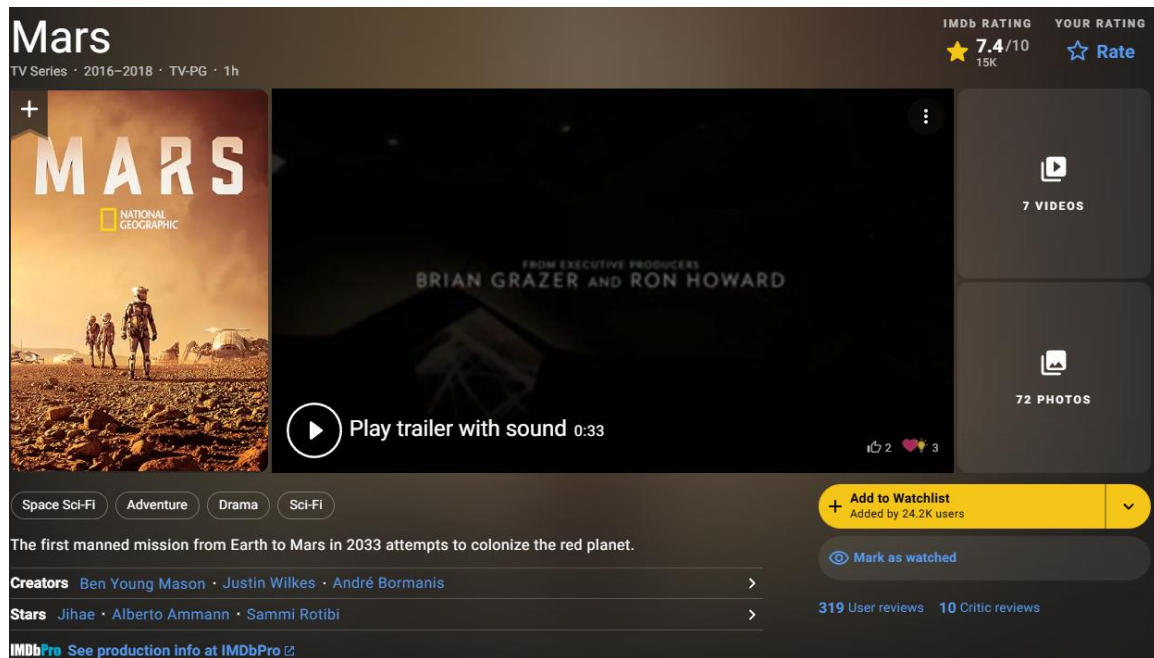


Figure 2.2.1: MARS Documentary Poster

2.3 Away (Netflix, 2020)

Away is a science fiction drama on Netflix where a crew of multinational people go on a long-term mission to Mars. The show gets down deep and dirty in the kinds of failing life support systems, psychological breakdowns, and how teams troubleshoot under pressure that it would be essential to know in realistic "human survival" scenarios in projects like MARS100 [11].

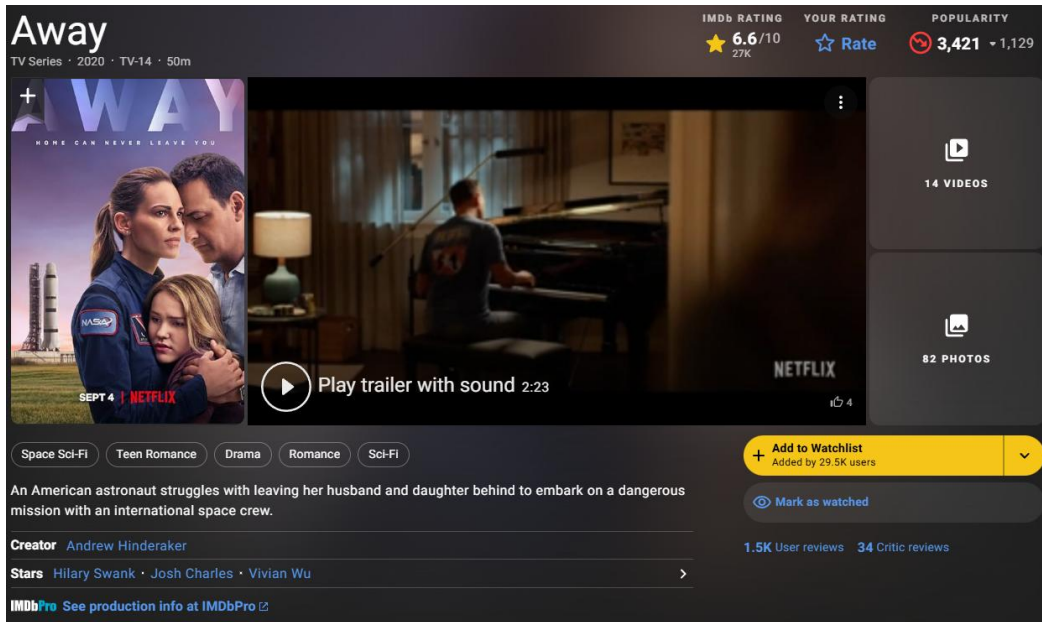


Figure 2.3.1: Away Movie Poster

2.4 Mission to Mars (2000)

Even though Mission to Mars carries over into a bit of speculative, fictional storytelling it still does touch on the fundamental problems of first-hand exploration - the dangers of the atmosphere, getting around on the surface, how would you go about saving yourself if something were to happen to your mission. Watching its graph on environmental risks and navigation on the Red Planet affords a good visual springboard for any early survival-focused Mars narratives [12].

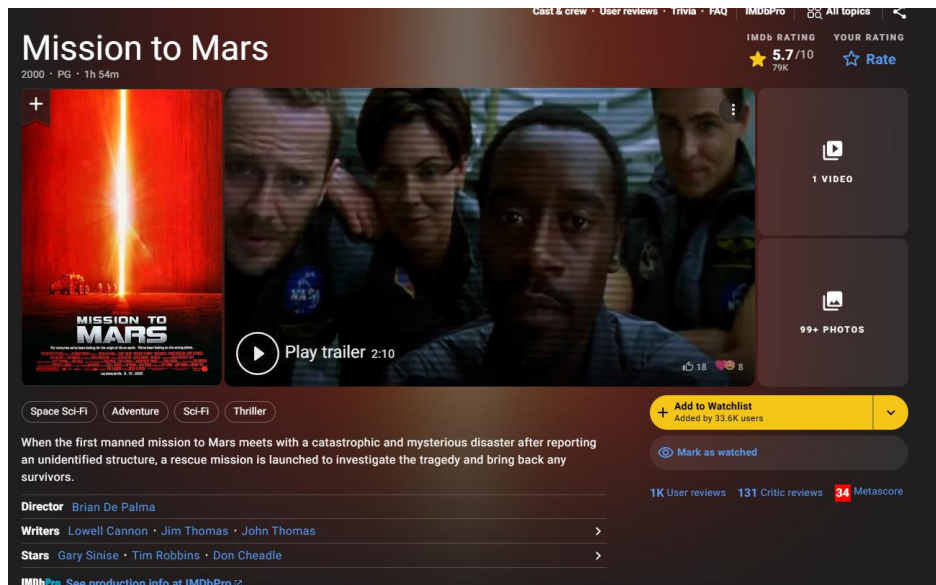


Figure 2.4.1: Mission to Mars Movie Poster

2.5 WALL·E (Pixar, 2008)

Pixar's WALL·E offers a portrait of a future vision of planet Earth left to rot after an environmental collapse. While it's not Mars-based, its focus on sustainability, ecological degradation and human dependence on technology makes it a good conceptual background for forward-looking off world survival stories that MARS100 is pushing [13].



Figure 2.5.1: Wall. E Poster

2.6 For All Mankind (Apple TV+)

For All Mankind is an alternate-history sci-fi programmer that takes the human space flight beyond the moon. Future seasons venture down to the issue of Mars missions being developed, base construction, crew survival and Geopolitics through space. These illustrations of Martian environments and long-term planning are incredibly useful graphics resources to simulation projects that are survival focused [14].

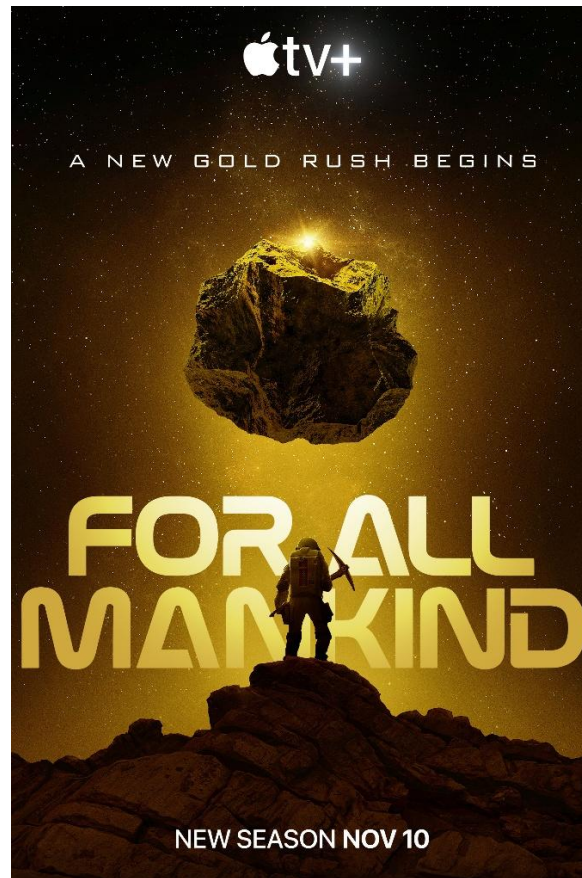


Figure 2.6.1: For All Man Kind Poster

2.7 DW Documentary: Mars – Life on the Red Planet? (2024)

DW Documentary Mars: Life on the Red Planet? 2.7 DW? This documentary includes interviews with actual scientists, engineers and researchers talking' about whether humans could really live on Mars. It contains 3D reconstructions of actual Martian scenery, ISRU concepts, and survival methods, which makes it a good reference for research on science - based visualizations frameworks such as MARS100 [15].

2.8 ADWAR (2022, 3d Animated Short Film)

An animated 3D short animation that I developed as a multimedia and creative technology student that would make you gain an appreciation of storytelling using animation sound design and compositing benchmark for creative & academic animation production processes & creative work.

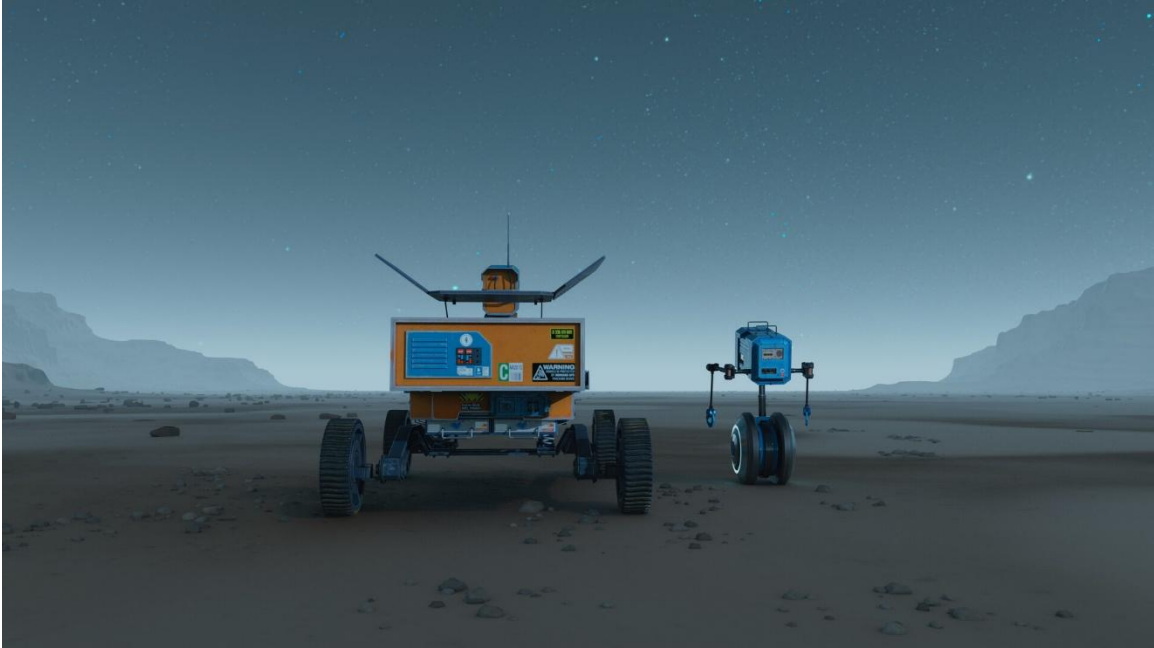


Figure 2.8.1: ADWAR Film Scene Part 1



Figure 2.8.2: ADWAR Film Scene Part 2

CHAPTER 3

LITERATURE REVIEW AND RESEARCH CONTEXT

3.1 Overview of Sustainable Human Habitation on Mars

McHenry and colleagues (2022) dropped the idea of the JEANNE (Joint Enhanced Architecture for Navigating New Environments) Habitat Design, investing it as a set up for a crewed Mars mission in 2033 [16]. Scholarly sense, JEANNE Habitat is an example of a strictly modular, scientifically sound project meant to guarantee the survival of a small crew on the Martian surface as well, without undermining the state of mental health. The architecture is synergistically combined with structural efficiency, exceptionally improved radiation shielding and construction approaches based on ISRU, thus offering an entire package of amenities needed to sustain long-term living.

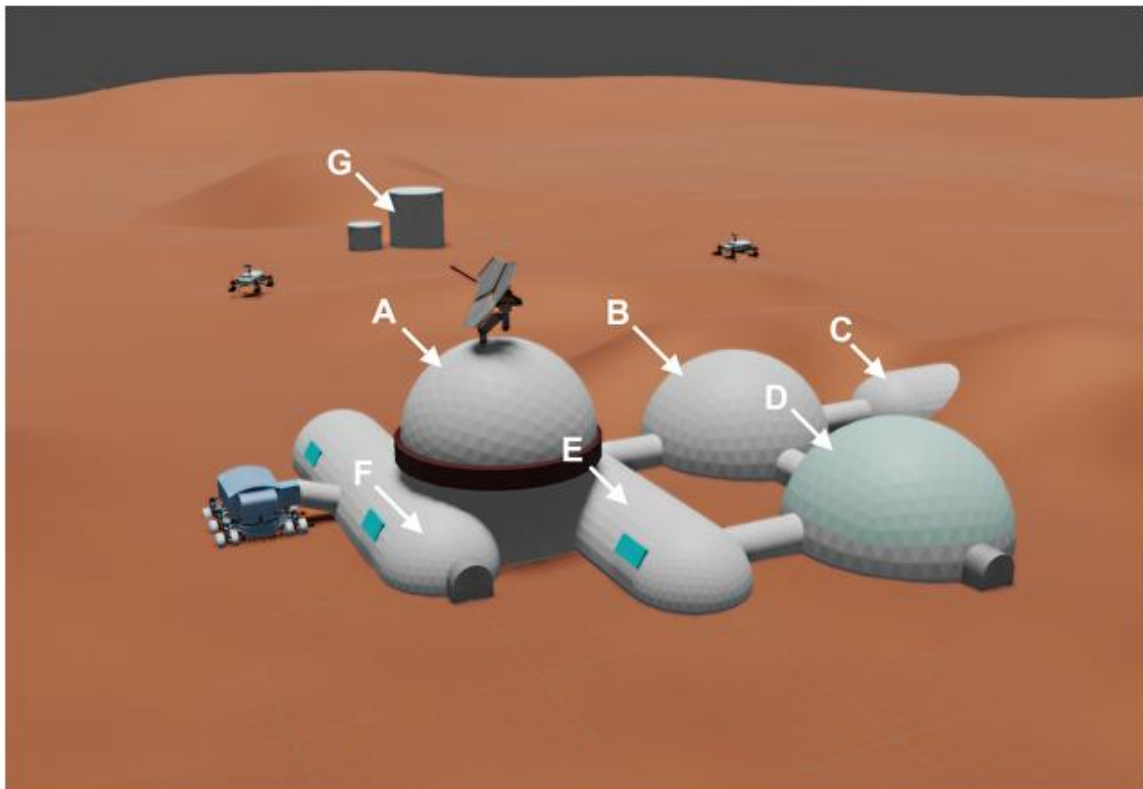


Figure 3.1.1: JEANNE habitat exterior layout

The outside is divided into seven modular units which are skillfully positioned to reduce cross-contamination, noise and make every day routines easier. Each block has a job of its own, such as food production, medical care, relaxing, EVA prep or command ops, using a Computerized Relationship Layout Planning (CORELAP) system to ensure the layout is practical (see Figure 3.1). The hotspots (e.g., the gym and med bay) are in the center and food zone is right next to the greenhouse so that you can get organic waste and plant care

out quick to keep the sustainability loop tight [16].help mitigate noise issues, and the medical suite is centrally located to allow for fast response in case of an emergency (McHenry et al., 2022).

#	Room	Area (m ²)	Area (m ²) (Rounded)	# of Grids
1	Garage Robots	18.580	18.5	37
2	Dining Hall	5.574	5.5	11
3	Exercise Module	17.651	17.5	35
4	Food Prep Area	1.858	2	4
5	Greenhouse	55.741	56	112
6	Living Quarters	49.238	49	98
7	Medical Room	23.225	23	46
8	Workshop & Engineering	18.580	18.5	37
9	Relaxation Room	7.432	7.5	15
10	Bathroom & Shower	4.645	4.5	9
11	Command Center	9.290	9.5	19
12	EVA Prep Area	7.432	7.5	15
13	Airlocks	0.929	1	2

Figure 3.1.2: JEANNE Habitat Module Dimensions and Functions

Hybrid 3D-printed basalt structures combined with inflatable habitat modules are used in the design, and Mars in-situ resources (ISRU) will be exploited for construction (McHenry et al., 2022). Multilayer radiation shielding is adopted, which consists of water/ice filled gaps between 3D printed basalt walls that provided both radiation protection and thermal mass (McHenry et al., 2022).

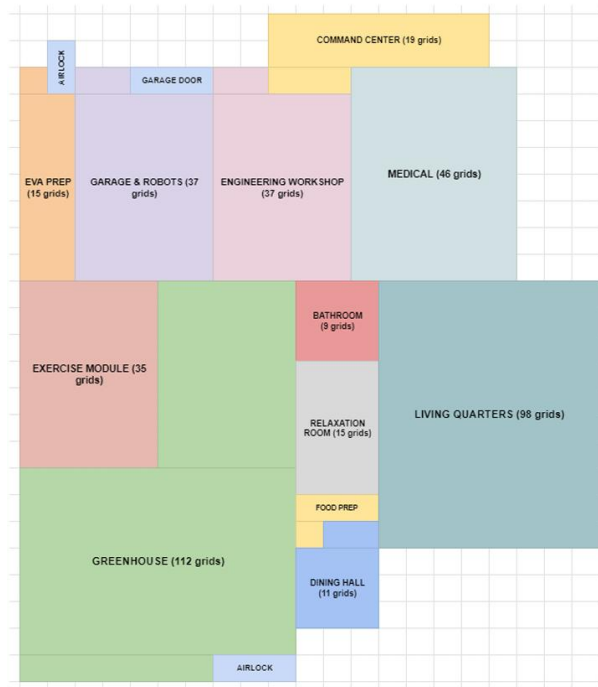


Figure3.1.3: JEANNE Interior Floor Plan with CORELAP Room Relationships

3.2 Oxygen Generation and ISRU Systems (MOXIE)

Hecht et al. (2021) report about MOXIE experiment that uses solid-oxide electrolysis to produce oxygen using the CO₂-rich atmosphere on Mars. This technology forms the basis of the Martian survival research; it was launched onboard NASA's Perseverance rover and demonstrated the ability to generate oxygen on site thus avoiding the necessity of hauling oxidizers on the Earth. The ensuing generation of breathable air, made at amounts that will be required by future missions, highlights the viability of MOXIE to be an in-place solution to resource utilization.

The consequence of the MOXIE is of relevance on a significant scale to habitat-design, energy-management, and life-support-planning. The integrated system in the MARS100 simulation, where the oxygen-generation subsystem is represented, is nascent schematics of animated airflow and the chemical decomposition cycle $CO_2 \rightarrow O_2 + CO$, which has been combined with the greenhouse and pressurization subsystems. This visualization does not only reflect the mechanism underpinning it, but also demonstrates that ISRU saves on cost, as well as mission duration, which leads to long-term sustainability.

3.3 Ice Mining/Water Resource System

Subsurface ice deposits on Mars provide a major source of water for drinking, food production, oxygen production and thermal control. Research confirmed that mid-latitude and polar regions have accessible water-ice sheets that are suitable for thermal drilling or

microwave extraction and mechanical excavation [18]. NASA's PRIME-1 mission, which is scheduled for being sent to the Moon, is one of the significant precursors to ISRU water extraction on Mars, it tests for methods to drill through ice and measure subsurface properties [19].



Figure 3.3.1: The Polar Resources Ice Mining Experiment-1 (PRIME-1)

Hi resolution animation sequence robots' drillings systems melted ice going through the purification units water recycled loops hydroponics greenhouse This is indicative of the closed-loop character of the survival systems of Mars: here too, not a single drop of water can be wasted.

3.4 Surface Mobility and Communication Systems

Sustainable Zarathustra residence both needs solid habitat modules and constant surface rated systems. The JEANNE habitat is based on different hybrid 3D printed structures made of basalt, supported by inflatable interiors, adapted to endure the temperature, radiation environment, and dust storms of Mars [20]. Internal zoning which provides accessible living, working and emergency response spaces.

The Spitzer rovers Have evolved from the Mars Pathfinder jump drive to the Space Exploration Vehicle (SEV) concept is believed to provide answers about rover-based mobility, EVA support, as well as transportability (SEV also enables modular transportation). Its pressurized cabin, docking ports, and long-range exploration capabilities are used as a reference for the MARS100 rover simulation to demonstrate how

astronauts are able to navigate the terrain, move materials and conduct scientific missions on the surface [21].

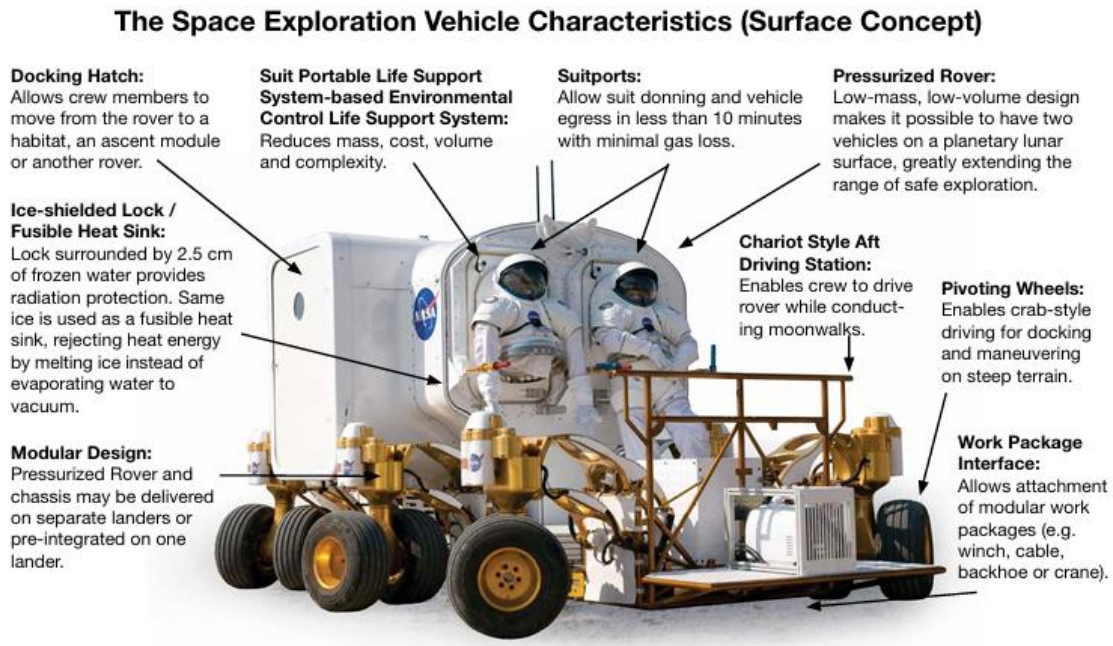


Figure 3.4.1: Space Exploration Vehicle Concept

Scientific visualization has a significant role to play in interpreting complicated engineering information into formats that the public can understand. NASA Scientific Visualization Studio An operating mission data explorer website that can transform raw data acquired by the mission into animated models, interactive maps and cinematic sequences [22]. Research on visualization design indicates that visualizations that blend accuracy of data with a narrative storyteller enhance the level of comprehension, involvement and retention - particularly when explaining future technologies or speculative environments [23].

MARS100 takes this approach by combining the accuracy of simulation with cinematics (storytelling). Through scene-based narration, motion graphics and environmental animation, the project helps to boost the clarity and attributability of some scientific concepts like ISRU, greenhouse operations and habitat workflows.

3.5 Long-duration Colony integrated ISRU Architecture

A detailed model of studying the supporting nature of human life with the help of resources which are available on the site is offered in the study that has been published under the title Mars Colony In Situ Resource Utilization: An integrated Architecture and Economics

Model [24]. Through a unified ISRU loop, the study has identified interlinked sub systems that include oxygen production, water recovery, fuel production, agriculture and waste recycling. This model states that the main feedstocks of life-support and fuel systems will be water ice, atmospheric CO₂ and regolith. The article finds that combined ISRU lowers mission expenses by more than half and allows scalable habitats that can serve lengthy missions (ages). MARS100 makes use of this structure to animate the movement of resources between MOXIE, ice-mining units, greenhouses, recycling units, and energy systems to exhaustively show how ISRU connects all the elements of survival.

3.6 Early Habitat Architecture and Layout of Missions Ideas

In the AIAA article titled First Mars Habitat Architecture, a stepwise program to early settlement is suggested, in which robotic delivery of power units, inflatable habitats, and others are deployed before the crew first arrives [25]. Radiation shielding, redundancy, airlock safety, and internal zoning are considered the ways of supporting psychological well-being and operational performance by the habitat architecture. Its design is modular to enable the base to expand a small crew landing facility into a more complicated one by adding workshops, bases, and laboratories and power stations. Most of these early architectural principles guide the aesthetic design of MARS100 where eponymous domes, tunnels and EVA interventions are guided by comparable architecture principles.

CHAPTER 4

SOFTWARE AND TOOLS

4.1 Production-Level Software

The production software is broken down according to the three stages of batch processing:

1. **Pre- Production Software:** Adobe Photoshop, Illustrator, Microsoft Office
2. **Production Software:** Autodesk Maya, Autodesk 3ds max, Blender, Substance Painter, Unreal Engine for version 5.6 .
3. **Post- Production Software:** Adobe After effects, Adobe Premier Pro, Davinci Resolve, FL Studio

4.2 Core Production Software

4.2.1 Unreal Engine 5.6

Unreal Engine 5.6 Unreal Engine 5.6 is basically the major rendering and environmental assembly tool for MARS100 like the backbone of our project. The engine contains a Nanite virtualized geometry system that allows us to import high-resolution 3D models, think film-quality model from Brush, directly into the engine, and to be rendered in real time in next-generation consoles. Physically Based Real Time Lighting Lumen is the solution we're using It works to have Physically accurate indirect and Global Illumination Effects, so everything gets light authentically across the surface of the planet.

UE5.6's fog and atmospheric scattering technology allows us to have flexible control over the level of the haze in different layers. We can add effects such as low-pressure days, night Martian dust storms, as well as sunsets, light from a star or stars scattered across the dusty atmosphere. Plus, the skies get a simulated Rayleigh backscatter effect and Sequencer allow us to make non-nonlinear cinematics for camera animation/shooting composition/working at CG at cinematic frame rates.

4.2.2 Autodesk Maya

State of the art industry standard 3D software for JEANNE Habitat module modelling, mechanical rigging and character animation. Maya: Strong polygon modelling tools enable the possibility to undertake technical modelling complying with JEANNE specifications

4.2.3 3ds Max by Autodesk

3ds Max has some seriously advanced architectural modeling tools which are ideal for designing the interior of habitats, to put up mechanical parts. This tool is used in this project for making hard surface modeling. After that, we export the models to Unreal Engine in order to set everything up and do the final rendering.

4.2.4 Blender

Blender open-source 3D package is excellent to that additional modeling I get to do with a particular preference going with the extra in cases where I need to sculpt organic terrain, or other material on this occasion procedural via Geometry nodes and the shader editor. The procedural techniques of Blender are slot, and we have procedural techniques of realistic rock formation, crater detail, surface erosion detail, etc. All of which I can make use in my projects. Some of the animation render is also borrowed here.

4.3 Texturing & Material Creation

4.3.1 Substance Painter

Adobe texturing tools for the PBR habitat modules, rovers and mechanical parts are actually pretty solid. The Multi- close high-resolution detail of super-resolution tiling is available with me because I can essentially pull gigantic UVs. We also used to create textures or the material for tunnels and greenhouses. Since Substance Painter is an industry orientated programme, we're trying to make PBR based materials from it.

4.3.2 Blender Procedural Materials

We also use procedural material in this project in this case we used blender default material editor for making material for our project. And the process is comparatively smooth. Some other material support directly in unreal engines that are a cool part of this tool.

4.3.3 Procedural Material Built-in in Unreal Engine

The Unreal Engine Material Editor of making a Martial environment is quite a challenge, yet not insoluble, so we resorted to the Unreal procedural method of attaching textures to objects, namely Unreal material. We also then employed material blending in order to have a more realistic look- particularly the surface of Mars. We combined 3 materials and painted them on the floor as though it were the actual Mars.

4.4 Post-Production

4.4.1 Adobe After Effects: We used After Effects mainly for handling compositing parts and for using special effects (VFX)

4.4.2 Adobe Premiere Pro: We used it for timeline edits, assemble sequences and rough cuts using Unreal Engine rendered sequences

4.4.3 DaVinci Resolve: Color grading, HDR mastering, and final touch ups all handled with DaVinci Resolve used to make the Mars

4.4.4 Adobe Audition: we edited the sound and cleaned up dialogues, soundscape and mixed it up.

4.4.5 FL Studio: We did sound design and produced a soundtrack based on the theme of Mars discovery.

4.4.6 Adobe Photoshop: We prepared posters, promotional visuals and images.

4.4.7 Adobe Illustrator: We created vector based 2D designs by using this tool.

CHAPTER 5

METHOD OF DEVELOPMENT

To achieve the best possible results for MAR100 we devised a state-of-the-art pipeline which mimics established animation film pipelines, also accommodating special technical requirements of Mars-based scientific visualization.

5.1 Pre Production

- a) Researching, reference, and mood boards
- b) Story creation & screenwriting.
- c) Concept art for domes
- d) Sound design concept
- e) Storyboarding.

5.1.1 Researching, Reference and Mood boards

New technical papers collated (JEANNE Habitat/MOXIE/PRIME-1/NASA SEV) collected architectural materials, and reference images of mars surface, habitats and machinery. A full mood board was developed that went all the way down to actual reference images, like hi-res pictures of Mars from NASA, for color palette, texture, landscape and atmosphere effects.

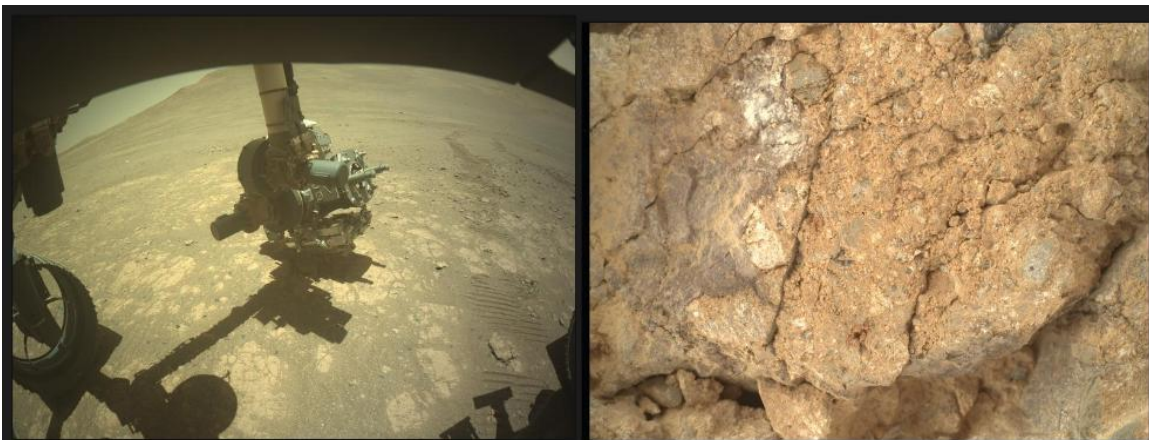


Figure 5.1.1.1: MARS Raw Footage

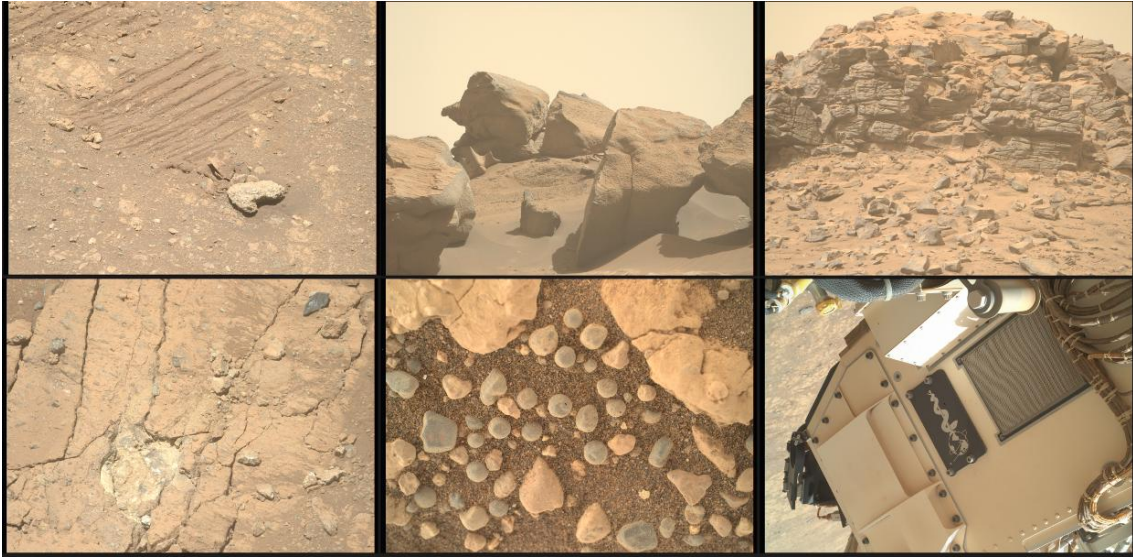


Figure 5.1.1.2: MARS Raw footage with detail of surface



Figure 5.1.1.3: MARS Raw Footage of detail rock

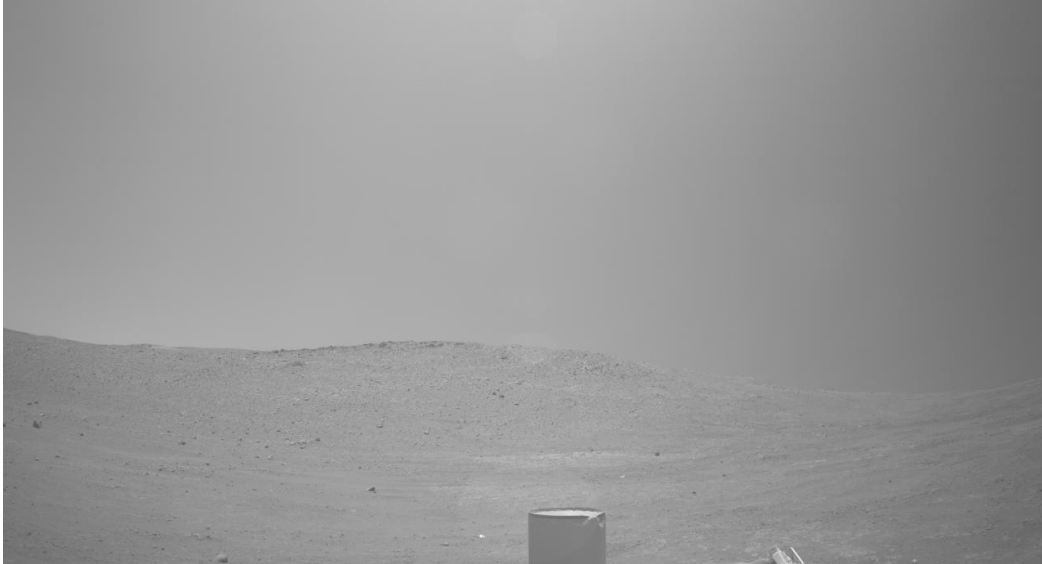


Figure 5.1.1.4: MARS Raw footage with detail of surface



Figure 5.1.1.5: MARS Raw Footage of Stone

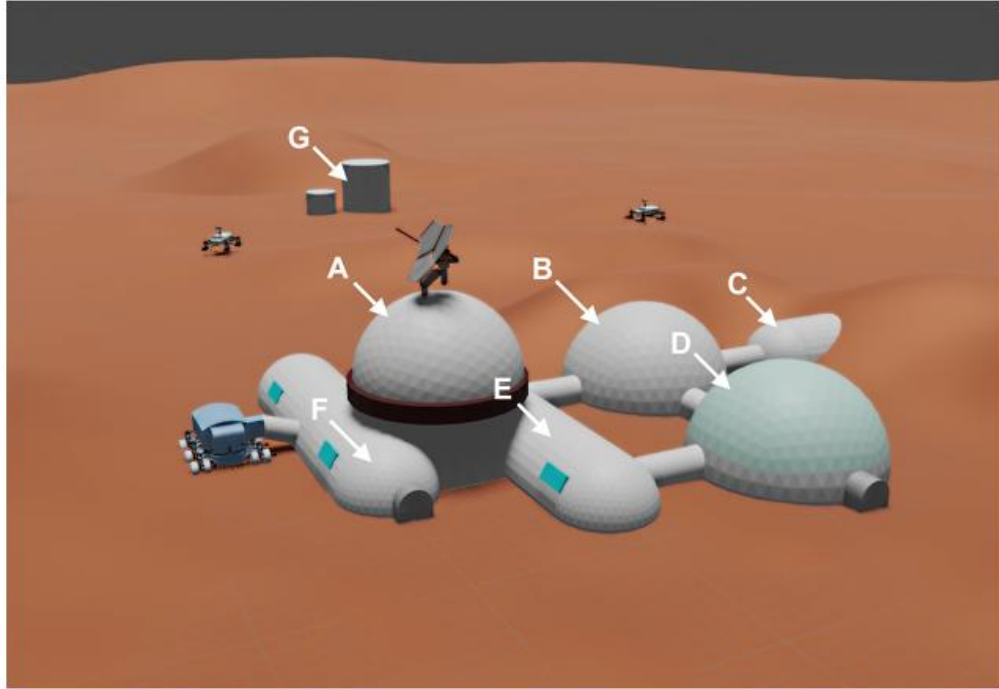


Figure 5.1.1.6: JEANNE habitat exterior layout - labeled modules A through G

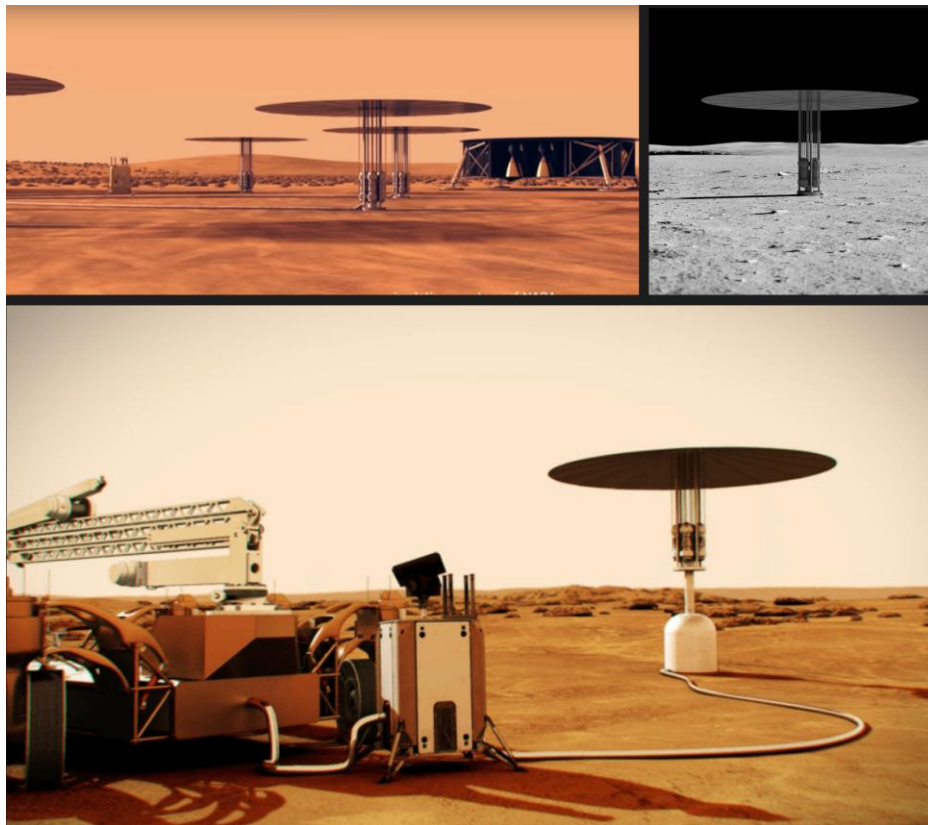


Figure 5.1.1.7: Image of Nuclear reactor designs for Mars

meaningful progress.

VII. Base Location, Mobile Bases, and the Habot

A key strategic issue for the development and investment in a lunar or Martian base is where to locate it on the surface. It is a huge wager to pick one location on which to land tens of billions of dollars of equipment. What if, after a short period of further exploration, the crew or science observers discover a much better site too far from the Mars base to "commute"? In addition, the idea of coupling so much of the crewed Mars mission so closely together in one or two immense pieces of hardware evoked reservations and doubts. Clark (1991) recommended an alternative approach of "highly decoupled elements and conservative practices" that would not put so many eggs in one fragile basket.

What are the odds of picking the optimal Mars base site on the first try? What was the probability of success to land one 40-ton habitat or other payload at that site on Mars? From these concerns, alternative positions arose, arguing that at least for the initial series of human Mars (or Moon) landings, the capability should arrive in multiple smaller payloads and be mobile rather than stationary. The ideas of decoupling the elements, leveraging modularity at a smaller scale, and enhancing mobility on the Lunar or Mars surface raised the question: why not make everything mobile? This mobile habitat and lab would potentially include an EVA airlock, a sample airlock, and a docking pressure port to access the surface habitat (Cohen, 2004). There would be no pretensions about flying the crew to Mars in such small modules; they would need to be separate and distinct from the IPV habitat. However, it might be possible to convert such a small crew module to a DAV. On the other hand, one potential advantage of the mobile base design problem decomposition was that it would not be necessary to human-rate the mobile modules for

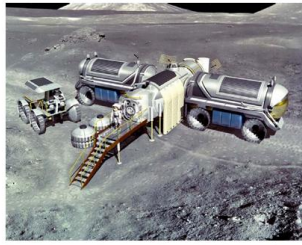


FIGURE 15. Wagon Train Base—1993 (top, NASA Image, Artist Credit: John Frassantio).

National Aeronautics and Space Administration

Space Exploration Vehicle Concept




Background



NASAFacts



One of the goals for testing prototypes on Earth is to identify the features that are going to be the most useful in space. Although not all features currently being tested will end up on the flight vehicles, the following features are being designed and considered:

Range of Exploration
On the surface of distant destinations, travel range is limited primarily by how quickly astronauts can get back to a safe, pressurized environment in case of an emergency. During the Apollo program, exploration was confined to the distance astronauts could expect to walk back wearing spacesuits if their rovers broke down: about 6 miles. The presence of two or more service SEVs on a planetary surface would extend that potential range to more than 125 miles in any direction, greatly increasing the scientific opportunities during missions. Even in the midst of challenging terrain, emergency shelter and support can be less than an hour away.

Astronaut Protection
The greatest risk to space explorers is from unanticipated solar particle events. With a heavily shielded cabin, the SEV doubles as a storm shelter. The rapidly accessible, pressurized, radiation-hard safe haven can sustain and protect exploring crew members for up to 72 hours against solar particle events, acute suit malfunctions and other medical emergencies. The radiation shielding in the SEV cabin provides protection that the Apollo crew did not have on their unpressurized rover – or even on their lander.

Rapid Ingress/Egress
The SEV system's support concept allows astronauts to go out for a spacewalk at almost a moment's notice. The support will allow the crew to enter and exit their spacesuits without bringing the suit inside, keeping the internal space mostly free of dust and other contaminants and reducing wear and tear on the suits. The support also minimizes the loss of air inside the cabin when it is depressurized for spacewalks, extending mission durations by maximizing available SEV resources.

Intra Vehicular Activity (IVA) Capability
By combining a pressurized cabin with a support, the SEV gives crew members the unprecedented flexibility of being able to easily switch between working in plain clothes or spacesuits. Although astronauts may want to exit the vehicle to take a closer look at something outside, activities requiring fine manipulation and unfettered visual access are best performed without the confines of bulky gloves and helmets. Astronauts can sit comfortably in a cabin and look at workstations or geologic formations without the continuous exertion of working in a spacesuit, which allows them better use of computers, robotic operation, maps and dialogue between crew members. The cabin can also serve as a rolling science lab for studying samples.



Figure 5.1.1.8: Space Exploration Vehicle Concept

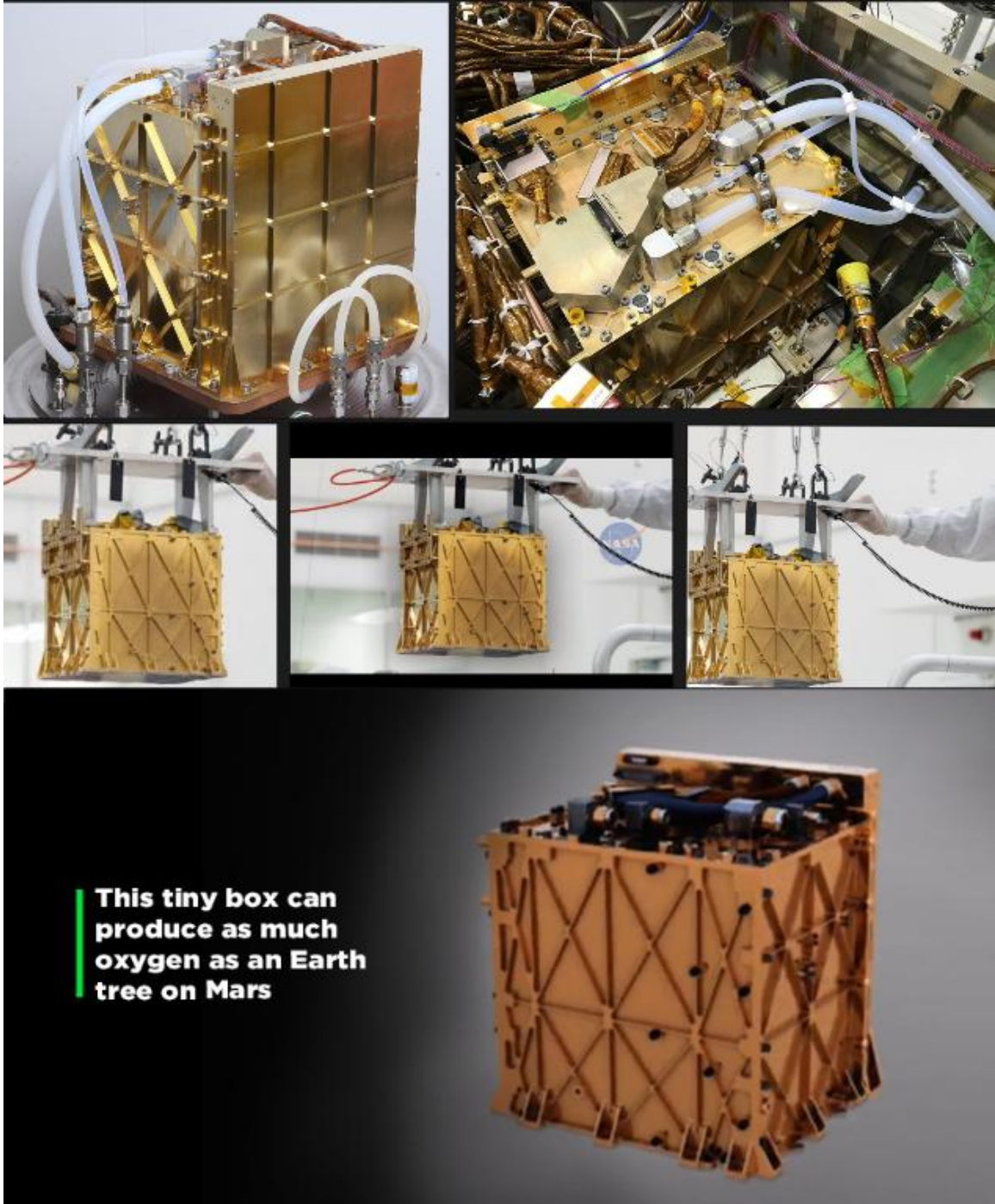


Figure 5.1.1.9: MOXIE Machine Image

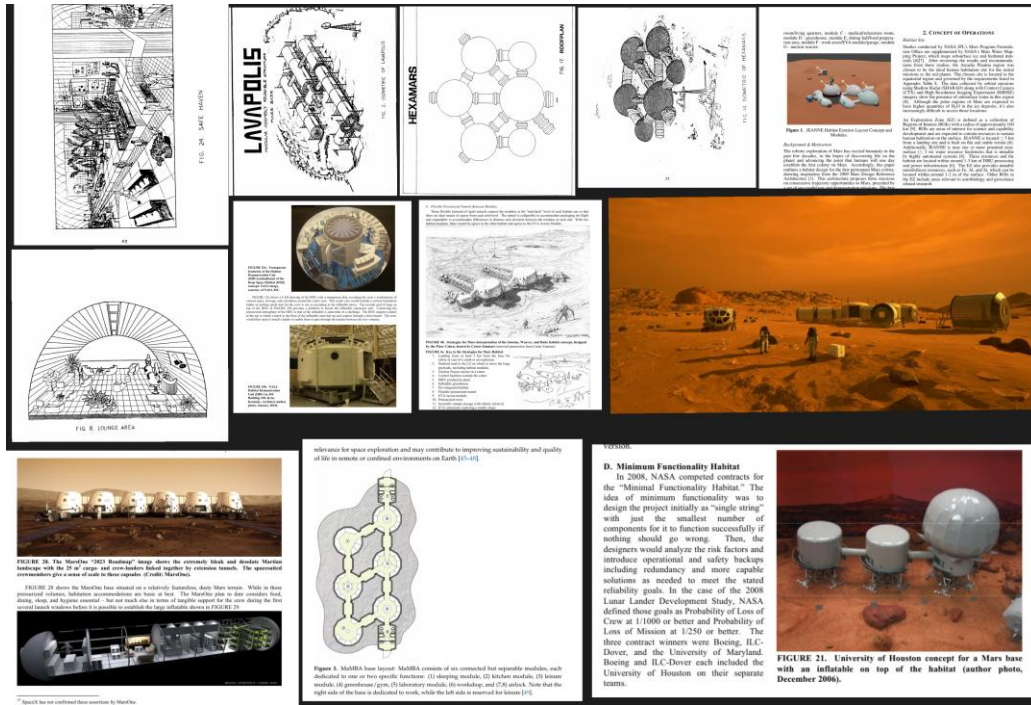


Figure 5.1.10: Habitat Structure found from Paper



Figure 5.1.1.11: Other Habitat Structure found by Google and AI

5.1.2 Story Creation and Screenwriting

The MARS100 thing was a result of a blend of science facts, creative visual vibes, and movie style storytelling. It basically starts with asking, what would human life look like on Mars, if we were going to base such an artificially settled base on real research and sustainable design? The whole point of it was an attempt to demonstrate survival and have this emotional, philosophical-"start over on earth" look.

The story's set is right around the turn of the 21st century, when the Earth hierarchy is about to collapse due to issues with the climate and overpopulation. So, we relocate our search for survival as a species to Mars which happens to be a homage to hope and perseverance. Influenced by designs created by the JEANNE Habitat design team at the National Aeronautics and Space Administration (NASA), MOXIE (the Mars Oxygen In Situ Resource Utilization Experiment), and good old In - Situ Resource Utilization (ISRU), the film presents one possible way how astronauts may establish a system for living on the red planet.

It's a visually told script, with ten scenes which are almost like a short film documentary. Each scene takes another step towards human survival-than a dying Earth, the Mars trip, erecting a first dwelling, a slow development of a living ecosystem, etc. The voice over narration weaves all these jumps together keeping that same kind of poetic, info-heavy stuff going that combines science and emotion.

Writing maintains a rhythm without a lack of facts. Real numbers (like oxygen output for MOXIE, greenhouse biosphere cycles, agriculture recycling, water extraction from ice mining, and so on) were tamed down to mere short story snippets. Each line is constructed to accompany the visual cues and camera movements and sound design to keep the audience immersed.

The script got re-shuffled many times to ensure the logical flow of the story is evident on screen. The pacing changed from loss and uncertainty on Earth to a rapid pace which inspires repentance and balance on Mars. By the end draft, MARS100 became one very-fleshed out, science-based survival and rebirth story - a creative vision of how humanity might someday make the knowledge real and turn a dead planet back into a real home for us.

5.2.1.1 Story

মার্স ১০০
-মোঃ তুহিন ইসলাম

যখন পৃথিবী অনিশ্চয়তার এক গভীর যুগের মুখোমুখি, তখন মানবজাতি দাঁড়িয়ে আছে অস্তিত্ব আর বিলুপ্তির মধ্যবর্তী এক সঙ্কটময় মোড়ে। যে নীল গ্রহ একসময় জীবনের আশ্রয় ছিল, আজ সে নিজস্ব উন্নতির ভায়ে ক্লান্ত। জলবায়ু পরিবর্তনের তীব্রতা মহাদেশ বদলে দিচ্ছে, সমুদ্র উঠছে শহর গিলতে, বাতাসে জমেছে ধোঁয়া আর ধুলোর ভার। বন পুড়ে যাচ্ছে, নদী শুকিয়ে যাচ্ছে, আর মানুষের লোভে প্রকৃতির ভারসাম্য ভেঙে পড়ছে। সভ্যতার কোলাহলের মাঝে একটাই প্রশ্ন বারবার ফিরে আসে যদি এই পৃথিবী আর আমাদের বাড়ি না থাকে, তবে আমরা কোথায় যাব?

এই প্রশ্নের উত্তর খুঁজতে মানবদৃষ্টি আবার ফিরেছে আকাশের দিকে। দূরে, লালচে এক আলো নিঃশব্দ, শীতল, অথচ আশার প্রতীক **মঙ্গল গ্রহ** একসময় যে গ্রহকে মৃত মরুভূমি ভাবা হতো, এখন সেটিই হয়ে উঠছে মানুষের দ্বিতীয় সম্ভাবনা। পৃথিবীর বিজ্ঞানী, প্রকৌশলী আর স্বপ্নদর্শীরা নাসা, ইএসএ থেকে শুরু করে স্পেসএক্স পর্যন্ত একত্রে কাজ করছে অসম্ভবকে সম্ভব করতে। রোবট রোভার মঙ্গলের মাটি ঘুরে বেড়াচ্ছে, স্যাটেলাইট বিশ্লেষণ করছে তার বায়ুমণ্ডল, আর **MOXIE**-এর মতো পরীক্ষাগুলো প্রমাণ করছে, মঙ্গলের বাতাস থেকেই অক্সিজেন তৈরি করা সম্ভব।

২১শ শতকের ত্রিশের দশকেই শুরু হচ্ছে মানব অভিযানের নতুন অধ্যায়। প্রথম কার্গো মিশন নিয়ে যাচ্ছে ভবিষ্যতের বসতি মডুলার হ্যাবিট্যাট, সোলার প্যানেল, রোবট নির্মাতা, এবং ক্ষুদ্র রিঅ্যাক্টর। এর পরের ধাপেই মানুষ নামবে লাল মাটিতে, শুরু করবে এক অবিশ্বাস্য পরীক্ষা শূন্য থেকে জীবন গড়া। কাঁচের গন্ধুজের ভেতরে গাছপালা জন্মাবে, পাতার নিঃশ্বাসে ভরবে নতুন বাতাস। মাটির নিচে বরফ গলে পরিণত হবে পানিতে, আর ওপরে সূর্যালোক ছুঁয়ে যাবে সোলার প্যানেলগুলোকে। প্রতিটি শ্বাস, প্রতিটি ফোঁটা পানি, প্রতিটি শক্তির কণাই তৈরি হবে, পুনর্ব্যবহার হবে, সংরক্ষণ হবে টিকে থাকার এক নিখুঁত চক্রে।

তবু এ শুধু বিজ্ঞানের গল্প নয় এটি মানুষের আশা আর টিকে থাকার গল্প। এক সভ্যতার, যে নিজের ধ্বংসের মধ্যেও নতুন পৃথিবী খুঁজে নিতে জানে। **“MARS 100”** সেই ভবিষ্যৎকেই কল্পনা করে যখন পৃথিবীর শেষ প্রজন্ম হয়ে উঠবে মঙ্গলের প্রথম বাসিন্দা। এটি পালিয়ে যাওয়ার গল্প নয়, বরং পুনর্জন্মের এমন এক দৃষ্টি, যেখানে মানুষ শিখছে কীভাবে অন্য গ্রহে বেঁচে থাকা যায়, আর সেই সঙ্গে কীভাবে নিজের গ্রহটিকেও আবার বাঁচানো যায়।

Figure 5.2.1.1 Main Story

5.2.1.2 Screenwriting

[SCENE 1 - THE FADING EARTH (0:35)]

VISUAL: MELTING ICE, BURNING FORESTS, STORMS, CROWDED CITIES. BLUE FADES TO WARM ORANGE. MUSIC: DEEP AMBIENT STRINGS, SLOW BUILD.

Voice-over:

Earth - our cradle of life.

For billions of years, it gave us air,
water, and warmth. But the balance
that held our world together is
fading. Oceans rise. Forests burn.

We built cities... and broke the system
that sustained them. (music pause - 3
sec)

If home itself can no longer hold us...
where do we go next?

TRANSITION: EARTH FADES INTO DARKNESS. A RED GLOW EMERGES
MARS RISES SLOWLY.

[SCENE 2 - THE SEARCH BEYOND (0:25)]

VISUAL: ROCKETS LAUNCH, SATELLITES ORBIT, ROVERS TRAVERSE THE RED TERRAIN. MUSIC: RISING SYNTHS WITH PULSING PERCUSSION.

Voice-over: When Earth's future grew
uncertain, we looked beyond. The Moon
was too barren. Venus, too fierce.

But Mars - cold, silent, and rich in
promise - called to us. For decades,
our machines searched its surface, and
with each discovery, the question
changed - not can we reach Mars, but
can we live there?

TRANSITION: THE SURFACE FADES INTO A CALM MARTIAN PLAIN - THE
JEANNE HABITAT STANDS COMPLETE.

Figure 5.2.1.2.1 Screenwriting Part-1

[SCENE 3 - THE FIRST HUMAN BLUEPRINT (≈ 0 : 30-35)]

VISUAL: THE JEANNE HABITAT STANDS BENEATH SOFT ORANGE LIGHT - DOMES LINKED BY TUNNELS, SOLAR PANELS GLEAMING ACROSS THE HORIZON. THE CAMERA DRIFTS SLOWLY ABOVE THE COMPLETED BASE, QUIET AND STILL. **MUSIC:** GENTLE, SPACIOUS STRINGS WITH FAINT AMBIENT PULSE.

Voice-over: In 2022, the JEANNE Habitat Design offered Mars its first

2.

true roadmap for human life. (pause 1 sec)

By 2031, robotic scouts had tested the soil, the ice, and the power that could sustain us. Two years later, in 2033, cargo Starships carried the foundations of a new home. (pause 2 sec)

Now, for the first time, human footsteps mark this red horizon. Six astronauts, six hundred days - a world both familiar and unknown. (pause 1 sec)

What will their lives be like beneath these domes? How will they eat, breathe... and endure?

Figure 5.2.1.2.2 Screenwriting Part-2

[SCENE 4 - THE GREENHOUSE: LIFE AND BREATH (≈ 0:50)]

VISUAL: A SOFT MECHANICAL HUM FILLS THE AIR. THE FRAME REVEALS A SMALL GOLDEN UNIT - THE MOXIE OXYGEN GENERATOR - GLOWING GENTLY AS AIR FLOWS THROUGH ITS FILTERS. ANIMATED INFOGRAPHICS APPEAR BRIEFLY, SHOWING PARTICLES OF CO₂ SPLITTING INTO BLUE O₂ BUBBLES AND GRAY CO LINES. THE CAMERA PANS SLOWLY TOWARD A VAST GLASS GREENHOUSE DOME, GLOWING GREEN UNDER THE SOFT PULSE OF RED-BLUE LIGHT.

Music: Calm ambient sound blending the hum of machinery with a slow, uplifting orchestral rise.

Voice over: How will they eat? How will they breathe? (pause 1 sec) One answer begins with MOXIE - a compact unit first tested aboard NASA's Perseverance rover. It pulls in Mars' carbon-dioxide-rich air and, through high-temperature electrolysis, breaks it apart - releasing pure oxygen while carbon monoxide flows out as a by-product. In future systems, that same carbon monoxide could feed a Sabatier reactor to create methane fuel and water - closing the loop of life and return.

(pause 1 sec)

It produces around twelve grams of oxygen every hour - a remarkable start, but not enough to sustain life. (music softens)

To truly live here, we need nature.

That's why the JEANNE Habitat introduced the greenhouse a living system designed to recycle air, water, and hope. Inside these domes, life begins to breathe.

Plants turn carbon dioxide into oxygen,

Figure 5.2.1.2.3 Screenwriting Part-3

NEW SCENE 4.1 - WATER: BENEATH THE DUST (≈ 0 : 20)

VISUAL:

A ROBOTIC DRILL LOWERS INTO THE FROZEN MARTIAN SOIL. BLUE-TINTED ICE LAYERS APPEAR BENEATH THE RED DUST.

PIPES DRAW MELTED WATER INTO STORAGE TANKS; FILTERS PULSE WITH A SOFT GLOW. STEAM RISES FAINTLY AS THE SYSTEM CYCLES.

MUSIC: LOW AMBIENT TONE WITH SUBTLE FLOWING WATER EFFECTS - COOL, SERENE.

Voice-over: Beneath the surface of Mars lies frozen water - the hidden foundation of life.

Automated drills reach deep to extract ice, melting and purifying it for drinking, oxygen, and fuel. Here, even water becomes technology -

a bridge between survival and future growth.

Figure 5.2.1.2.4 Screenwriting Part-4

[SCENE 5 - INSIDE THE DOME: THE HUMAN SPACE (0 : 25)]

VISUAL:

THE CAMERA GLIDES FROM THE GREENHOUSE TUNNEL INTO THE LIVING DOME. SOFT AMBER LIGHT FILLS CURVED CORRIDORS; QUIET AIR CIRCULATES THROUGH VENTS.

WE SEE COMPACT SLEEPING PODS, A SMALL DINING AREA, EXERCISE GEAR, AND A MEDICAL BAY.

MUSIC: WARM, CALM AMBIENT TONES - GENTLE AND REFLECTIVE.
VOICE-OVER:

Inside the habitat, the systems of life come together. Air flows through the dome, filtered and renewed.

Here, people find rhythm - a place to rest, to work, to stay healthy. Every wall shields against the thin, frozen air outside, while inside, warmth and light return.

Transition: The camera moves toward the corridor where cables hum beneath the floor.

The ambient tone deepens, leading naturally into Scene 6 - Energy: The Pulse of a Colony.

Figure 5.2.1.2.5 Screenwriting Part-5

[SCENE 6 - ENERGY: THE PULSE OF A COLONY (≈ 0 : 20)]

VISUAL:

THE CAMERA FOLLOWS GLOWING CABLES TO THE POWER HUB. SOLAR PANELS SHIMMER UNDER THIN SUNLIGHT; SMALL BOTS CLEAN THEIR SURFACE. CUT TO AN UNDERGROUND REACTOR - A SOFT BLUE GLOW PULSES STEADILY.

MUSIC: DEEP, CALM HUM WITH A SUBTLE RISING TONE.

Voice-over: Energy keeps every system
alive. Solar panels draw power by day,
and when storms or nights arrive, A
small buried reactor takes over.
Stored in silent batteries, This power
keeps air flowing, plants growing,

and life moving on Mars.

TRANSITION: CAMERA PANS UPWARD TO THE HORIZON - THE LOW HUM
BECOMES THE ROLLING SOUND OF WHEELS AS ROVERS APPEAR, LEADING
INTO SCENE 7 - MOBILITY AND COMMUNICATION.

[Scene 7 - Mobility and Communication (≈ 0 : 18-20)]

Figure 5.2.1.2.6 Screenwriting Part-6

[SCENE 8 - SUSTAINABILITY AND PROTECTION (= 0 : 20)]

VISUAL:

CAMERA MOVES THROUGH AN UNDERGROUND SECTION OF THE BASE. LAYERS OF REGOLITH COVER THE DOME ABOVE; LIGHT FILTERS SOFTLY THROUGH.

CUT TO COMPACT RECYCLING UNITS - WATER FLOWS THROUGH CLEAR PIPES, AND COMPOST CHAMBERS SLOWLY TURN WASTE INTO FERTILIZER.

A QUICK CROSS-SECTION SHOWS PLANTS ABSORBING RECYCLED NUTRIENTS.

MUSIC: LOW, STEADY HUM WITH SOFT AMBIENT TONES - PEACEFUL AND BALANCED.

Voice-over: On Mars, nothing is wasted
- not even protection. Waste becomes
soil, water is cleaned and reused,

and walls made from Martian dust guard
against radiation. Every system
depends on the next -

a cycle where survival and
sustainability become one.

TRANSITION: THE CAMERA RISES FROM THE UNDERGROUND LAYERS TO THE SURFACE, REVEALING A CITY OF DOMES GLOWING UNDER THE

Figure 5.2.1.2.7 Screenwriting Part-7

[SCENE 9 - MARS 2100 - THE LIVING WORLD (0 35)]

VISUAL: VAST COLONY OF DOMES GLOWING UNDER DAWN LIGHT.

Voice-over: Decades later, science becomes civilization. MARS 2100 - a city grown from endurance and hope. Greenhouses hum, reactors glow, oxygen flows. Mars - once silent - now alive with human rhythm."This is not the end of exploration... it's the beginning of a new home

(pause 3 sec music builds)

[SCENE 10 - REFLECTION: ARE WE READY? (= 0 : 20)]

VISUAL:

THE SUN SLOWLY RISES OVER THE COLONY. DOMES GLIMMER IN SOFT ORANGE LIGHT.

FAR ABOVE, EARTH APPEARS AS A TINY BLUE SPARK IN THE SKY.

MUSIC: SOFT PIANO AND STRINGS - CALM, FADING GENTLY.

Voice-over:

We built a home on another world...

but it began with a single question - could we? Now, the systems breathe, the lights endure, and Mars waits quietly for us. The next question is simple... are we ready?

END CARD: TEXT ON SCREEN: "MARS 2100 - A VISION FOR SUSTAINABLE HUMAN HABITATION." FADE TO BLACK AS MUSIC ENDS.

Figure 5.2.1.2.8 Screenwriting Part-8

5.1.2 Storyboarding

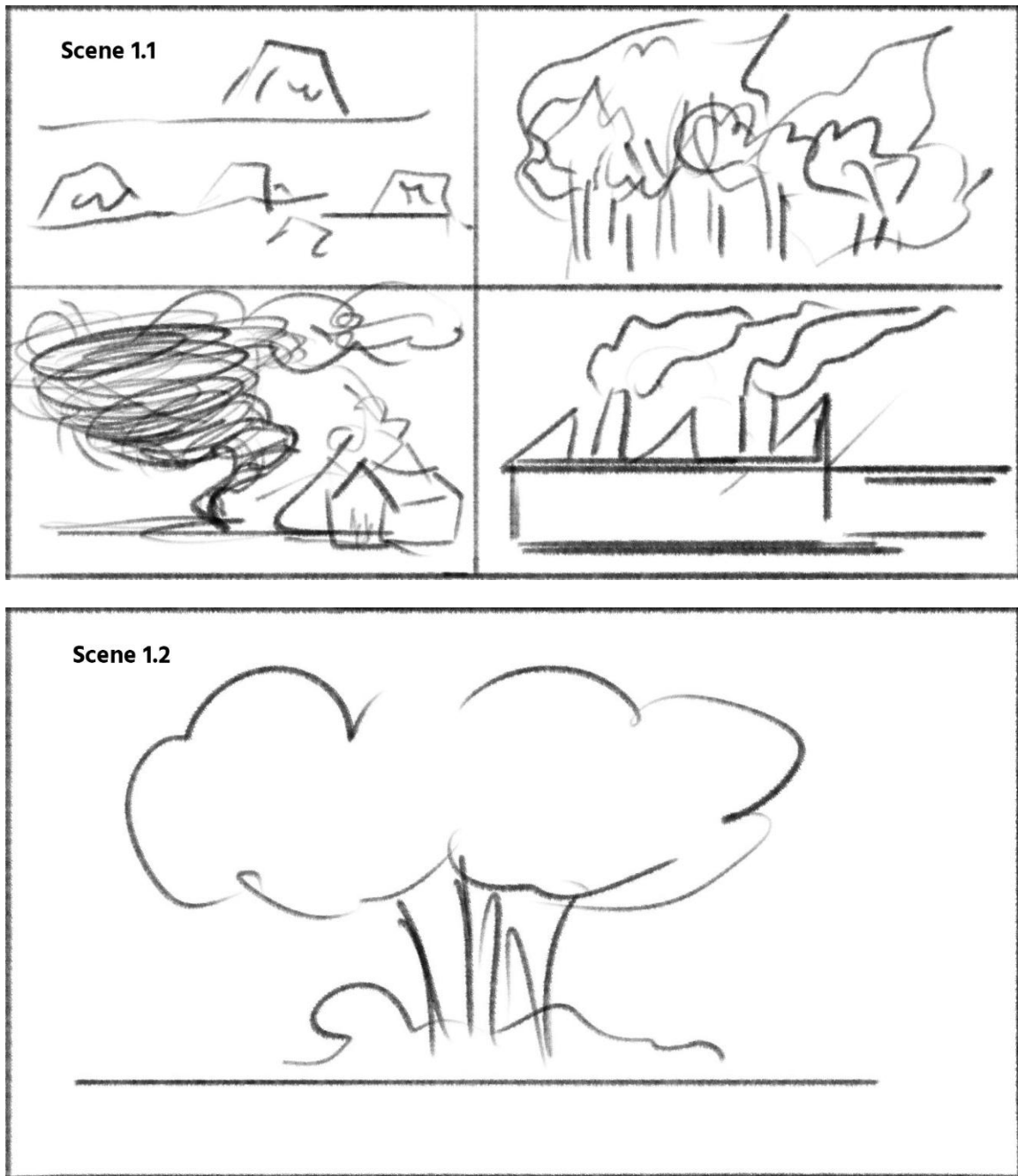


Figure 5.1.2.1: Storyboard Scene Part -1

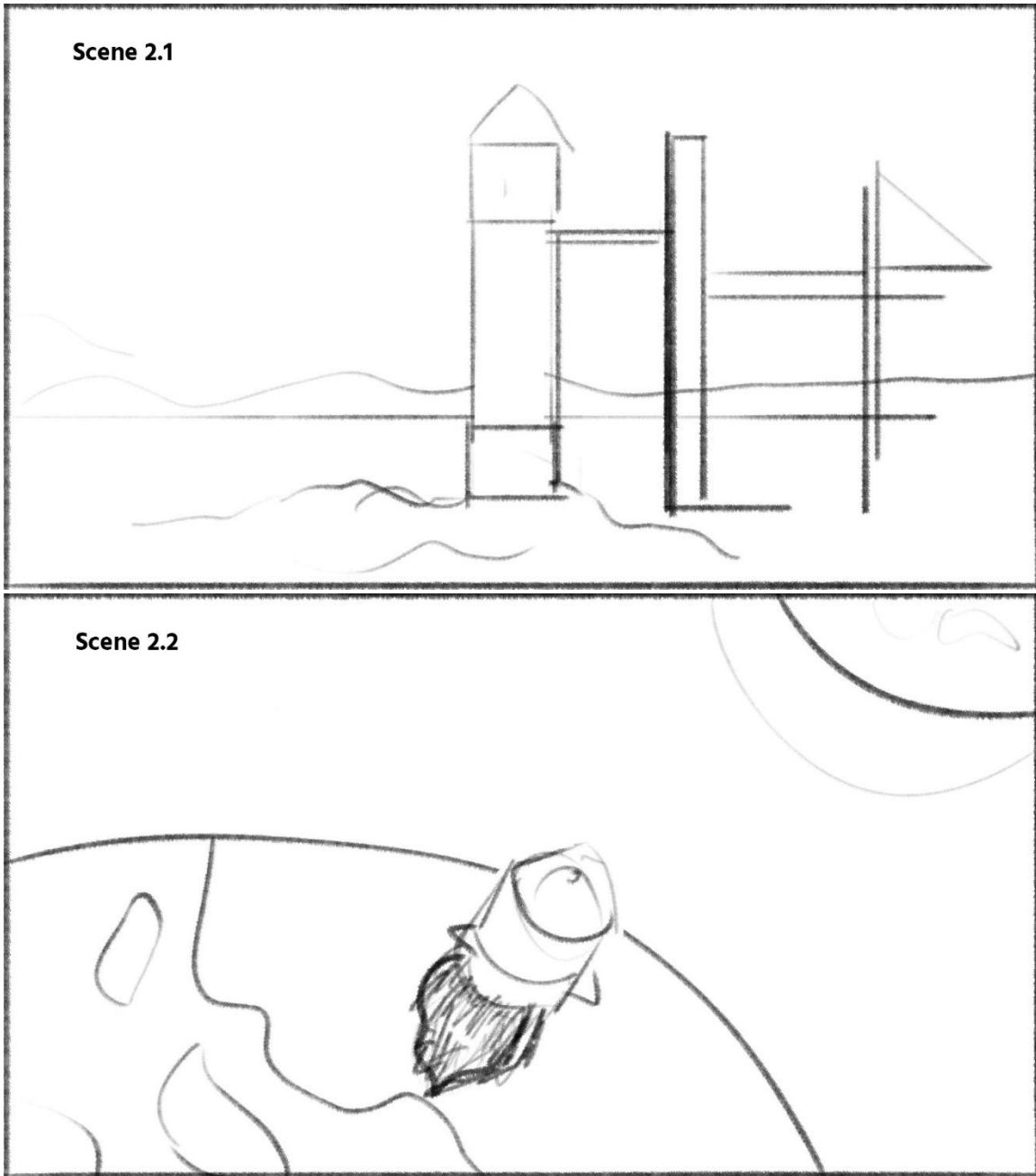


Figure 5.1.2.2: Storyboard Scene Part -2

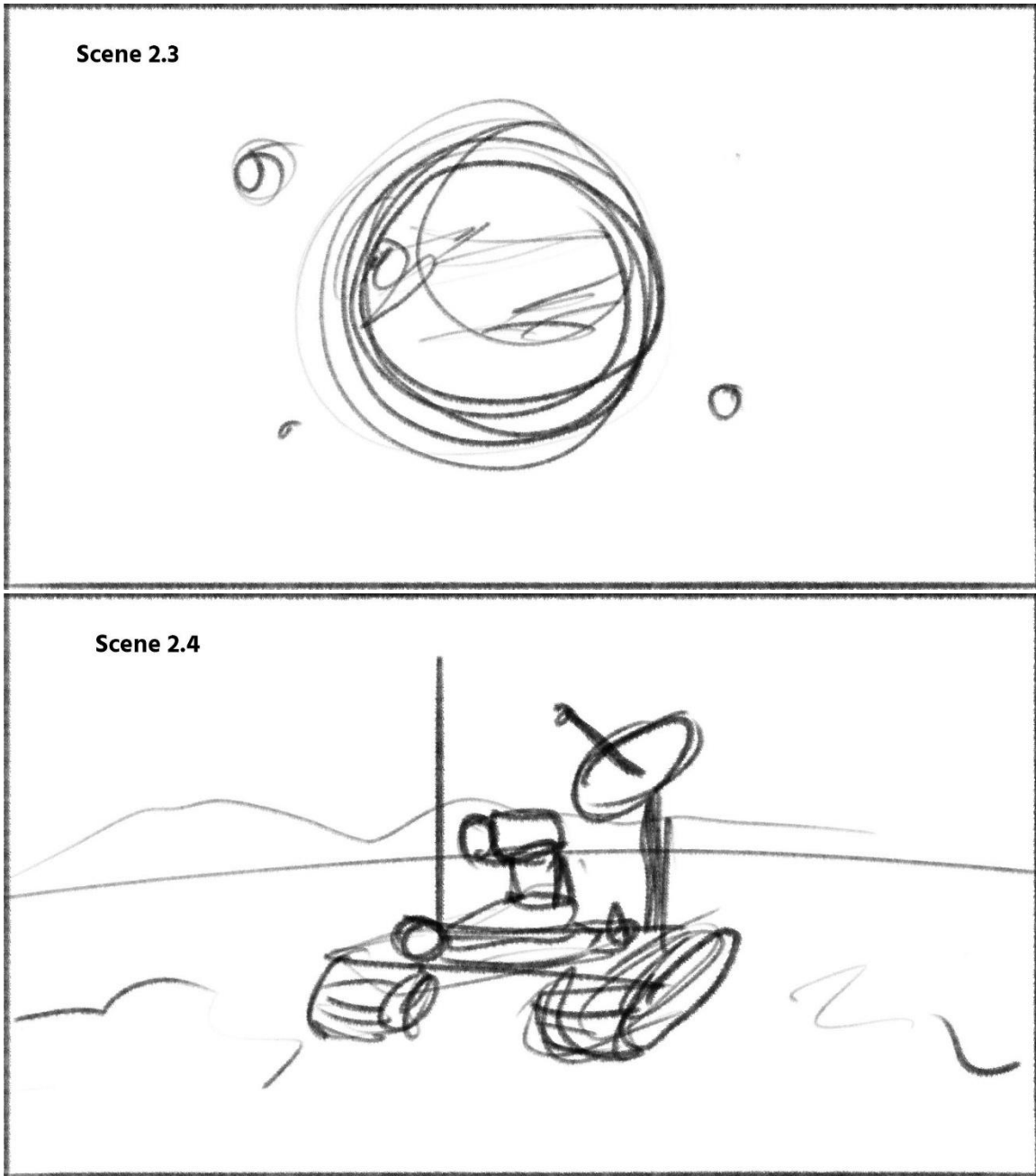


Figure 5.1.2.3: Storyboard Scene Part -3

Scene 2.5

Can we live on Mars?

Scene 3.1

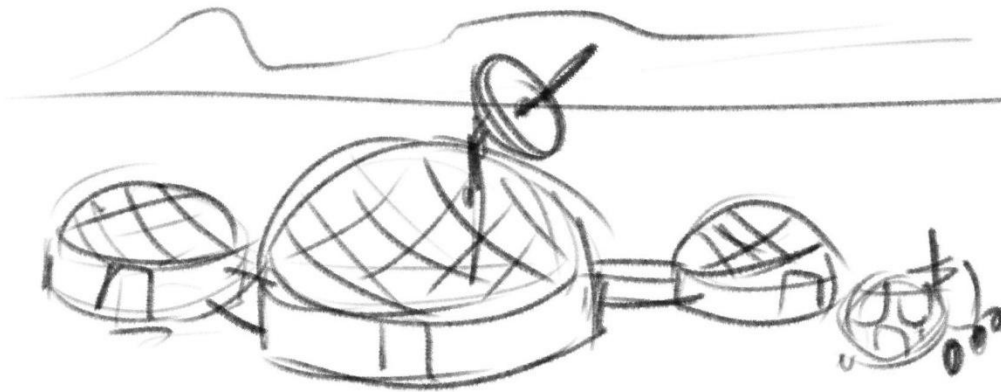


Figure 5.1.2.4: Storyboard Scene Part -4

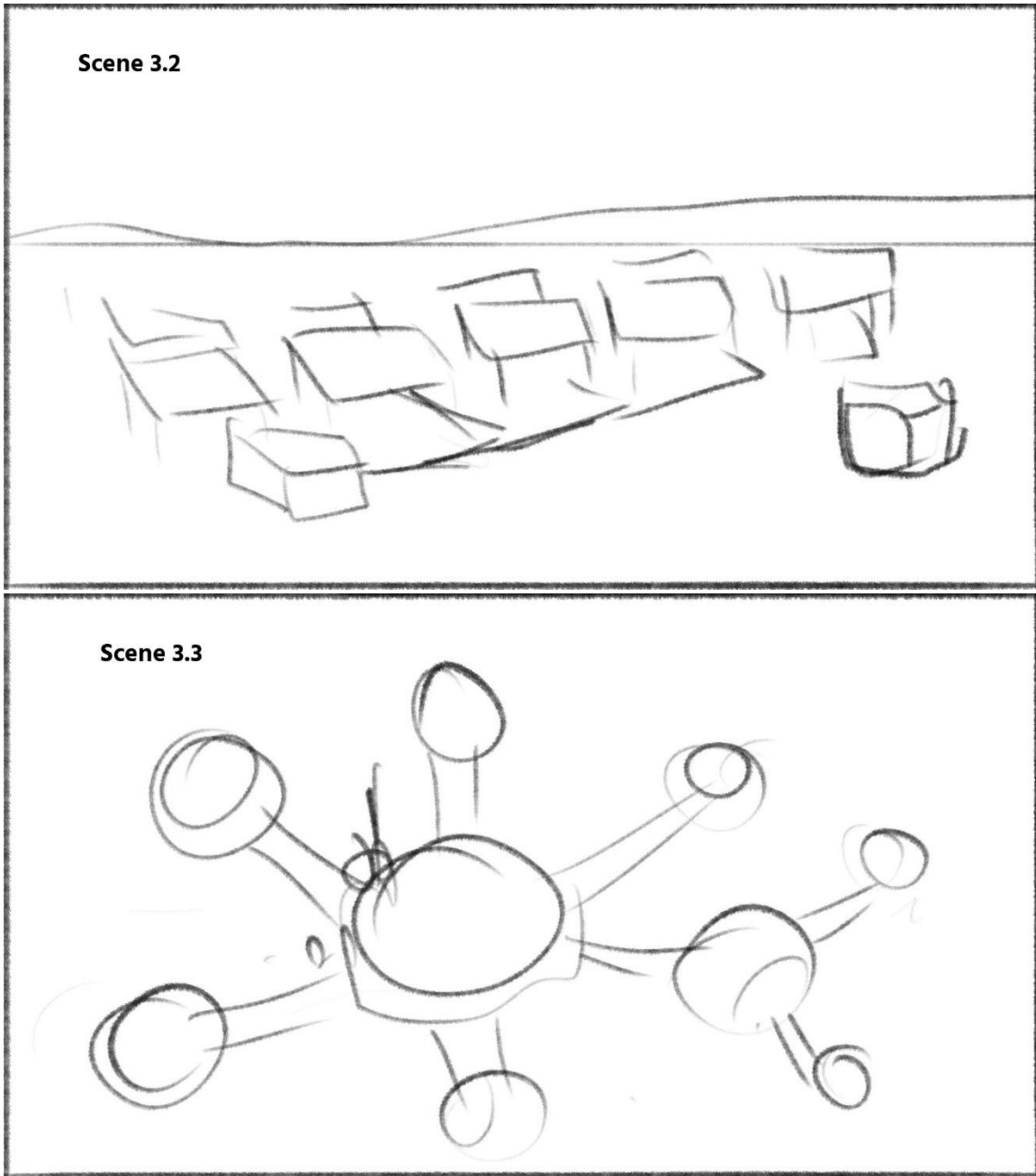


Figure 5.1.2.5: Storyboard Scene Part -5

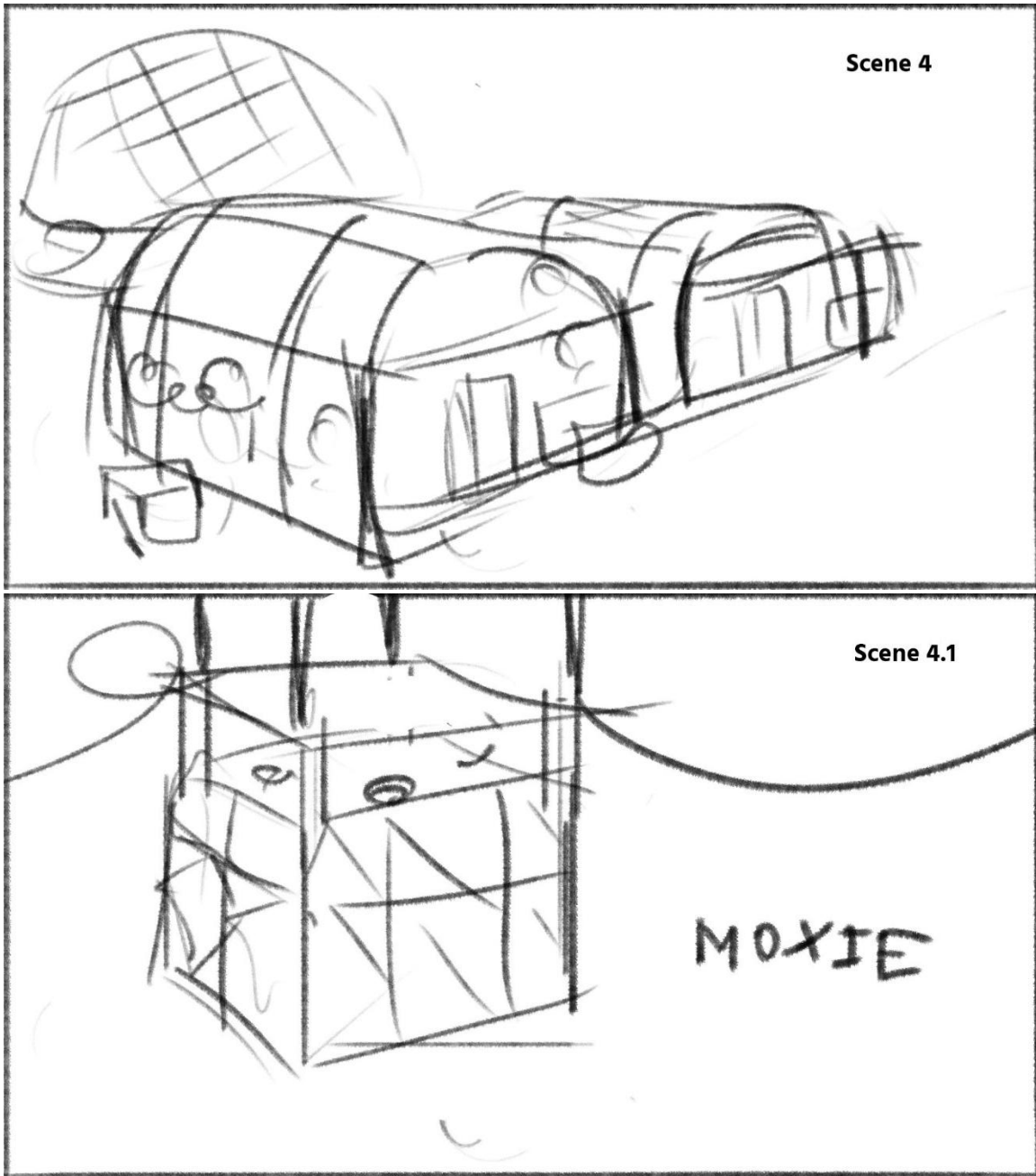


Figure 5.1.2.6: Storyboard Scene Part -6

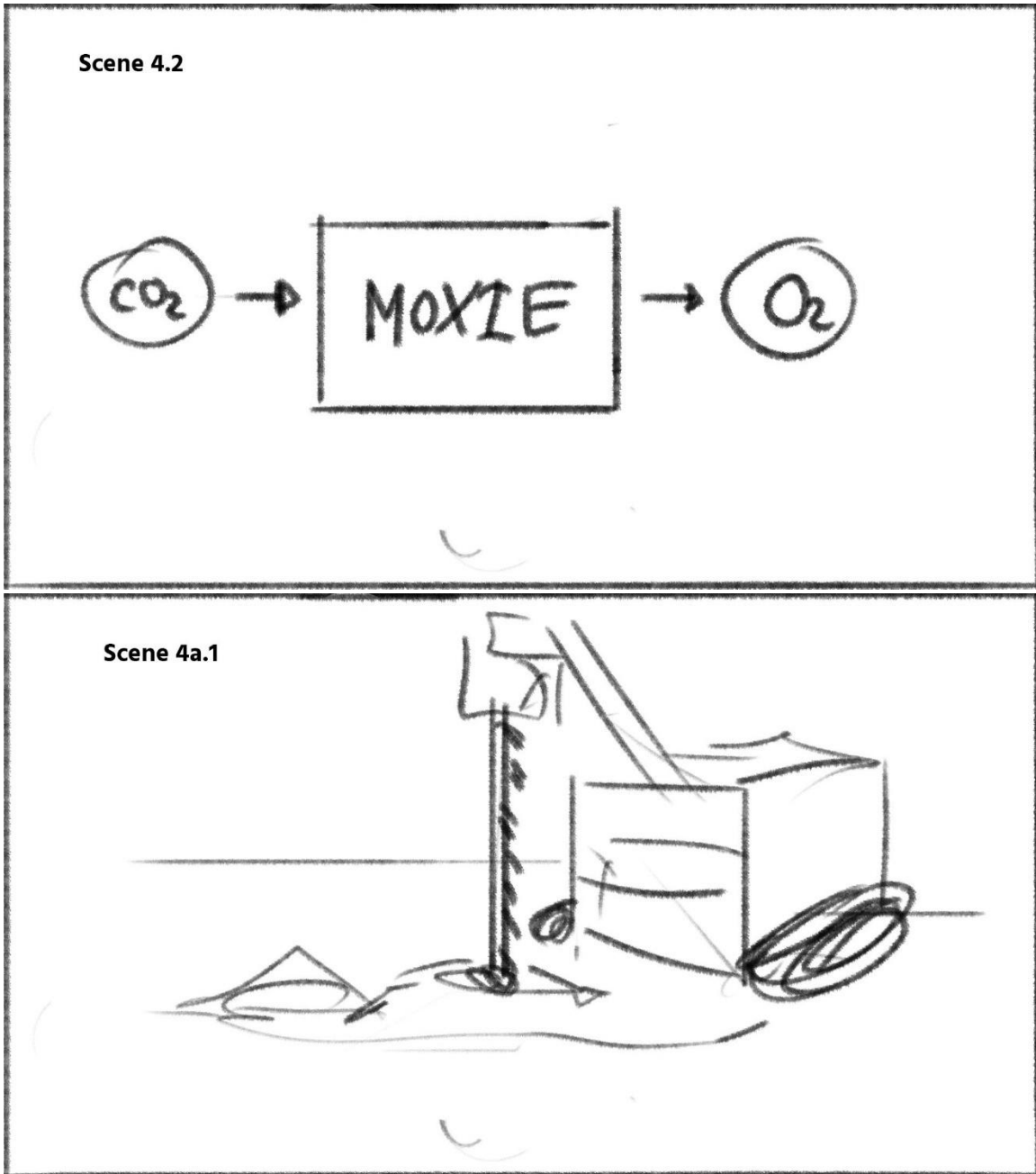


Figure 5.1.2.7: Storyboard Scene Part -7

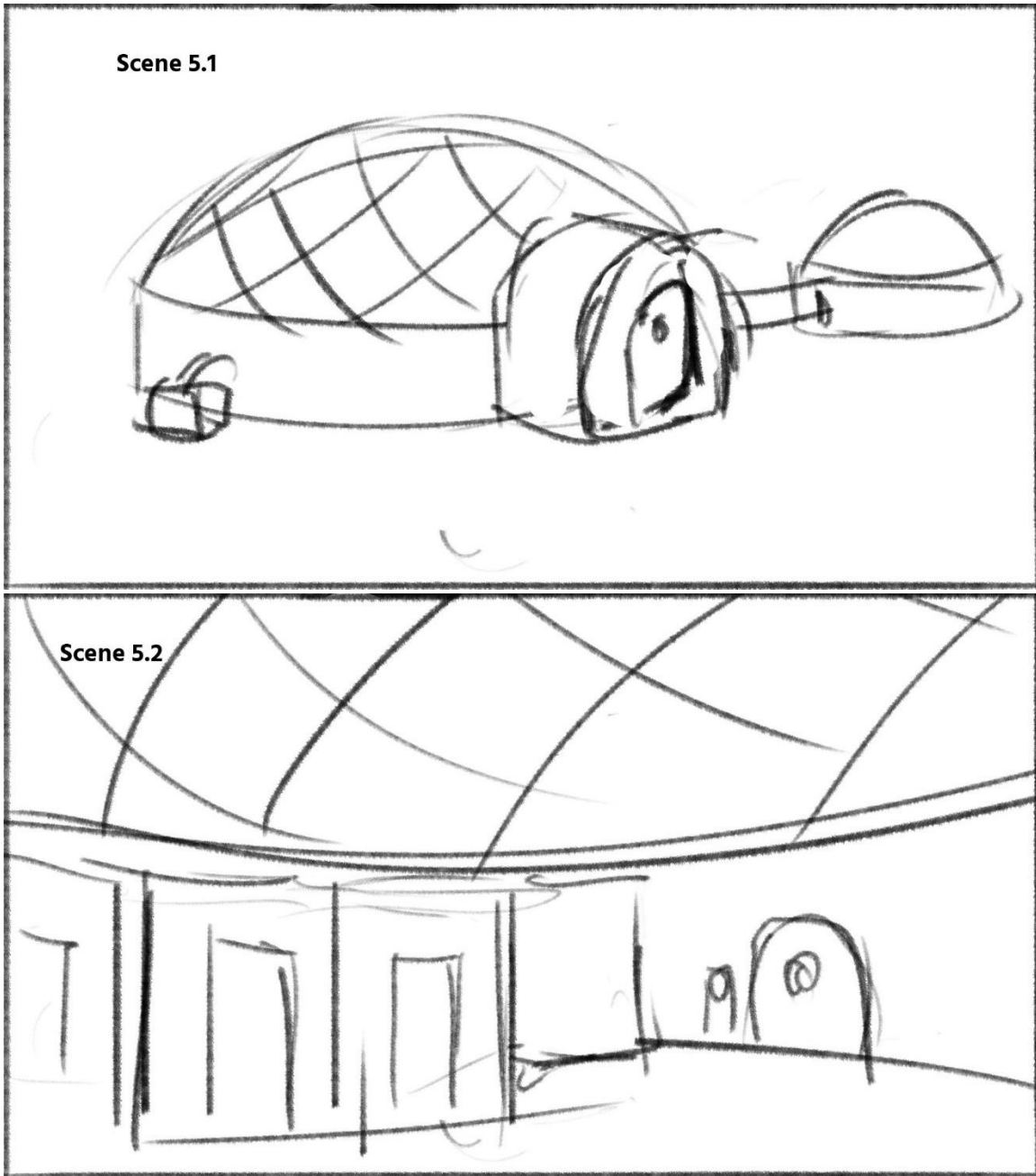


Figure 5.1.2.8 Storyboard Scene Part -8

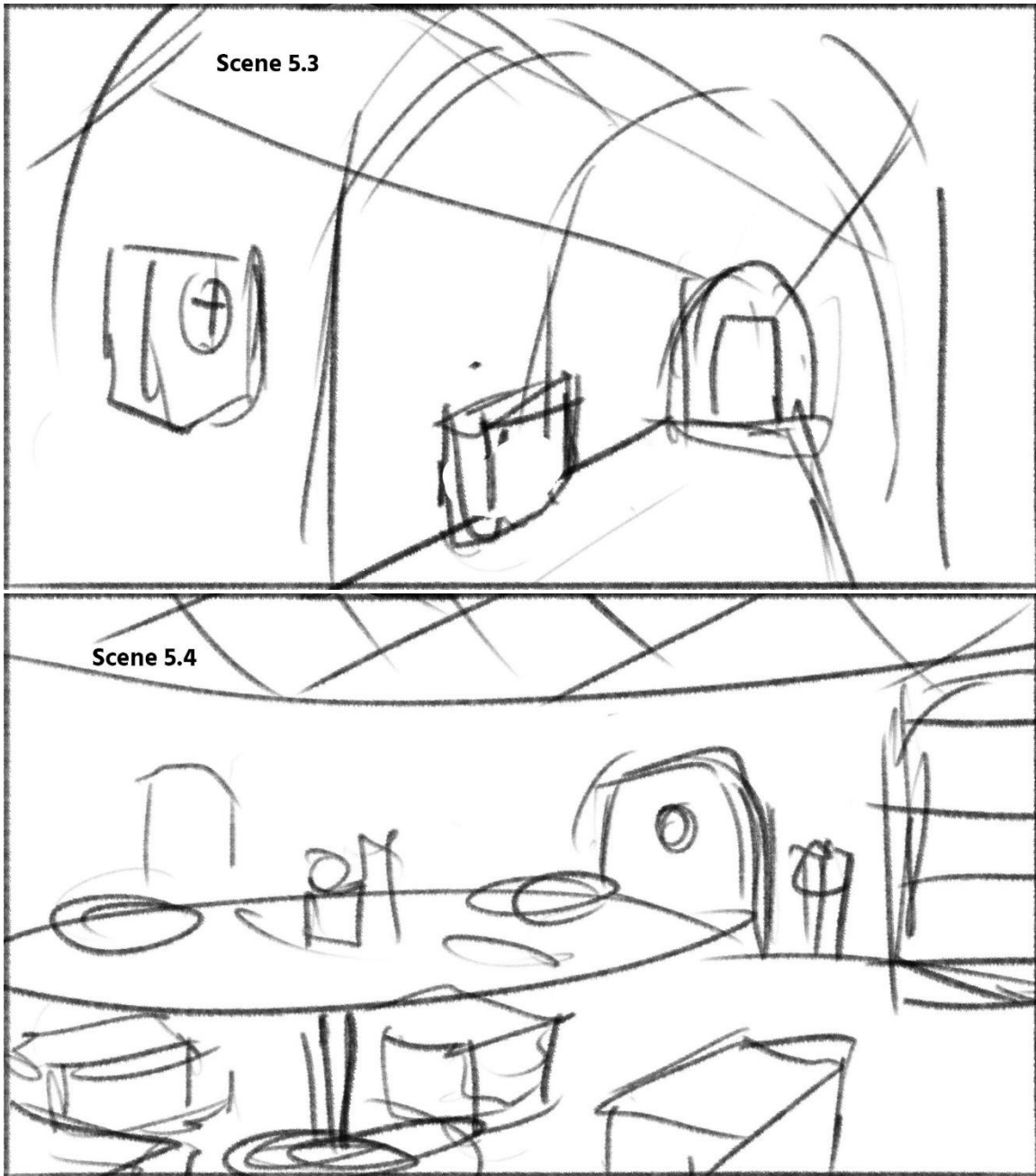


Figure 5.1.2.9: Storyboard Scene Part -9

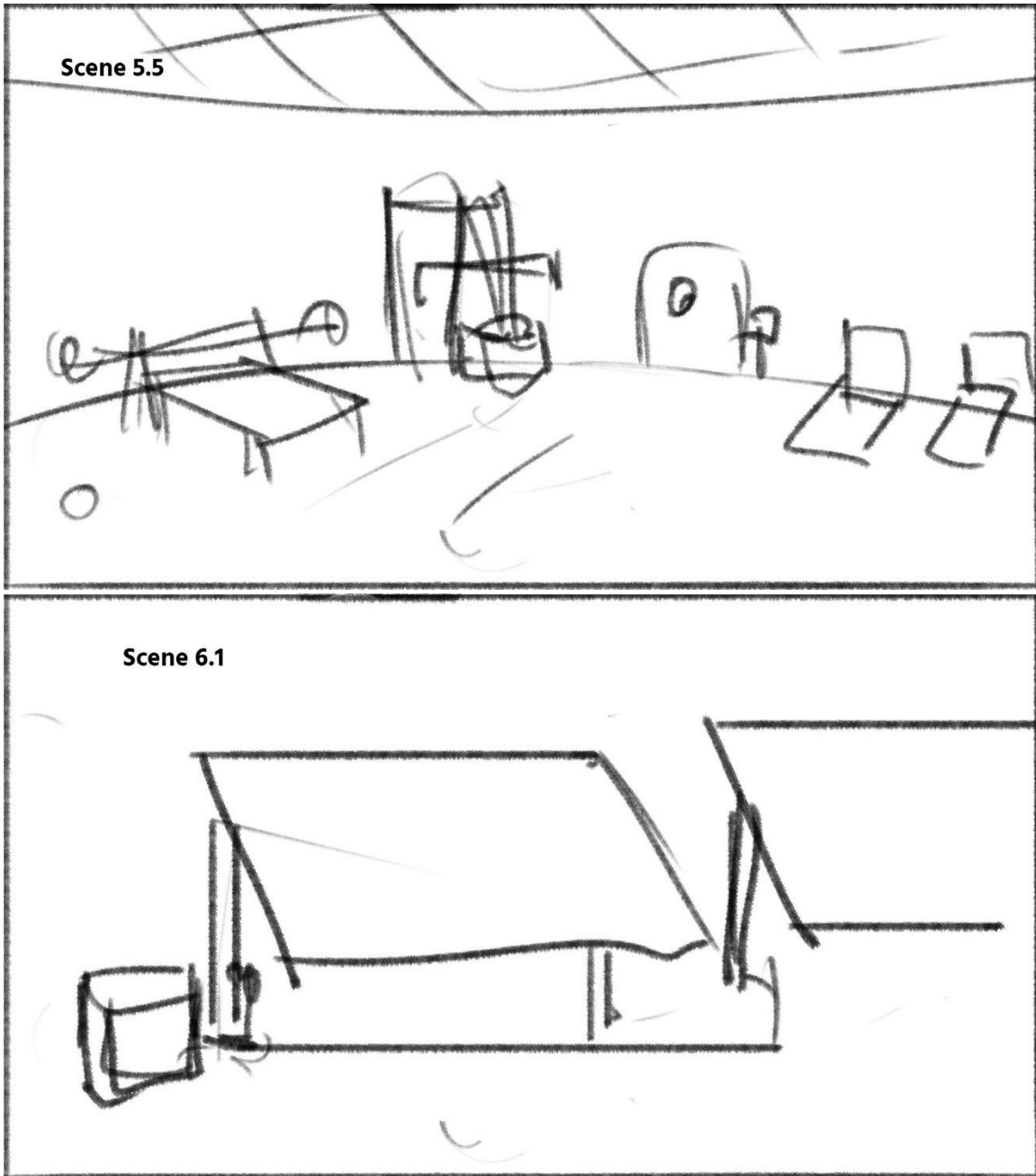


Figure 5.1.2.10: Storyboard Scene Part -10

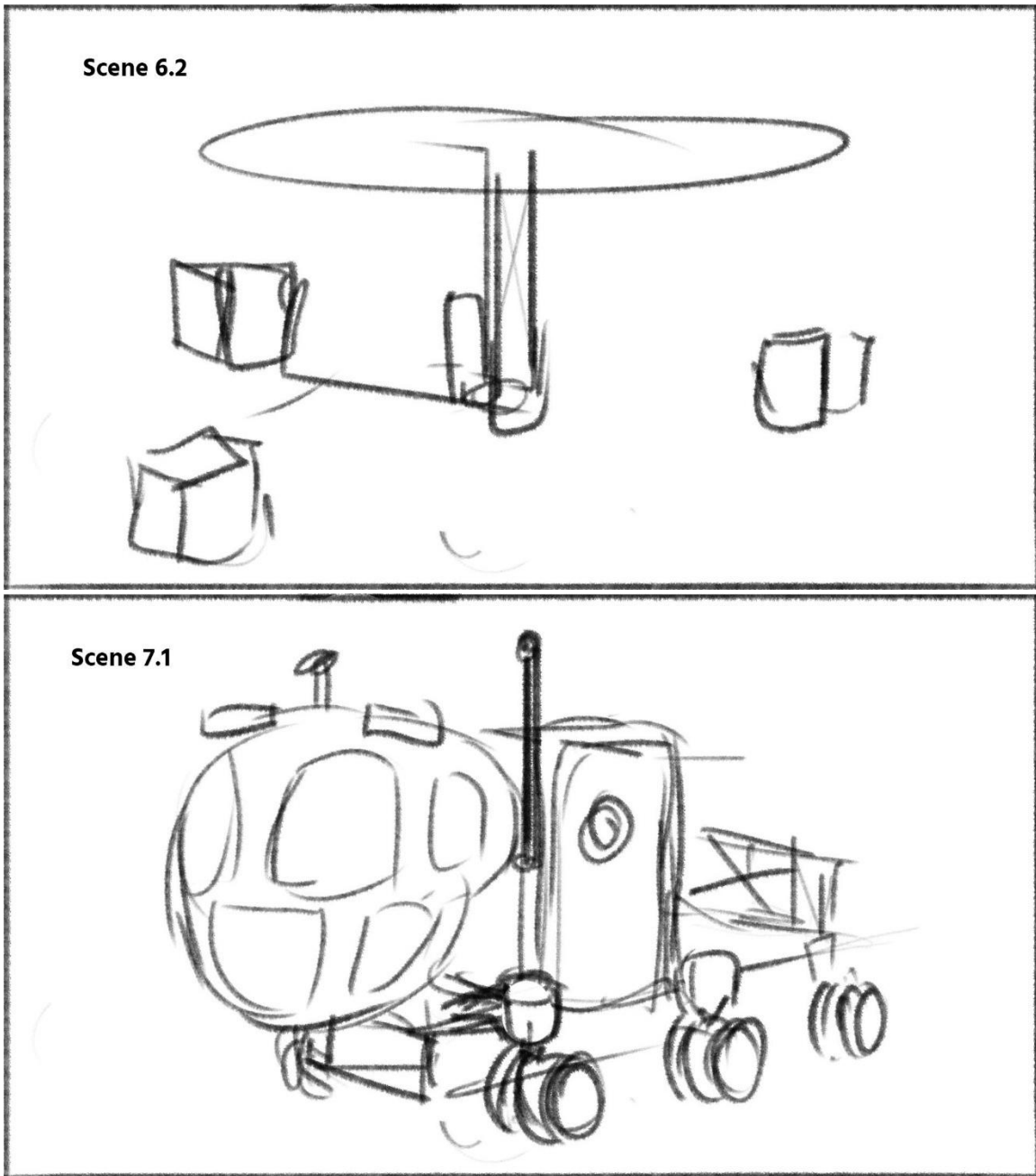


Figure 5.1.2.11: Storyboard Scene Part -11

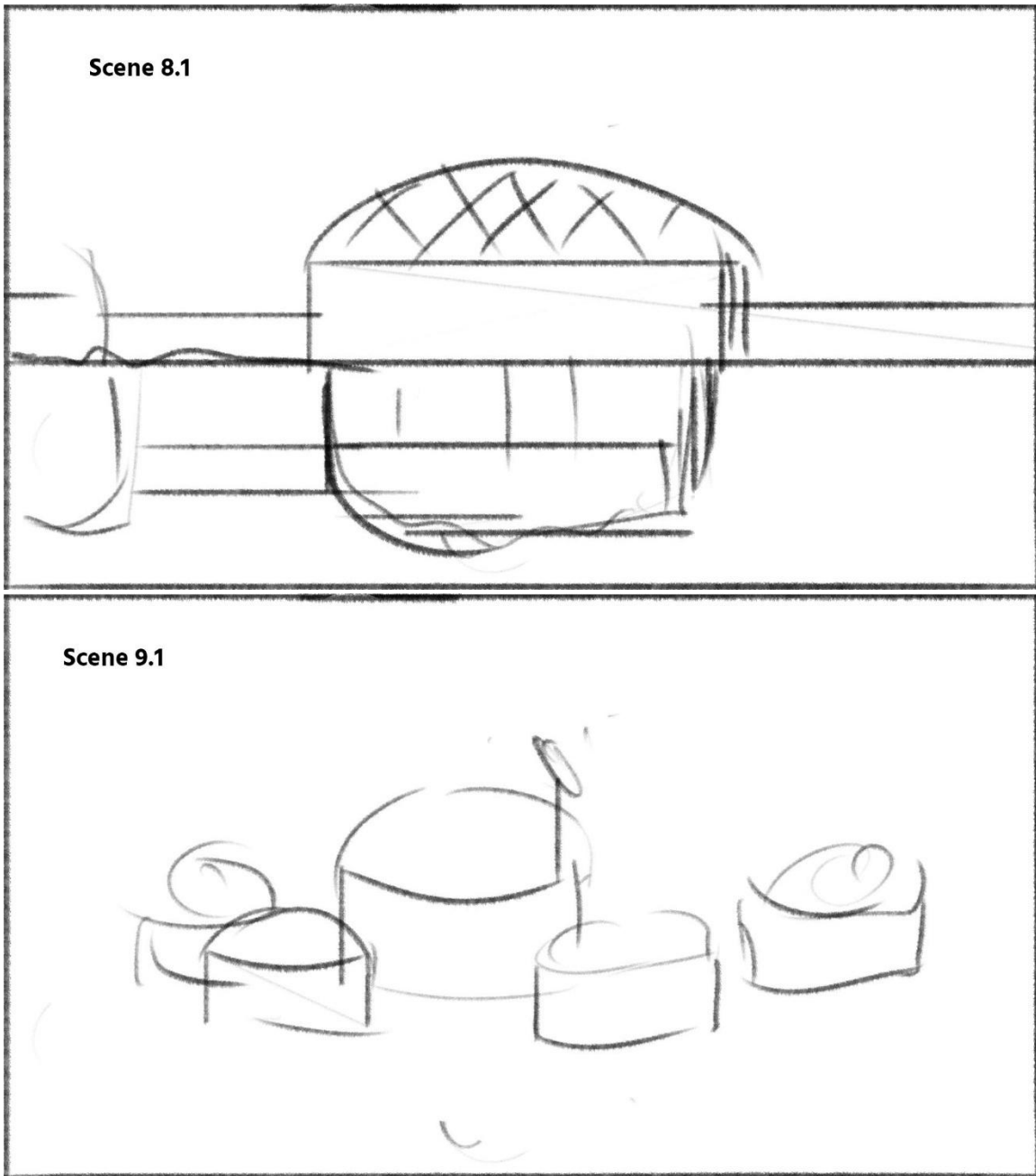


Figure 5.1.2.12: Storyboard Scene Part -12

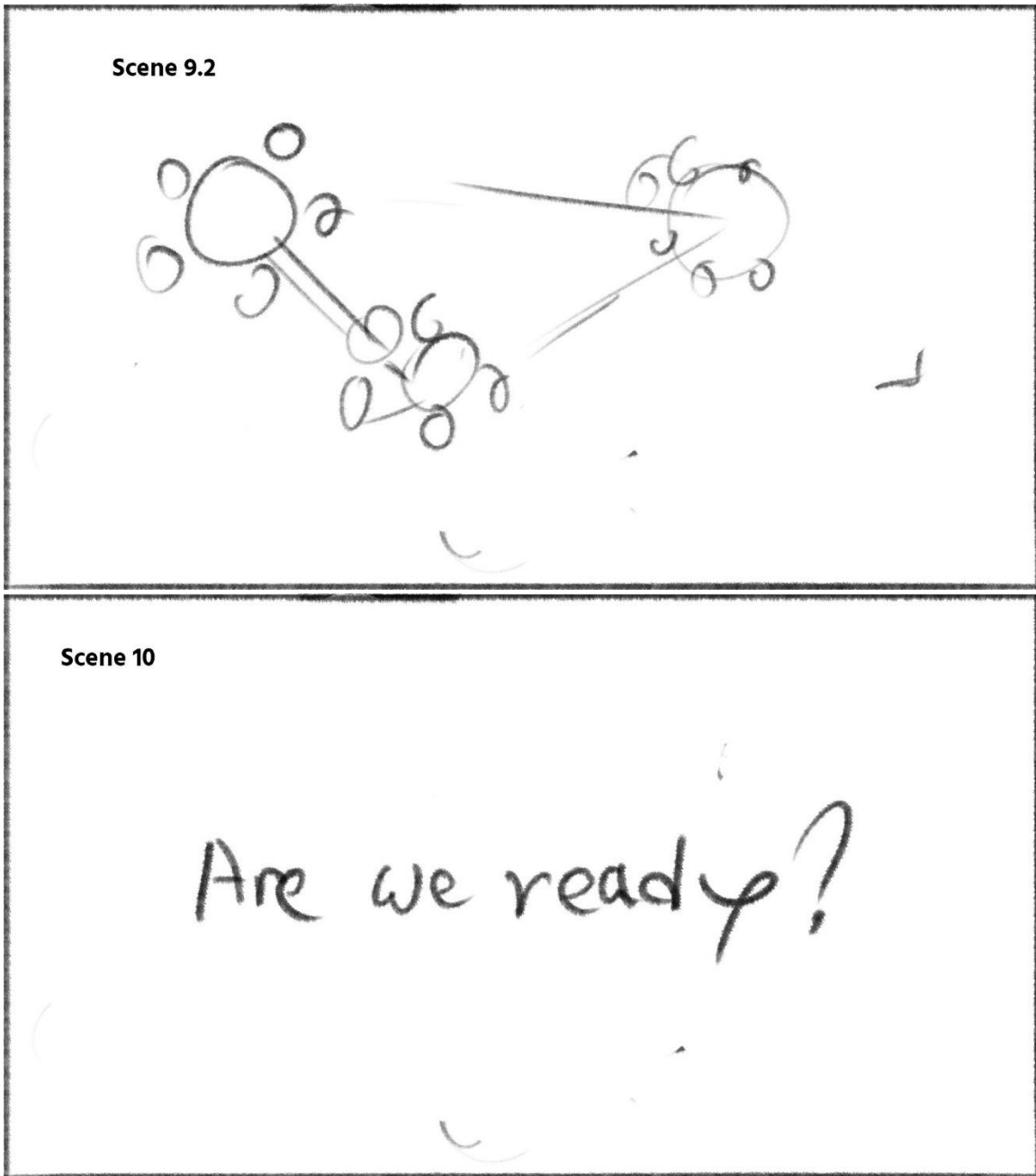


Figure 5.1.2.13: Storyboard Scene Part -13

5.1.3 Gantt Chart & Project Timeline

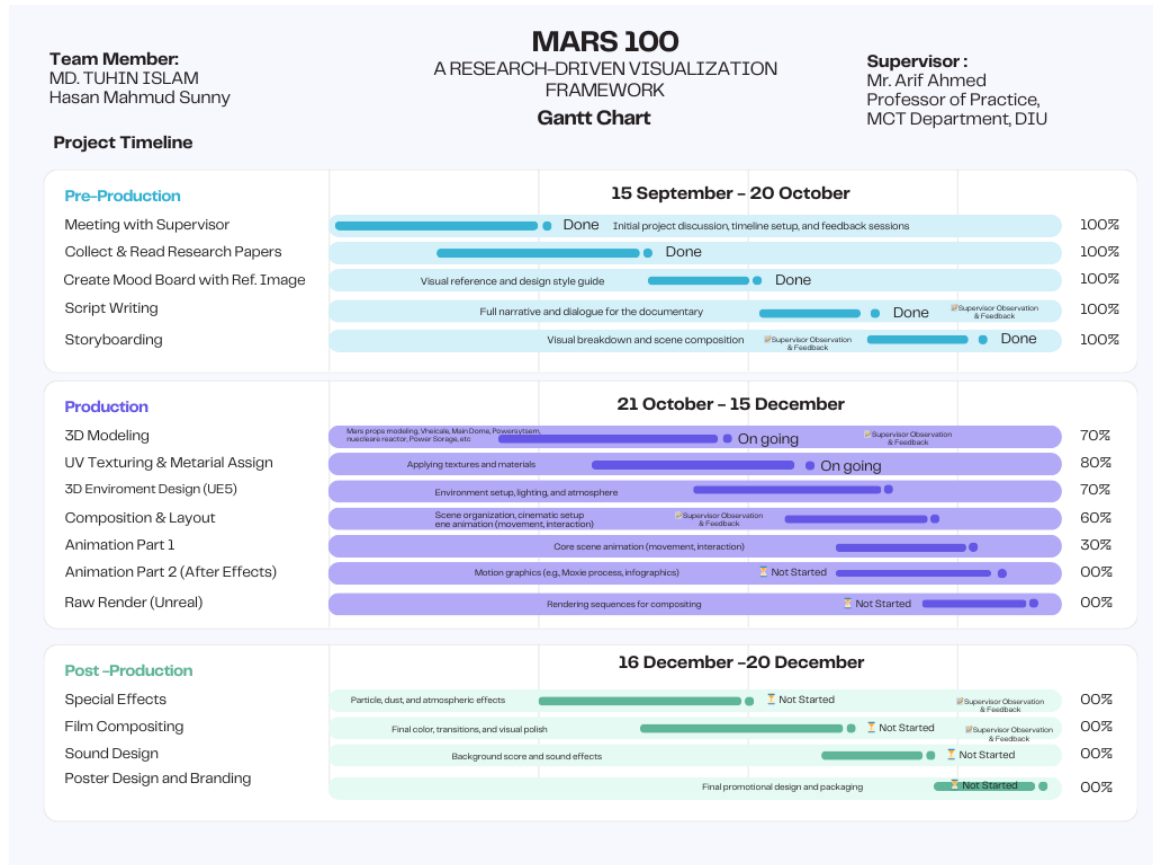


Figure 5.1.3.1: Gantt Chart & Project Timeline

5.2 Production

- a) Modelling assets- building the hulls, rigs & props in Blender/3DS Max, ensuring that the hulls, rigs and props are poly efficient considering the class deadline.
- b) Texturing: Creating PBR Textures and Procedural Material and wiping down surfaces like studio lab.
- c) Environment modelling - creating the planets, the caves, etc., the orbiting stations that ensure the FPS does not look like a big Entity.
- d) Animation-rigging and Keying the characters or magnificent parts of mech for free-flowing motion.
- e) Simulation and VFX - use of particle system, fluid dynamics, adding dust plumes etc. to push the visual wow factor.

f) Lighting - setup of the key lights, shafts & use of Look Development tools to fix the final look.

g) Scene optimization- Reducing the draw calls, Mesh batching, Compress the texturing based upon the performance requirements.

5.2.1 Modeling Asset

In the production of the MARS100, modeling is literally one of the most significant things. The entire 3D Project was created in the Autodesk Maya, Blender and 3DsMax with the correct scale, reference and proportions such that it was both scientifically accurate and visually true. All the models were grounded on the actual design sources of NASA and other research methods, yet I did not forget to preserve the aesthetic atmosphere of a future dystopian world.

5.2.1.1 Solar Panel Modeling

The project I intended to do in Autodesk Maya with solar panel on the other hand began with me simply throwing a simple cube onto the screen and then fiddling with it until I got those thin photovoltaic cells. I continued to sand the cube in a few instances until it began to resemble more like a panel and used the bevel tool on the edges, so that it was not so jagged, it appeared to look better and more natural. The hinged frame and a couple of cubes and a cylinder were pieces of wood which I had put together. To give the scale, I added the size of NASA Mars solar array dimensions to the mix to ensure that everything remained at the correct proportions. I took caution in the edges loops and smoothing levels and

attempted to retain the natural curves to have the mesh morphed into so that the animation looks natural and the lights are natural.

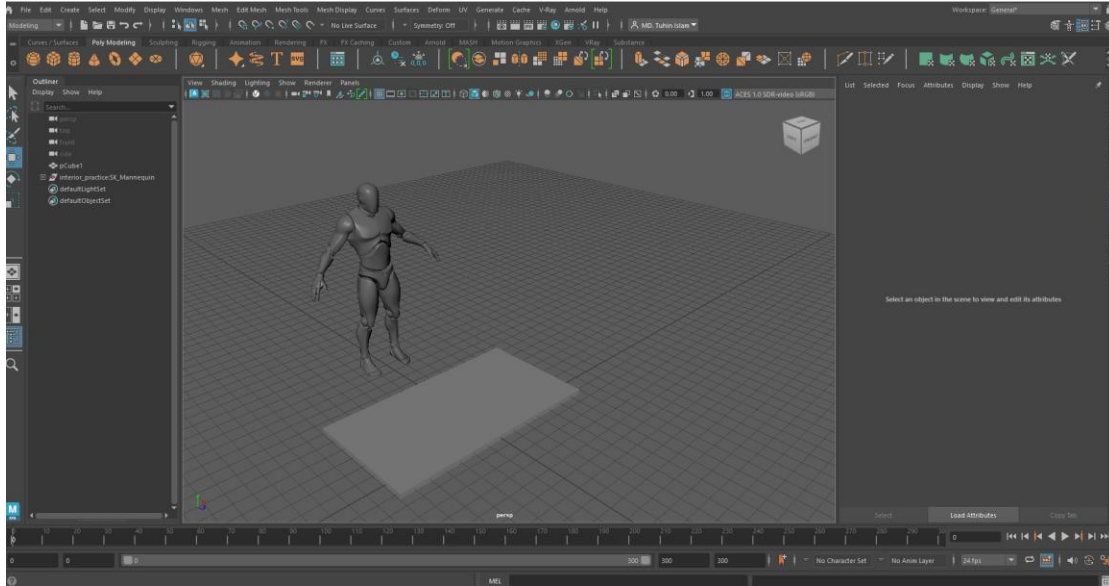


Figure 5.2.1.1.1: Solar Panel Modeling Part 1

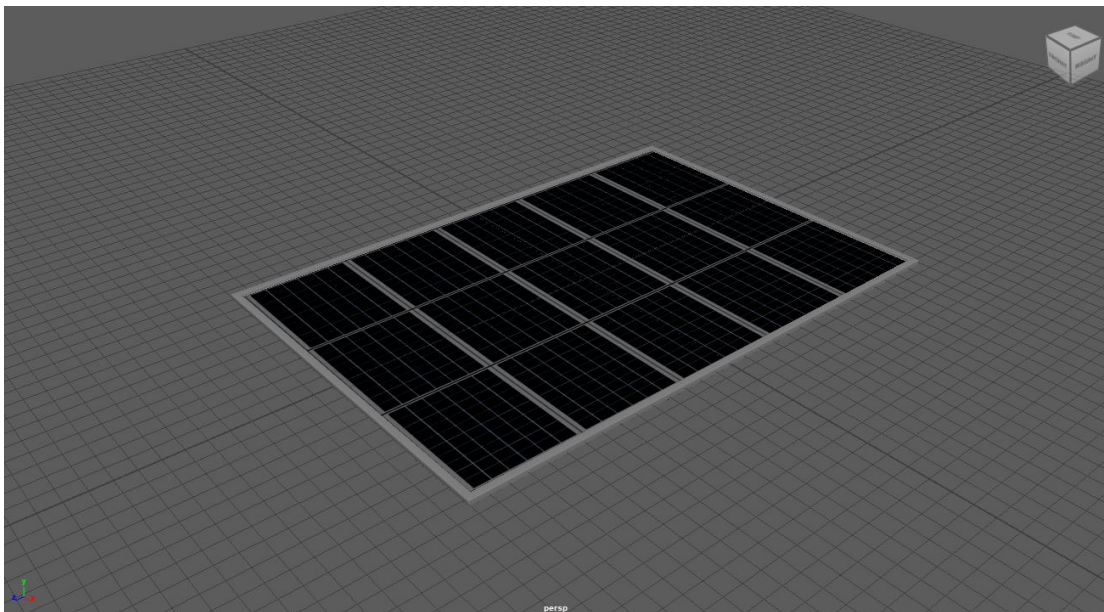


Figure 5.2.1.1.2: Solar Panel Modeling Part 2

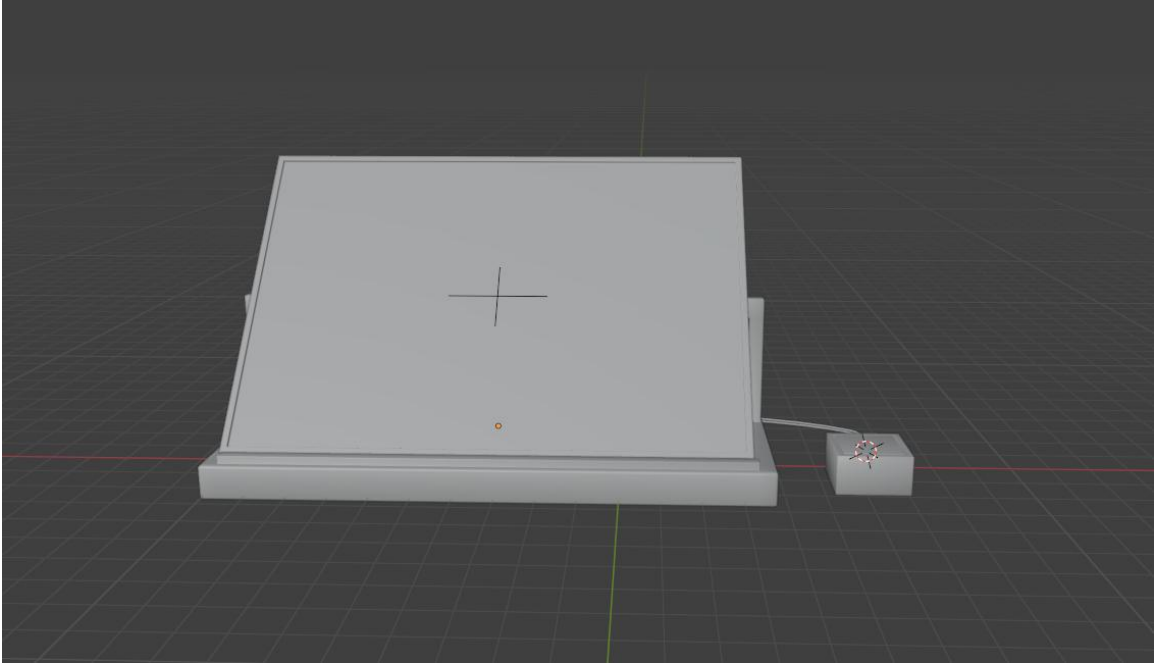


Figure 5.2.1.1.2: Solar Panel Modeling part 2

5.2.1.2 Nuclear Reactor Design

The nuclear reactor modeling starts with a cylinder. I pushed out the top and bottom to make what we had done in that course on industrial modelling to make the outer jacket and containment layers. Slight cylinders and what I refer to as trousers were put in to depict vents, connection pipes and power lines. In order to maintain the ratio and symmetry straight, I patched several reference views into the model. Bevels and insert-edge-loop were also applied to smooth the rolled curvature, and the superstructure edges that cause the reactor to appear like an actual industrial object. The room was themed with decorative detail of functional detail and Bison says that this was based on small Mars installations, which had fission-based ideas. I was attempting to bring home the sense of that Mars power talk of that conference. Each section would be as modular as possible to be textured and animated later, which would allow me to use it in the next step of the project but not to design the entire part again.

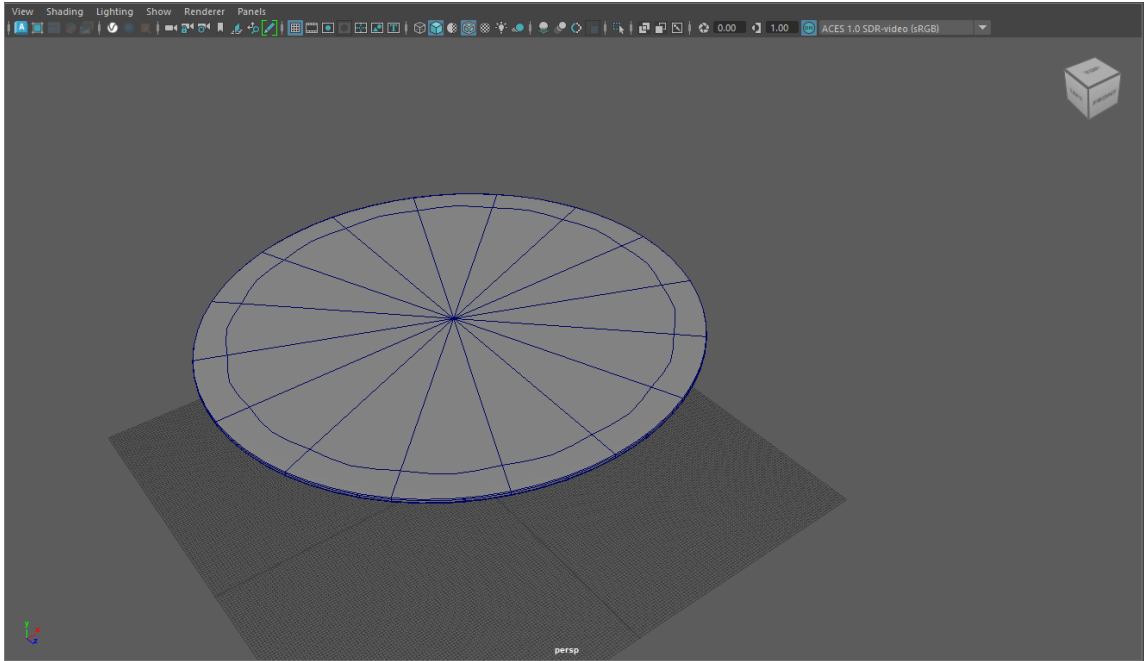


Figure 5.2.1.2.1: Nuclear Reactor Modeling Process Part-1

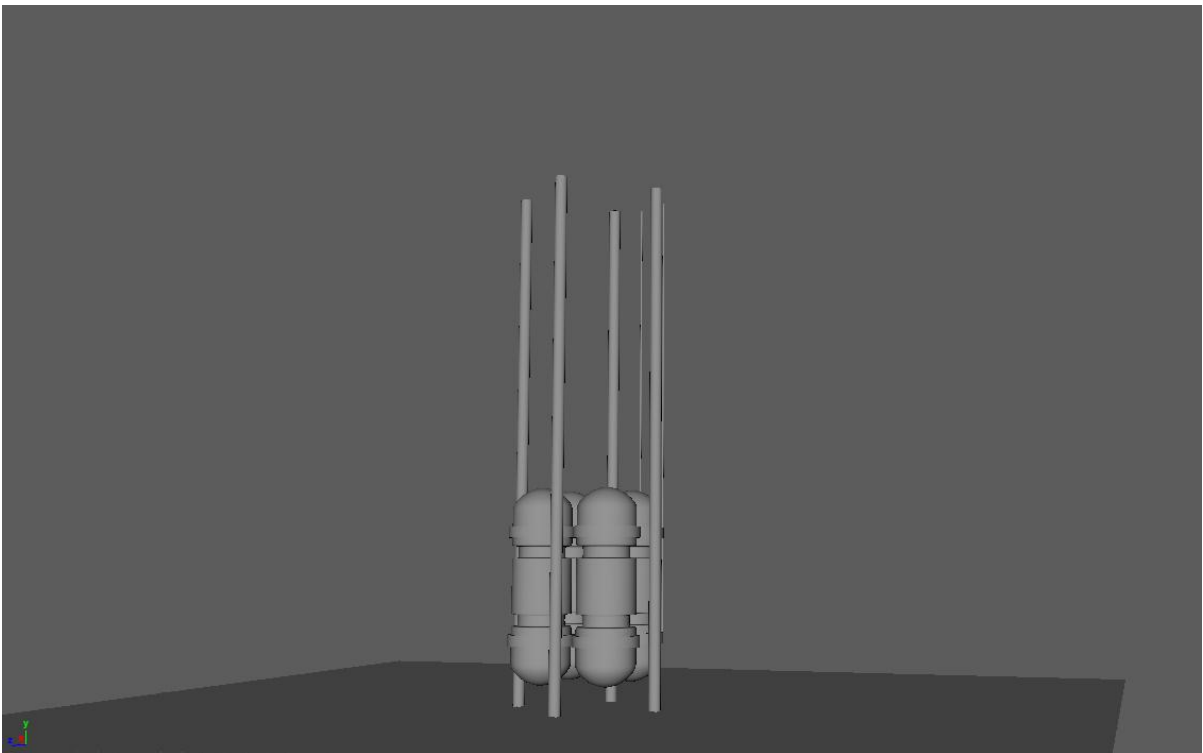


Figure 5.2.1.2.2: Nuclear Reactor Modeling Process Part-2

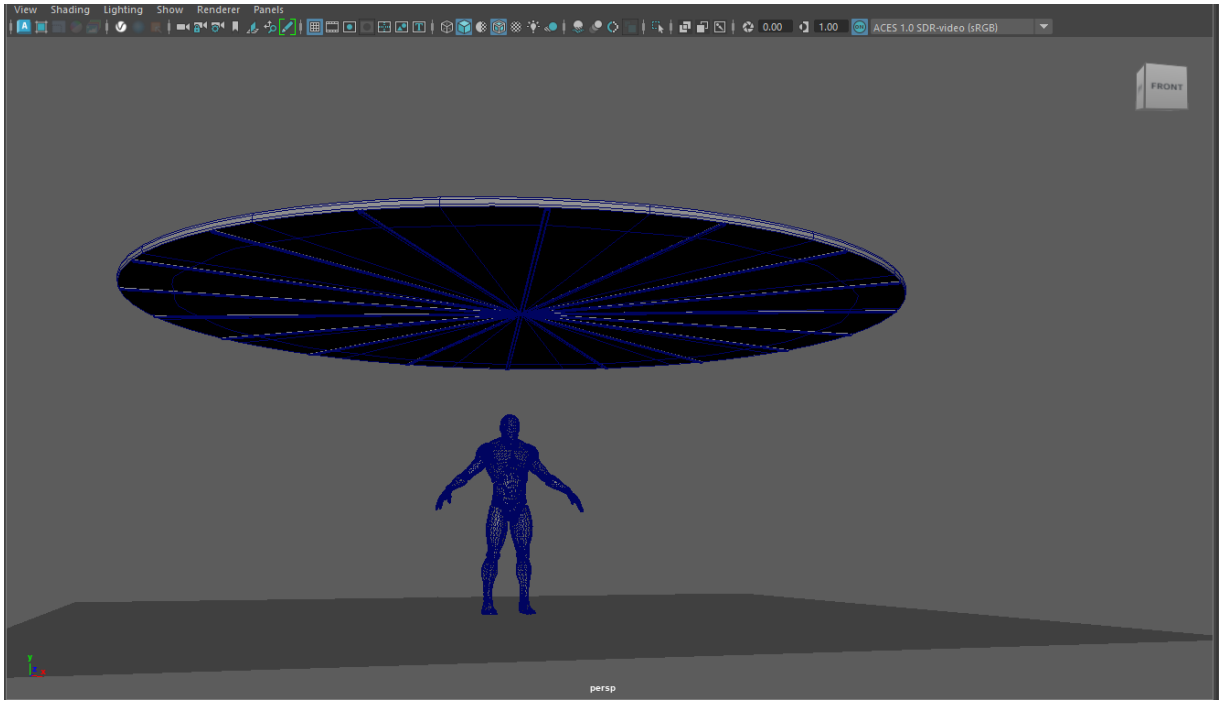


Figure 5.2.1.2.3: Nuclear Reactor Modeling Process Part-3

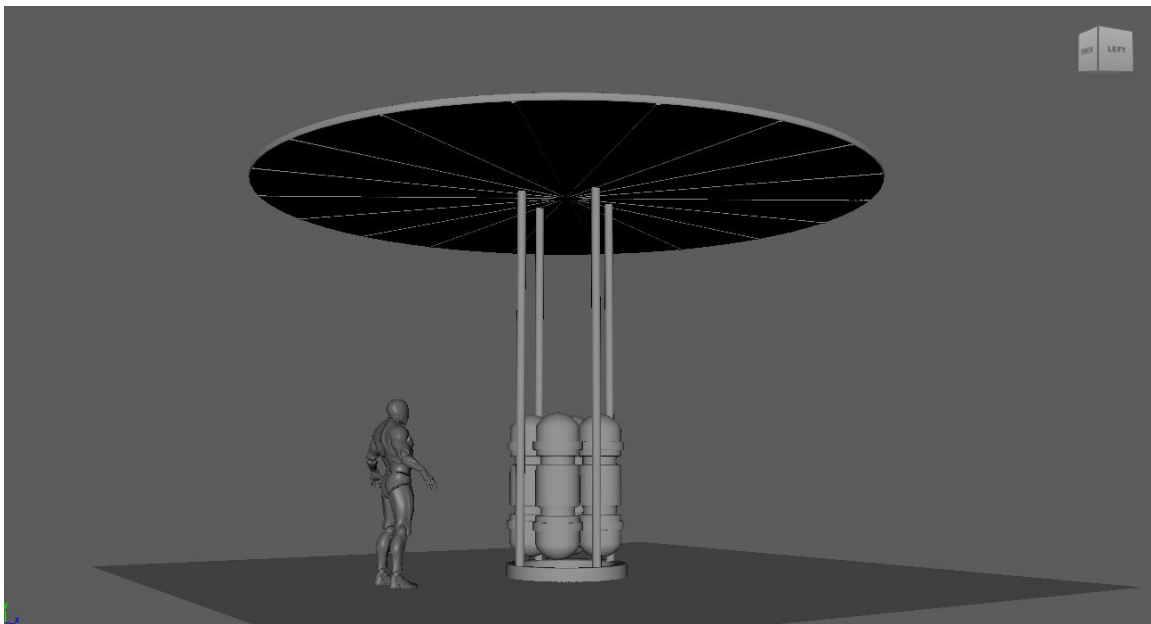


Figure 5.2.1.2.4: Nuclear Reactor Modeling Process Part-4

5.2.1.3 MOXIE Machine Model

Using the NASA reference prototypes, the MOXIE (Mars Oxygen In-Situ Resource Utilization Experiment) instrument was built using Autodesk Maya. For the basic body of the machine, a cube primitive was selected so that the design is more concise and practical. The edges were beveled for a more polished industrial appearance with extrusions for the panels, vents, and inlet ducting. Cylindrical parts were attached to simulate the connecting valves and the oxygen outlet. Work to scale, on proportion and symmetry was considered as close study of actual MOXIE images for scientific validity. This model also shows how the system creates oxygen from Mars' CO₂ atmosphere.

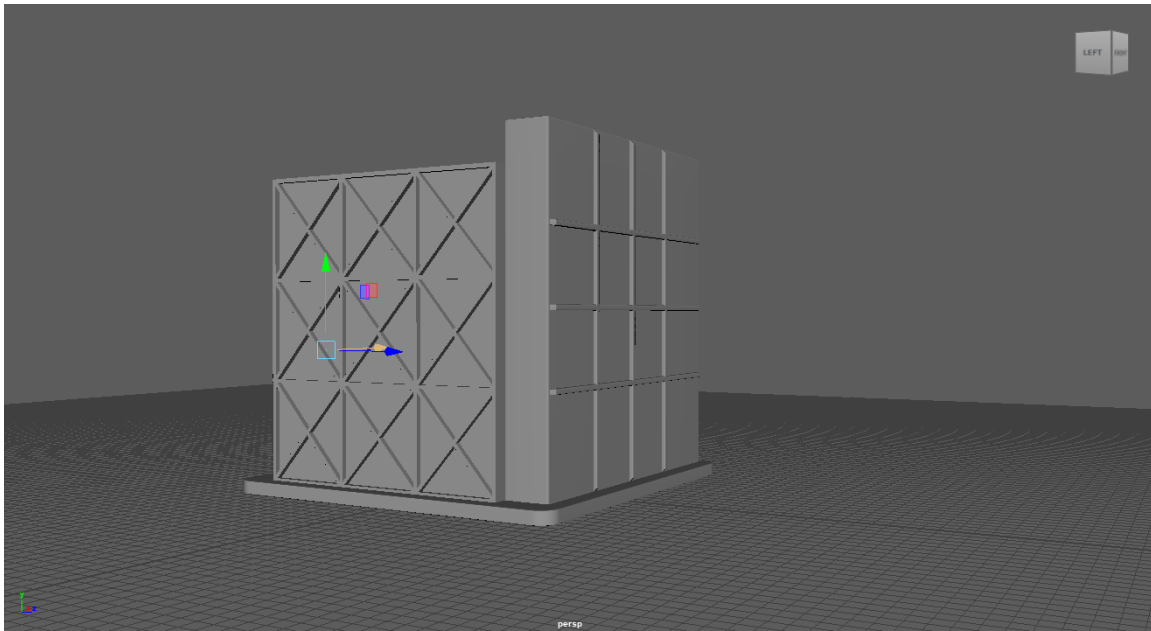


Figure 5.2.1.3.1: MOXIE Machine Modeling Process

5.2.1.4 Electric Box Model

The Electric Box is a management and control device designed for the habitat's power system. The model was made in Blender starting with a basic cube. The form was developed further using extrusions, bevels and loop-cuts to create cavities, hatches and fittings. Real-life reference images were taken from industrial electrical distribution boxes to adhere to correct proportions, structure and mechanical detail. The MDRS habitat's doors were modified to fit the sci-fi theme of the MARS100 habitat. Extra cylindrical meshes were included to model power shafts and cable exits. The edge flow and smooth subdivision of the mesh was optimized to have shading there matches for rendering.

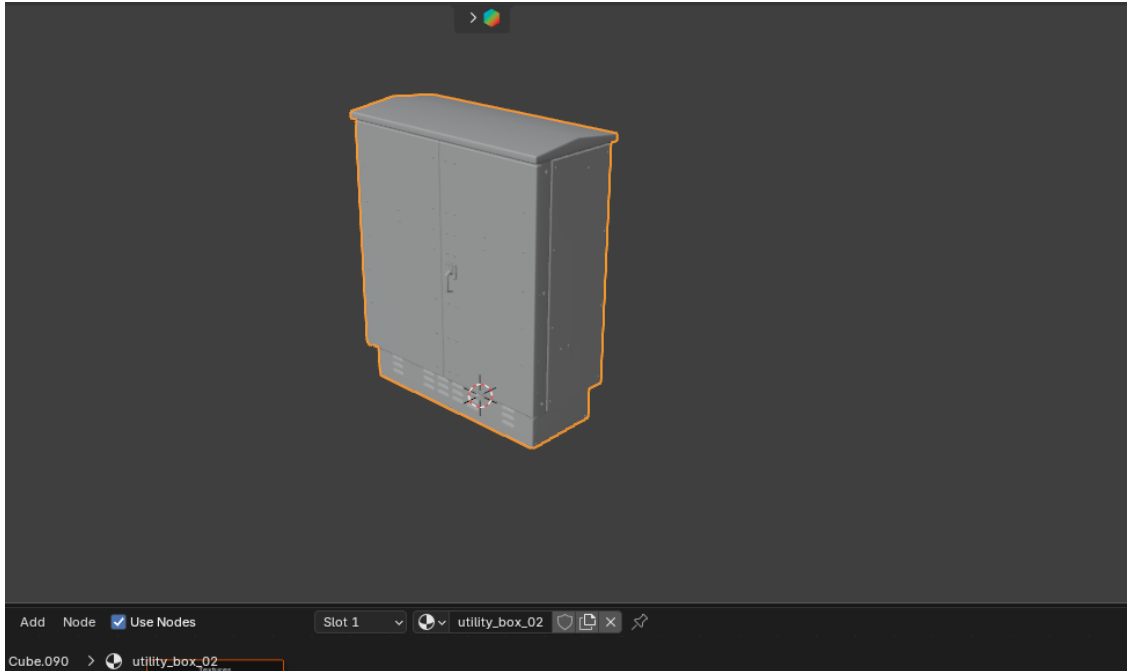


Figure 5.2.1.4.1: Electric Box Model

5.2.1.5 .X Modular Tunnel Model

The modular tunnel is the connective artery of MARS100 habitat connecting the main dome and the central control room and secondary (external) units via a corridor carefully sealed with air. The initial geometry was drawn in blender, and the default cube was used and then followed by a set of loop cuts and extrusion utilized to shape the base of the geometry into a rectangle shape that more closely resembled a tunnel. Rounded edges were also used with the mention of easier airflow dynamics which makes the design have realistic effects which relate to pressure. The beveling tool was used to soften the sharp edges, thus producing the bending corners in an industrial style of the architectural design of the habitat.

The model has been made to ensure the faithfulness of scale and proportion against a grid of reference of real grids and calibrated by measurements on a real scale based on previous research on Mars habitats. The modular nature of the tunnel; that it can be reversed, replicated, or extended, gives us a flexible structure which can easily add and combine several segments of a habitat. A balanced set of edge loops was also preserved all over the mesh to give the best smooth shading and UV mapping to be used on the mesh. Framing

pieces were reinforced to serve an exposed termini to enable them to mate securely with other 3D modules, such as airlocks, greenhouses, and reactor chambers.

The modelling methodology adopted has consequently high visual cohesion and functional realism with the technical strength needed by the visual rendering process and the animation process in the MARS100 simulation environment.

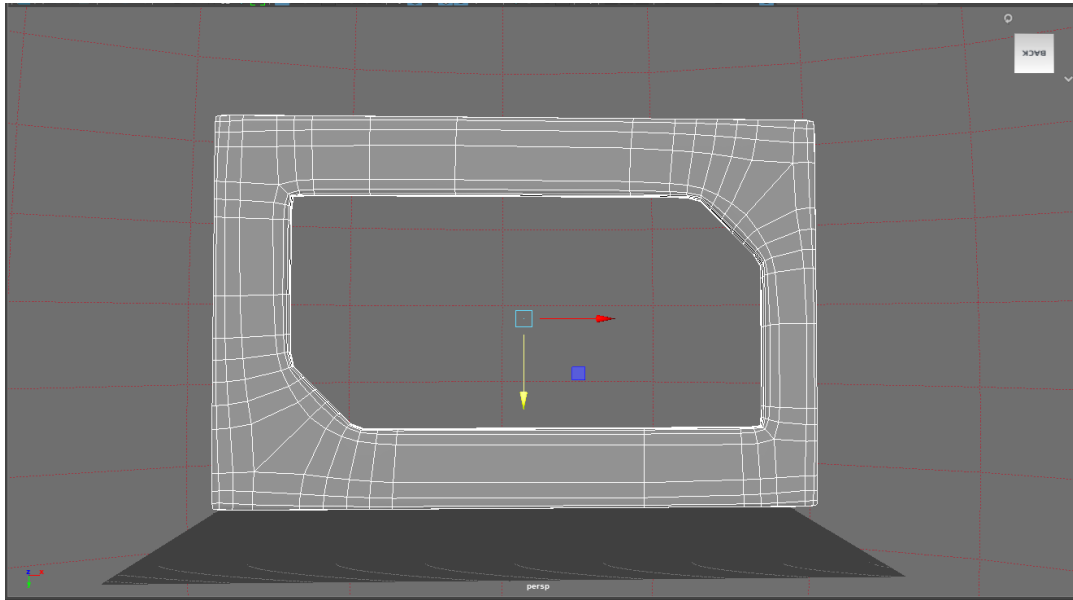


Figure 5.2.1.5.1: X Modular Tunnel Modeling Process Part 1

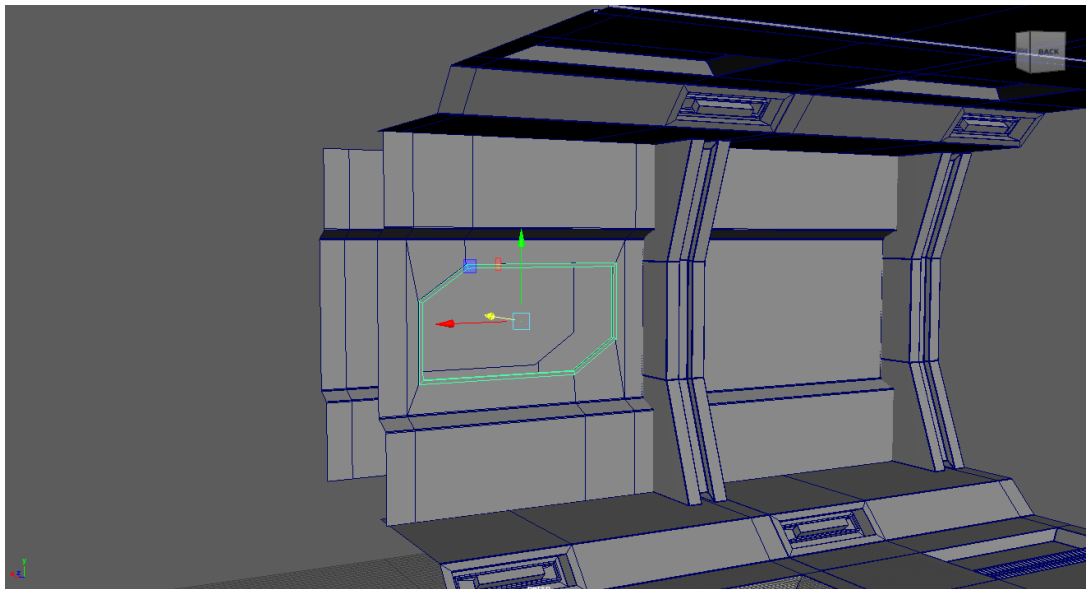


Figure 5.2.1.5.3: X Modular Tunnel Modeling Process Part 2

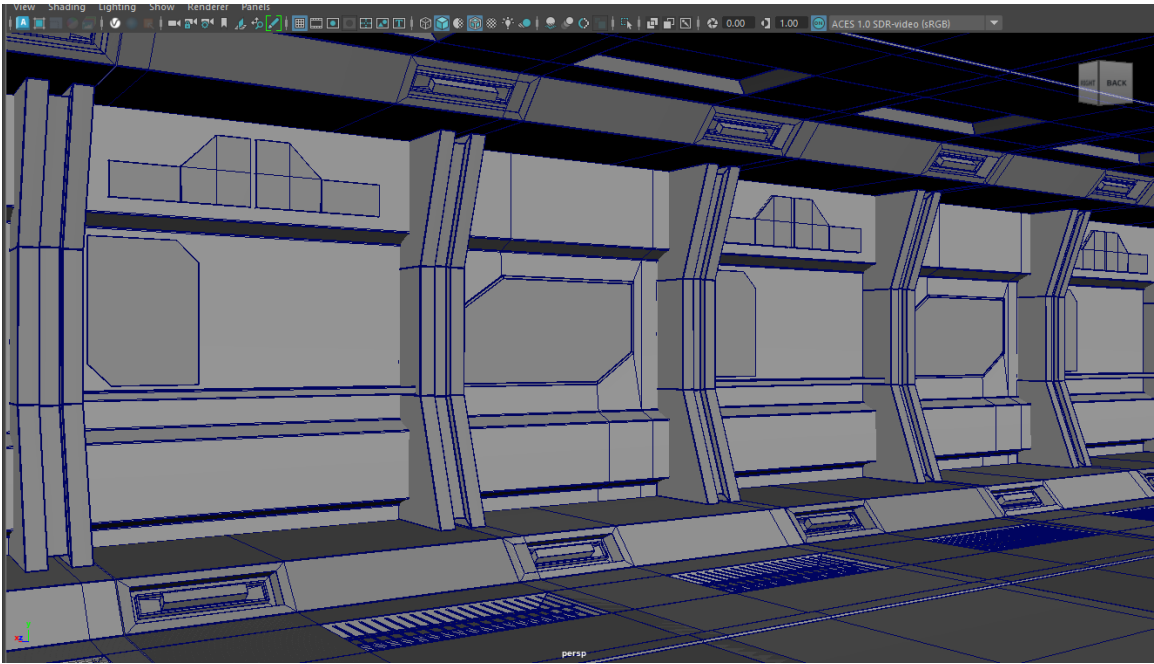


Figure 5.2.1.5.2: X Modular Tunnel Modeling Process Part 3

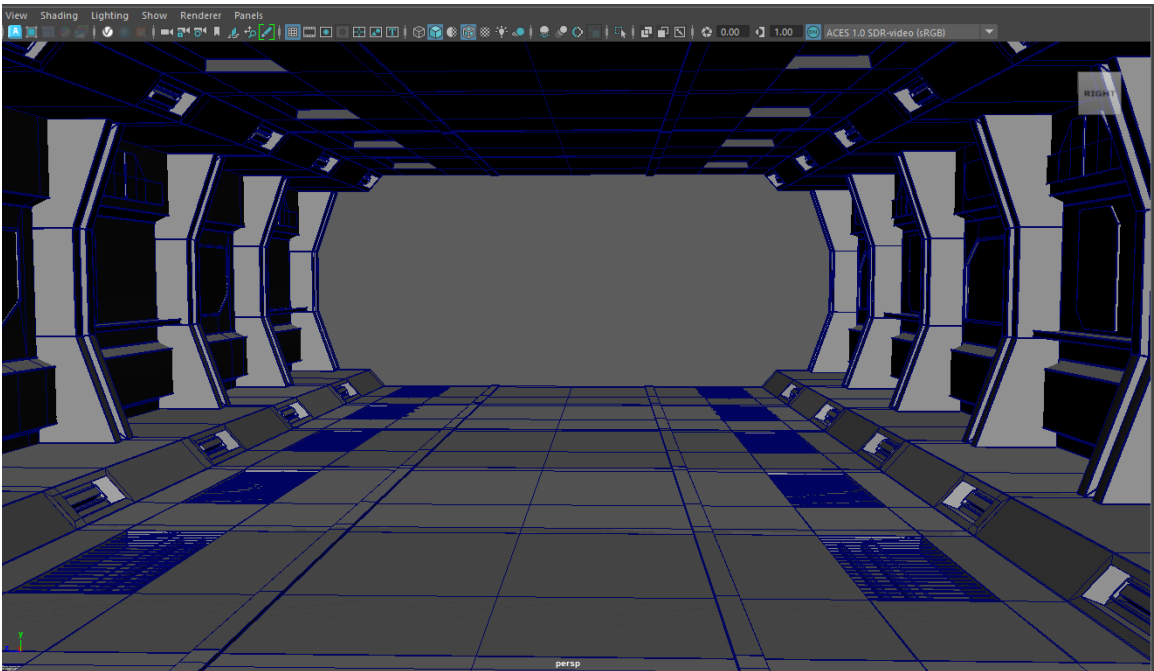


Figure 5.2.1.5.4: X Modular Tunnel Modeling Process Part 4

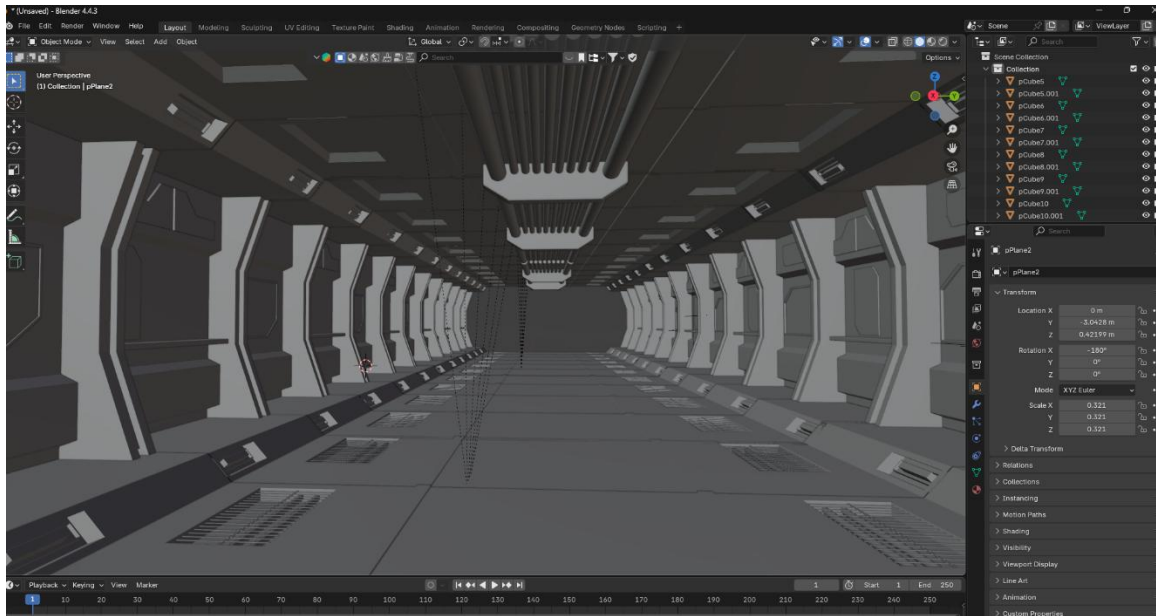


Figure 5.2.1.5.5: X Modular Tunnel Modeling Process Part 5

5.2.1.6 Greenhouse Air Compressor Machine

The Greenhouse Air Compressor Machine is a subsystem that forms part of the MARS100 habitat, it is created specifically to control the up and down movements of oxygen and carbon dioxide flow within and out of the greenhouse module and the human habitation quarters. The maintenance of an even-handed atmosphere cycle is fundamental in the circumstances of Martian colony: vegetative organisms require CO₂ to perform their photosynthesis, and the utmost population of humans is based on the oxygen levels generated by the greenhouse ecosystem. This exchange is, therefore, mediated by the air compressor unit which vents CO₂-laden air through the occupied modules into the greenhouse and receives the O₂-enriched air back into the rest of the habitat.

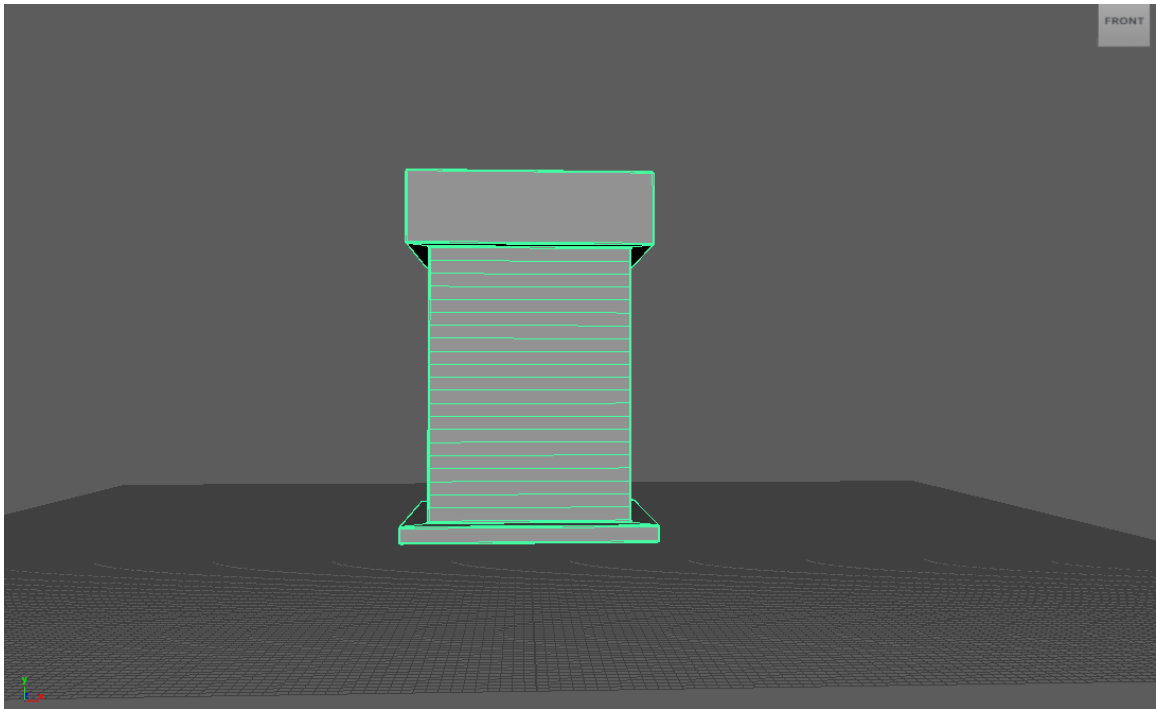


Figure 5.2.1.6.1: Greenhouse Air Compressor Machine Part 1

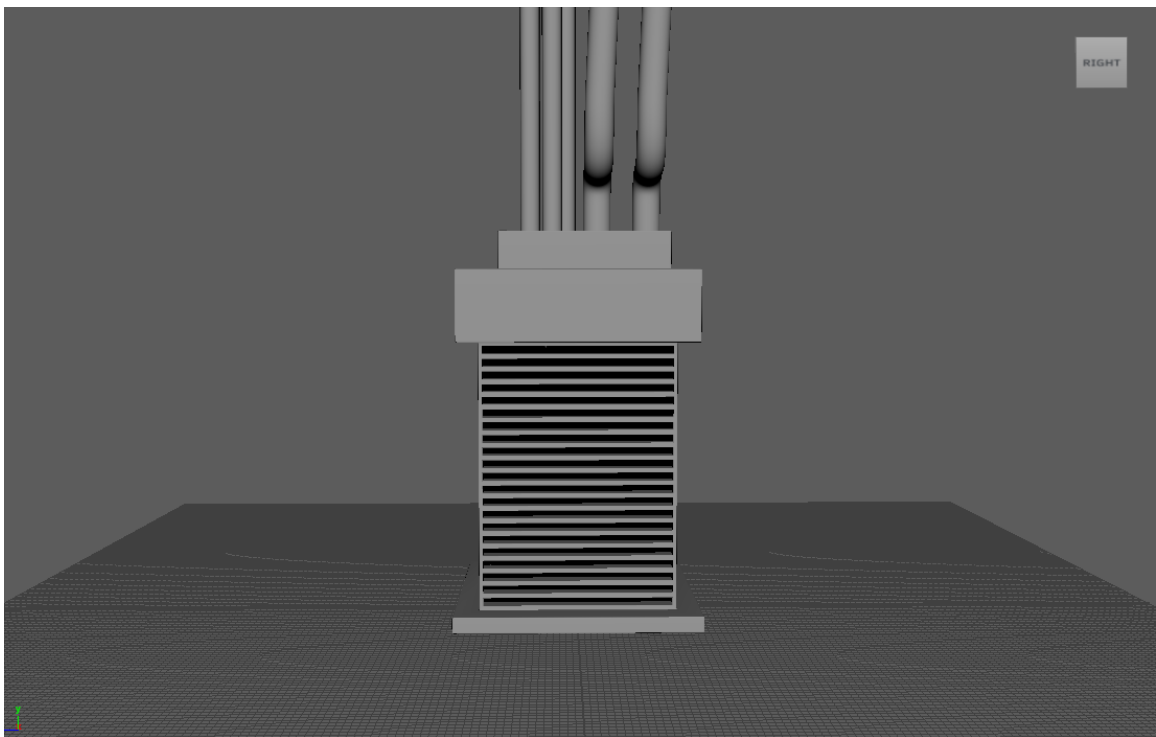


Figure 5.2.1.6.2: Greenhouse Air Compressor Machine Part 2

The whole entire machine was created using the Autodesk Maya starting with a primitive cube to define the geometry of the compressor body. Later subdivision feats specified edge loops, which allowed some fine-tuning of the ventilation slats. The Inset Edge Loop operation was exploited to create evenly distributed horizontal efforts with the operations followed by the Inset Face operations made to carve recesses in panels. Through deletion of particular faces, the model designed open vents where air intake is created, and exhaust is eliminated thereby giving it an aesthetic characteristic that is functional and industrial. The higher piping system was built using several cylinder primitives which were extruded and bent to give the appearance of the network system of air transfer; the piping which was used visualized the channels of CO₂ and O₂ flow that links the greenhouse with the habitation modules. To create the desired softening of edges, as well as contribute to realism, beveling was done selectively, but it conserved a clean topology that is suitable in texturing and animation in the Unreal Engine. Last geometry location renders the compressor units in a linear arrangement, thus aesthetically supporting the strength of the atmospheric control system which supports sustainable growth of plant life and human breathing.

5.2.1.7 Hydroponic Greenhouse Rack

The Greenhouse Rack is a structural component of the MARS100 botanical module, which refers to the design of vertical farming in a Martian environment while using the available space as efficiently as possible. The green houses in the Mars settlement paradigms in modern days should be carefully models to maximize the space available to them, control the exposure to light and make the space be utilized well to carry out plant maintenance and harvesting activities. The use of multi-layer flatbed racks in hydroponic applications are thus often recommended in Mars greenhouse studies because they allow constant crop rotation, even-distribution of nutrients, and increased production of oxygen in the pressurized tight cubes were frequent features of extra-solar environments.

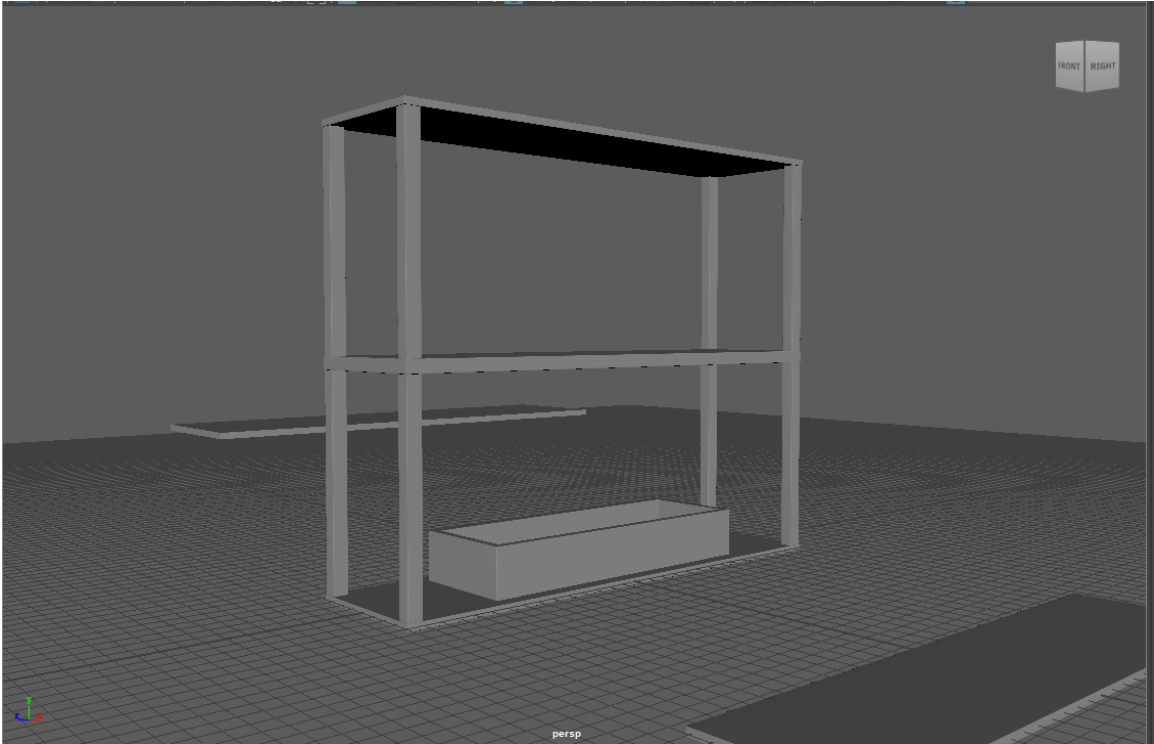


Figure 5.2.1.7.1: Hydroponic Greenhouse Rack Part 1

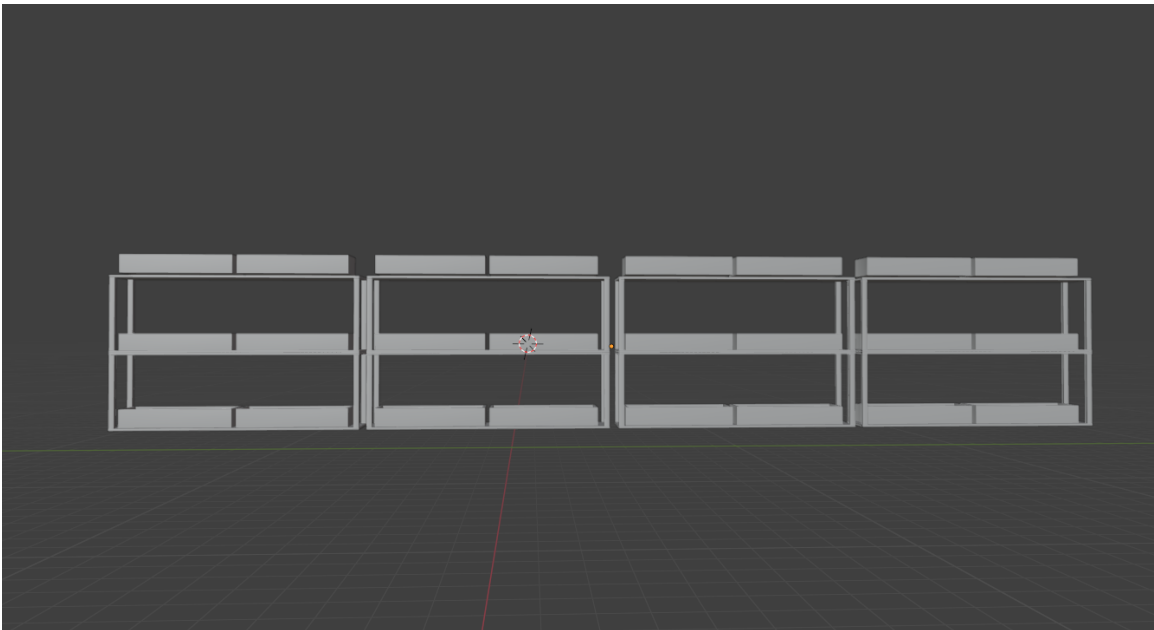


Figure 5.2.1.7.2: Hydroponic Greenhouse Rack Part 2

The rack model was developed in Autodesk Maya, starting with simple geometric structures in order to ensure that topology is clean and can be easily scaled to a modular functionality. The skeleton was formed out of long cube primitives, but they were counterparts to set up the pillars vertically and the supporting beams horizontally. These elements were then reflected off in a symmetrical manner to create the major rectangular frame. Especially attention was given to the retention of real-world proportions, thus, guaranteeing the sustainability of the rack through the provision of several plant trays and lighting systems in the greenhouse module.

Plant-bed containers were designed in the form of low-profile boxes that were shaped like rectangles and were placed on every stratification of the rack. Those, also, were created based on primitives of cubes, though, with slight beveling to make the edges softer and get a more lifelike physical reaction to light in the Unreal Engine. After the basic geometry was completed, then the model was elaborated by addition of edge-flow parameters and uniform spacing of the structural bars, resembling the industrial hydroponic racking systems used in the controlled-environment agriculture.

The last integration in the Unreal Engine is the rack of high-density plant meshes of the Martian crop varieties of leafy greens, tomatoes, herbs, and other nutrient-dense species. These vegetative resources were configured to experience active growth in greenhouse lighting and hence assist in the regeneration of oxygen as well as food sustainability in MARS100 habitat. The grid-like grid pattern of the rack can also be extended or moved around in the greenhouse, as it is realistic in planning agriculture applications during longer missions to Mars.

5.2.1.8 Terrain Model

The Martian Terrain was actually created in the Unreal Engine itself using their Landscape System to create a realistically based MARS100 project landscape that, at least scientifically, is accurate.

The first step was the creation of a large area of ground, based on an imported heightmap, to be used to give the overall structure and size of the Martian surface. A series of sculpting tools, such as Sculpt, Smooth, Flatten and Noise, was later used to form naturalistic ridges, crater impact craters and gradient valleys which in combination are used to replicate the rough topography found in Mars.

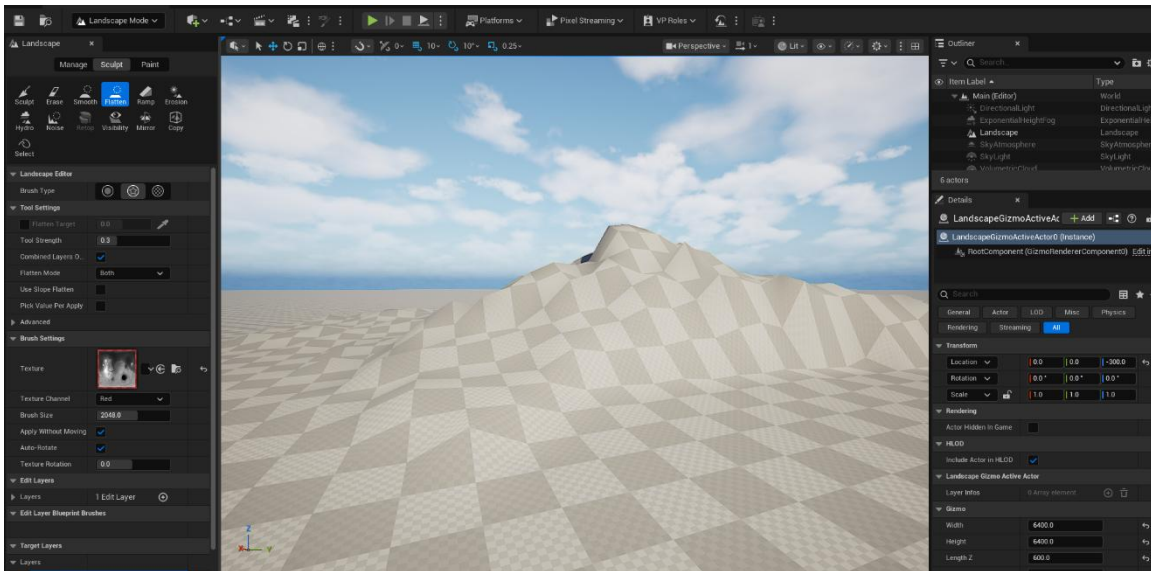


Figure 5.2.1.8.1: Martian Terrain Modeling in Unreal Engine

5.2.2 Texturing and Material Set up

The texturing process used on the interior of the greenhouse and the elements that are inside of it was carried out in a hybrid approach, which included UV unwrapping conducted in both Maya and Blender and followed using Unreal Engine 5 to carry out the material creation and shading steps. All the modular assets, including the greenhouse rack and air compressor machine and ancillary support structures, were carefully UV-unwrapped to ensure a smooth distribution of the texture coordinates and eliminate distortion in both the light and the render pass. Blender was later used to create refinement of secondary UV shells and to create special use lightmap UV channels where procedural support was necessary in real-time rendering. In the framework of the Unreal Engine, his procedural materials were created through the material editor, which supported dynamic shading controls, which then reacted physically to the artificial regimes of illumination of the greenhouse.

In the case of the Mars terrain, an effort was made to reproduce by a tri-layer material mixture detailed surface heterogeneities that are unique to Martian regolith. This included a fine dust layer, an in-between rocky texture and a darker more compacted sediment layer. The height maps and normal maps were also mixed using landscape material functions of Unreal which allowed blending of transitions in between layers and created a visually realistic surface on the ground, comparable to the high-resolution NASA images of Mars. Metallic, roughness as well as ambient occlusion maps were calibrated so that both indoor and outdoor features had consistent responsiveness to the conditions of illumination of the dome or any environment and its reflections. This technology of UV-prepared assets and procedure Unreal material has allowed the MARS100 environment to achieve a realistic

aesthetic of a scientifically inspired aesthetic without compromising the best performance of a real time simulator.

5.2.3 Environment Composition and Model Placement

The stage of environmental construction included the systematic integration of all simulation characteristics into a research-grounded Martian colony into the Unreal Engine platform. This phase required that a plausible terrain be established, the exact positioning of habitat features, proper positioning of power infrastructure, and the incorporation of greenhouse features in footing of the principles on PS of Mars habitat design. It featured a photographic array coupled with a nuclear reactor in the power system architecture which was linked with battery units and transmission lines to simulate a hybrid energy grid as outlined in the current Mars mission research. Structures of the exterior domes were placed as per the functional zoning requirements whereas the supplementary geological features of rock structures and high hills were placed all over the scene duly replicating the geological features recorded in NASA Mars surface images. The greenhouse zone hosted pre-modeled hydroponic racks in order to maximize the efficiency of vertical farming, and plant assets were chosen following the species that were delineated in the JEANNE Habitat design paper, thus giving a theoretically feasible crop selection in oxygen production and food sustainability. Each of the model placements was made to favor visual storytelling goals and maintain a realistic spatial relationship and logic of operation. The end product of all this effort is a complete, immersive setting and simulates perfectly the infrastructure of a research-based early Mars colony in the MARS100 program.

5.2.3.1 Mars Ground Making with blending material

During this phase, attention was paid to the scrupulous development of a Martian settlement in the Unreal Engine setting based on research. It included land forming, placing of domes, making of the power-system, setting up of the greenhouse and the purposeful positioning of environmental features meant so as to simulate the real Martian surface conditions. The arrangement of all elements was made to exhibit the logic of operation, scientific references that were documented and the narrative needs of the movie in the MARS100 framework.

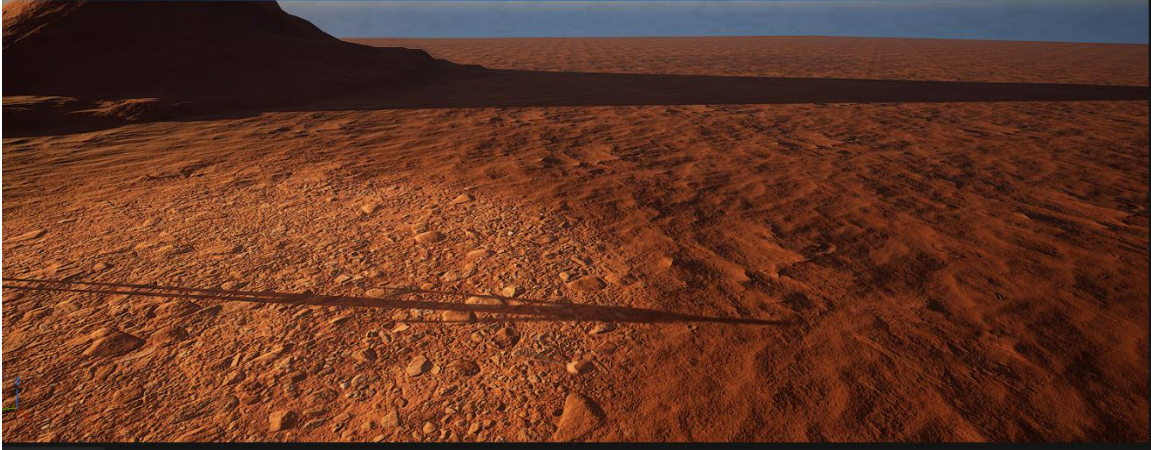


Figure 5.2.3.1.1: Martian Ground with blending material Part 1

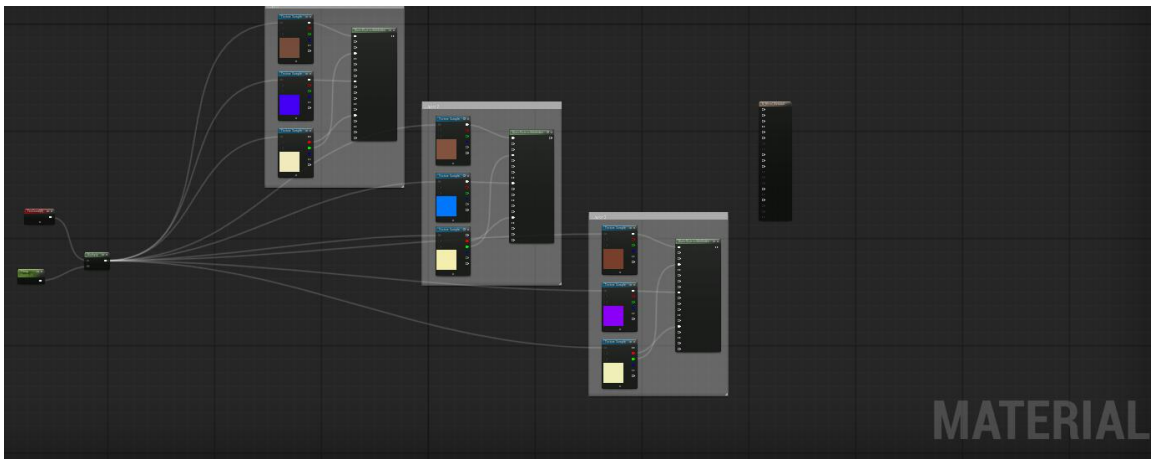


Figure 5.2.3.1.2: Martian Ground with blending material Part 2

The Martian surface on the ground has been designed with a three-layered blended material approach to Unreal Engine. Terrain sculptures created natural plateaus, dust plains and rocky outcrops all based on the images taken by NASA rovers. The intermixed layers of material mixed fine dust of red color, hardened sediment, and roughness of rocks causing the surface that has a visual similarity to the actual Martian regolith. Heightmaps, roughness and normal maps enhanced realism and guaranteed appropriate interaction of light dip by diurnal variations. This material approach offers a rationalized scientific approach to the whole environment of the habitat that is visually consistent.

5.2.3.2 Placement of Power System model.

The power-system topology consisted of the panel arrays of solar panels, a nuclear reactor chip, battery storage cells, and transmission lines of power, which were placed in strategic layout to create a layout of an energy infrastructure, consisting of hybrid energy source. The solar panels were aligned with the line of sun in order to gain the maximum amount of energy and the nuclear reactor was set away on a safe distance behind a terrain cover, as

Mars mission safety regulations required. We provided supply of electricity to greenhouse, habitat domes and the life-support systems with battery units and power distributors logically. This set up describes the manner in which a real settlement on Mars may combine solar and nuclear power to provide constant power supply at extreme factors.

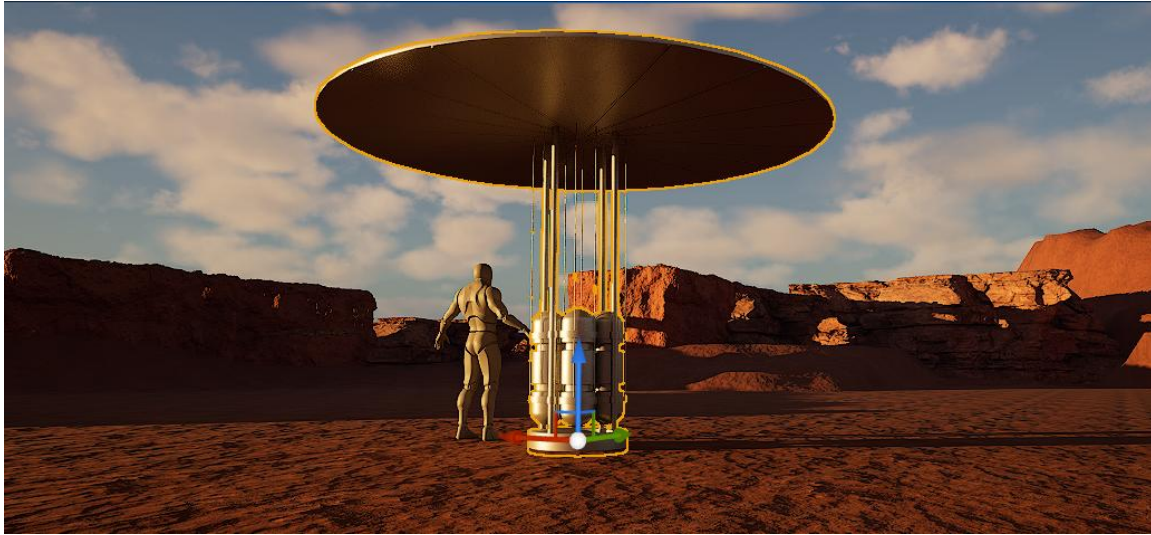


Figure 5.2.3.2.1: Nuclear Reactor Placement Part 1

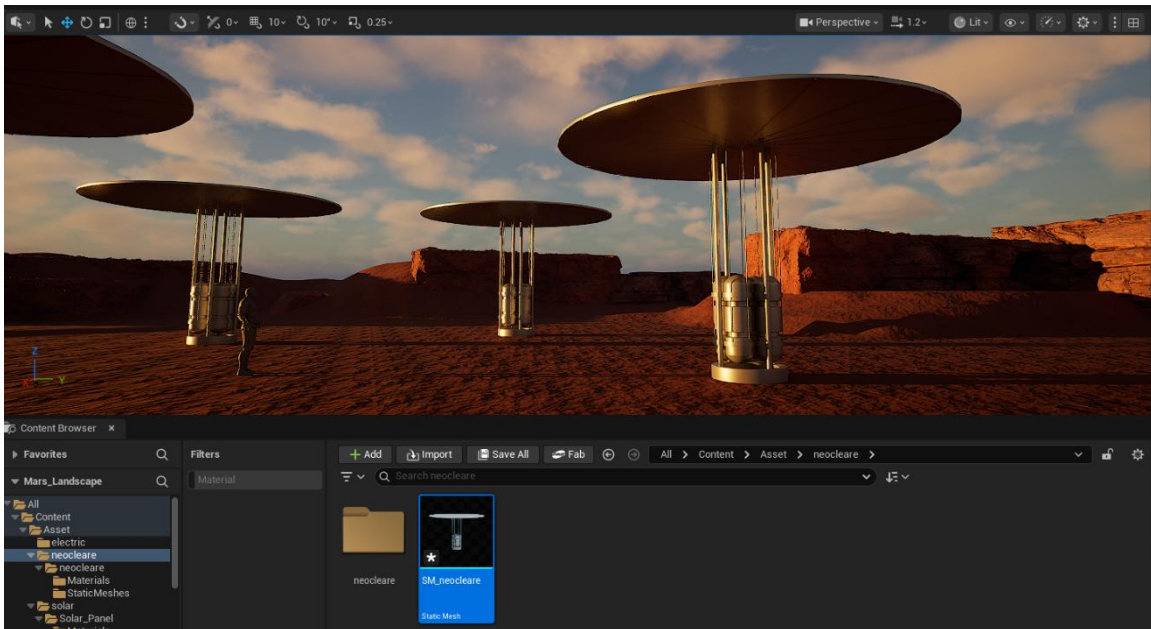


Figure 5.2.3.2.2: Nuclear Reactor Placement Part 2

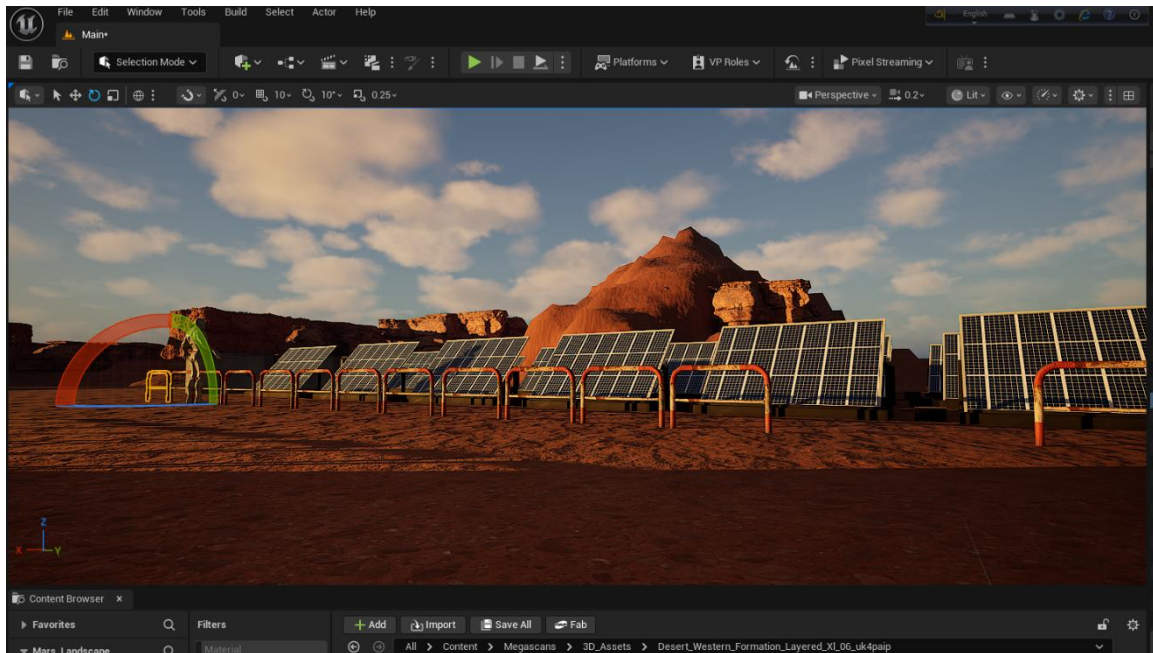


Figure 5.2.3.2.3: Solar Panel Placement

5.2.3.3 Building Placement of Exterior Dome.

The exterior habitat domes were organized based on functional zoning guidelines based on the research of Mars habitats done by NASA, including the JEANNE Habitat. It is proposed that living quarters, greenhouse modules, command centers and EVA preparation rooms were designed in such a way as to be optimized in terms of workflow, acoustic interference, and to aid in movement between modules. Further rock and hill structures were included in the domes to make it appear more like the Martian terrain to make it more lifelike. The dome on each side was placed so as to be on an equal footing with the surface of the ground in order to establish contact points which were stable and also seem natural parts of the landscape in the process of animation and simulation.



Figure 5.2.3.3.1: Exterior Dome Building Placement

5.2.4.4 Greenhouse Placement

Atmospheric processors, waste-recycling units and power modules were located near the greenhouse in order to facilitate a closed-loop life-support system. The greenhouse also contained hydroponic racks that maximized the growing area and the selections of the plant species were made on the basis of references as discussed in the JEANNE Habitat paper, thus, making the selections scientific. Special light and ventilation effects were built in placement to represent the real crops growth conditions. Such integration helps to emphasize how vital food production and oxygen generation is in an early-stage settlement of Mars.

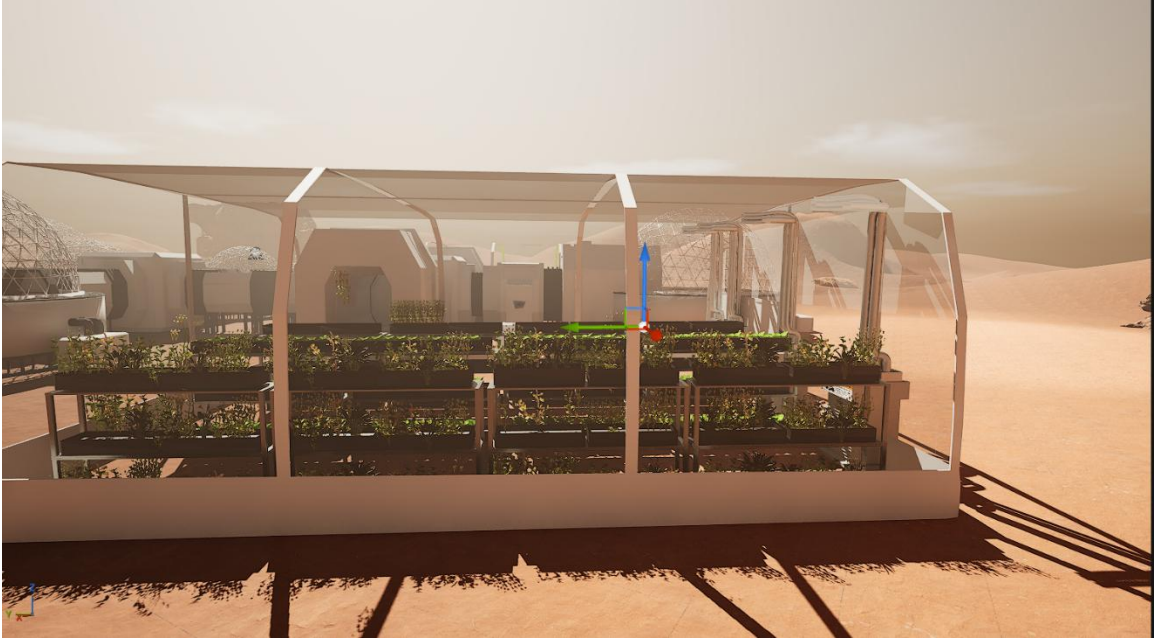


Figure 5.2.4.4.1: Green House Placement and Composition Part 1



Figure 5.2.4.4.2: Green House Placement with Air Composer Machine



Figure 5.2.4.4.3: Ground Refine in Green House



Figure 5.2.4.4.4: Collection of trees foliage at Green House

5.2.5 Lighting and Atmosphere Set-up.

The lighting and atmospheric design played a leading role in the formation of the visual idiom of MARS 100 environment, or rather as a production instrument, as well as an interpretive one, med nerve almost realist, almost affective. With the conscious crafting of the environmental nightscape, we can anticipate the aesthetic features of the Martian landscape, and we can at the same time direct the viewer in terms of his or her emotional involvement in the story.

We started by using a physically based directional light that was tuned to a high pigment temperature to simulate the sun in Mars. The choice of a soft and golden color with a low angle intensity was to be suitable to highlight the thin atmosphere and the scattering of the particulate to a high degree typical of the planet. This arrangement allowed the shooting of dramatic effects of sunrise and sunset, where long shadows cross the land and heaps of dust are lit in columns of light and volume, thus adding to the realism of the environment.

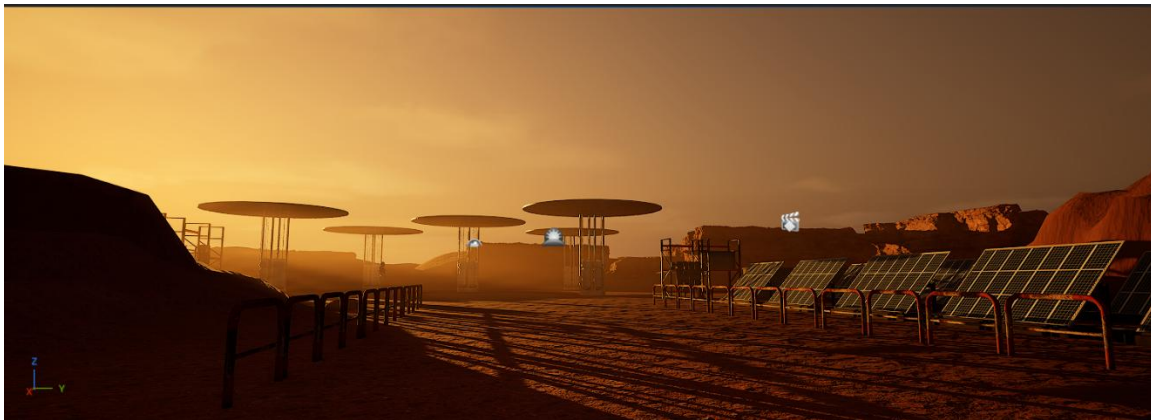


Figure 5.2.5.1: Exterior view with atmospheric light

In order to estimate the atmospheric scattering as evidenced in the imaging of the Mars Rooster on Earth, we used a mixture of Exponential Height Fog, Volumetric Fog, and Light Shafts. These elements worked together to create a hazy, a movie-like quality which is most successfully seen in geological formations, habitats domes, and massive mechanical components- nuclear reactor radiators and solar farms. The fog parameters were carefully adjusted so as to retain the visibility, yet, at the same time, the dust suspended in the atmosphere typical of the Martian weather is also conveyed.



Figure 5.2.5.2: Martian Cliff view with high volumetric fog

The domes and greenhouse buildings also appreciated additional lightings due to presence of interior and exterior fill lights which have been designed in a manner that represented the reflection of sunlight on the glass and polymer surfaces. These lights made low glimpse and specular that make the curves of the domes look trendier and more transparent. Also, the wind turbines, solar arrays and habitat entrances were vivified with low intensity rim lights which made sure that the visual aspect had clarity without breaking the coherence of the environment.



Figure 5.2.5.3: Dome Exterior View with Sky Atmosphere

There were also terrain materials that were dynamic and reacted to light and used normal maps and roughness that were calculated. Consequently, the sandstone cliffs, regolith dust and rocky surfaces revert to directional and ambient light to give a compelling story on all exterior shots, whether it is a panoramic image of the settlement, or a tight focus shot on solar panels, habitat domes or atmospheric processors.

Finally, the light and the atmosphere arrangement had managed to reach a consensus between scientific accuracy and narrative filmmaking. The impeccably edited lighting design shaping the visual fidelity of MARS100 environment in question not only serves to support the thematic channels of estrangement, endurance, and hope, at the heart of the film story, but is utilized to fortify them as well.

5.2.6 Unreal Engine: Animation Part-1.

The MARS100 project was a visual narrative and camera animation through the Unreal Engine was the core system in which this was accomplished. Using the Sequencer tool we animated exteriors and interiors in order to fit the cinematic tone befitting a research-based science-fiction documentary. The main goal was to usher the audience through the systems of the Martian environment and habitat in a smooth manner with an emphasis on the survival infrastructure that was unavoidable, and still maintaining a rich, immersive and air-filled delivery.

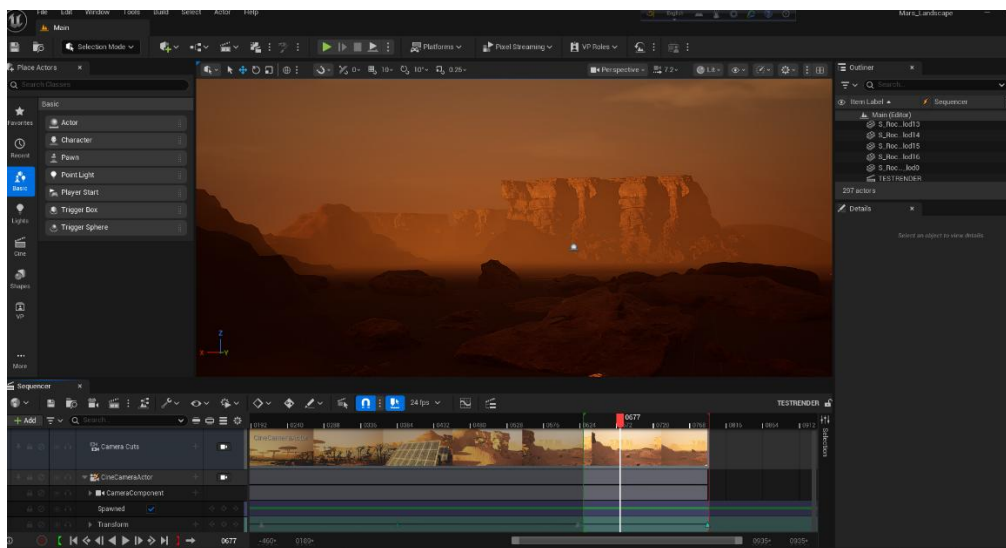


Figure 5.2.6.1: Exterior Part Camera Animation Preview

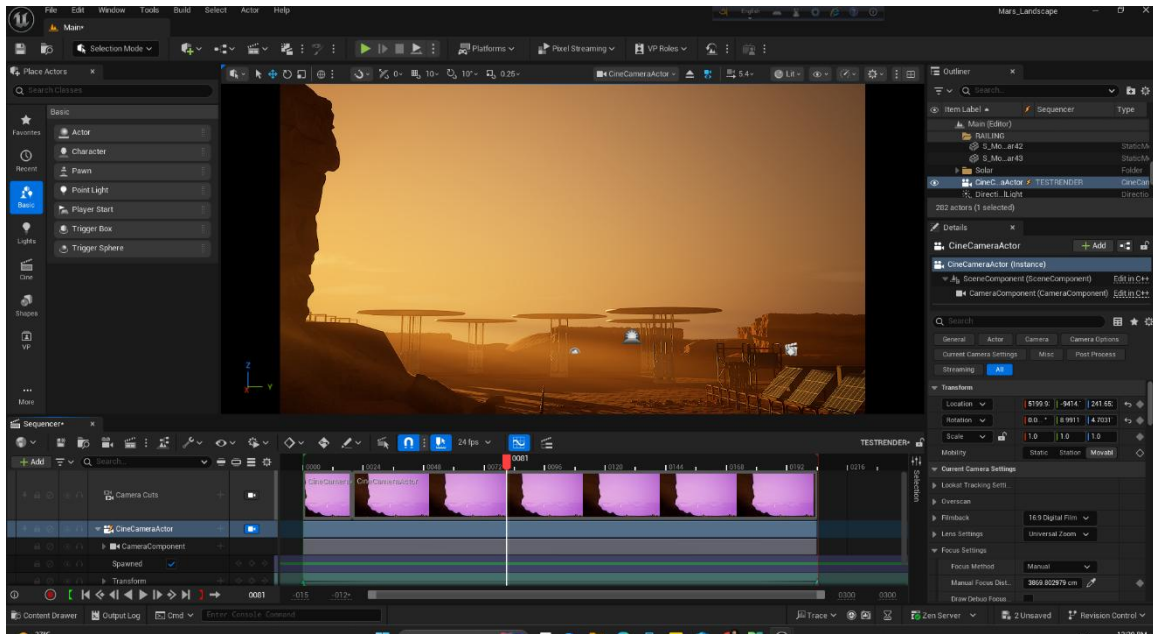


Figure 5.2.6.2: Camera Walkthrough Animation Preview

To shoot the Exterior shots, Cinecamera Actors were placed at effective points over the Martian landscape so that they could provide wide shots establishing shots of cliffs, solar farms, nuclear-reactor radiators and domed habitats. Paced camera motion has been carefully employed to focus on scale and environmental solitude; hence, reflecting the visual speech of real Mars rover photography. Through key-framing paths, the camera had the option of gliding across dunes, cross-moving parallel to solar arrays or making progress across processing stations in the atmosphere, all of which naturally respond to fluctuating light, density and direction of the fog, dust, and light variations. The camera motion, synchronization of golden-hour lighting, volumetric fog, and low-angle sun rays guaranteed the visual continuity of the transition and silhouette, resulting in sweeps in the cinematic reveals that not only removed the ugliness, but also the beauty of the Martian landscape.

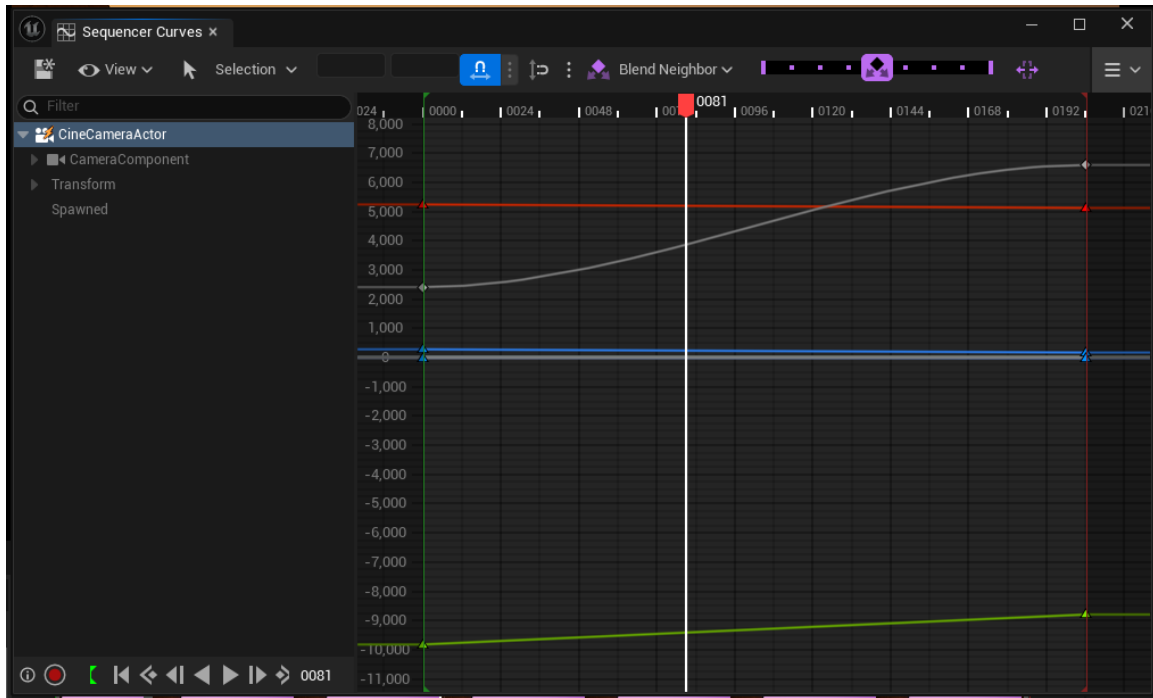


Figure 5.2.6.3: Camera Movement Graph Chart

The camera sequences inside were meant to focus on close-up movement that is controlled to bring out the functional systems in the habitat. In the greenhouse, there was animated filming of hydroponic racks, air compressor units, oxygen exchange and CO₂ exchange and plant-growth modules. Both in the living and technical dexterities, slower dolly-like movements and smart pans were used to convey constrained space, unnatural lighting and design innate accuracy of human thriving settings. The focus of the depth-of-field settings was to highlight a particular piece of equipment, including those of MOXIE-inspired oxygen processors, control consoles, and structural details of modules designed by JEANNE. Interior lighting, which was mostly warm, soft, and reflective, acted naturally under the camera courtesy to the post processing software like exposure control and ACES tone mapping.

Sequencer Workflow

The Sequencer Curve Editor helped achieve both interior and exterior animations by specifying the interpolation curves to take out sudden motion and creating smoothness in the cinematic flow. Several versions were displayed live so that camera travel, environmental effects and the story beats required by the voice-over script were perfectly matched.

5.2.7 Animation Part-2

The animation was done in the second step of animation pipeline in Adobe after effects, where the scientific phenomena were visualized into clear, instructively oriented, 2D visual sequences. It was devoted mostly to depicting how the CO₂ concentration of the Martian atmosphere was turned into usable oxygen with the help of the MOXIE (Mars Oxygen In-Situ Resource Utilization Experiment) system which is one of the key scientific principles of the MARS100 story. Whereas Unreal Engine generated 3D film shots, the After Effects has provided a confined setting upon which one can create meticulous motion imagery, infographics, and schematic animation that help in achieving scientific understanding.

To visualize the MOXIE process, layered animation workflow had been adopted. To start with, the CO₂ molecules were represented in the form of stylized particles coming into the MOXIE chamber. Using shape layers, trim paths and animated masks, airflow routes were created to show the attraction of CO₂ in the atmosphere in the solid oxide electrolysis system. Additional visual elements were used to outline the internal structure of the equipment such as the ceramic stack of electrolyze through which the high-temperature processing occurs. This was done through keyframe animation in which the CO₂ molecules were depicted as dissociating to the oxygen ions (O₂) and carbon monoxide (CO), and thus plainly depicted the chemical transformation in the center of the operation of MOXIE.

Light effects, line cycles, color-coded flows were also added to distinguish between output of oxygen and exhaust of CO, and this made the process understandable even by non-technical opinion. Text notes, labels, and dynamic arrows were incorporated, which helped to emphasize every phase of the reaction which encompassed intake, heating, separation of ions and finally release of oxygen and storage of oxygen. It is a style that reflects the professional scientific expositions that NASA and other educational platforms have used thus making it accurate and easy to see.

The final animations were rendered using soft shadows, motion blur and softening curves to render smooth transitions. These 2D educational images were then tied to the voice-over narration of the film and therefore contributed to the storytelling process and provided viewers with a better insight into Martian oxygen production as a part of the whole MARS100survival ecosystem.

5.2.8 Rendering Part in Unreal Engine

MARS100 project rendering was done through Movie Render Queue of the Unreal Engine that offers precision and control not achievable using the default Sequencer render. With this workflow we could adjust sampling, anti-aliasing, resolution and file format controls to meet high visual requirements of the actual world research-driven science-fiction documentary. The project was reproduced in 16-bit EXR image sequence with PIZ compression to achieve the best image fidelity. This data compression scheme and depth of color level allow for a large dynamic range, thus allowing more realistic color grading, exposure, and implementation of glow or atmospheric effects in the compositing in After Effects. EXR format has been specifically chosen due to the fact that it supports high dynamic range which in turn makes color grading, exposure corrections as well as glow or atmospheric effects simpler to achieve in After Effects. The Multilayer option can also be enabled to support more passes of the render (several passes can be packed into the same EXR file) including the lighting, reflections, fog and depth and this is a highly beneficial option even during advanced compositing operations.

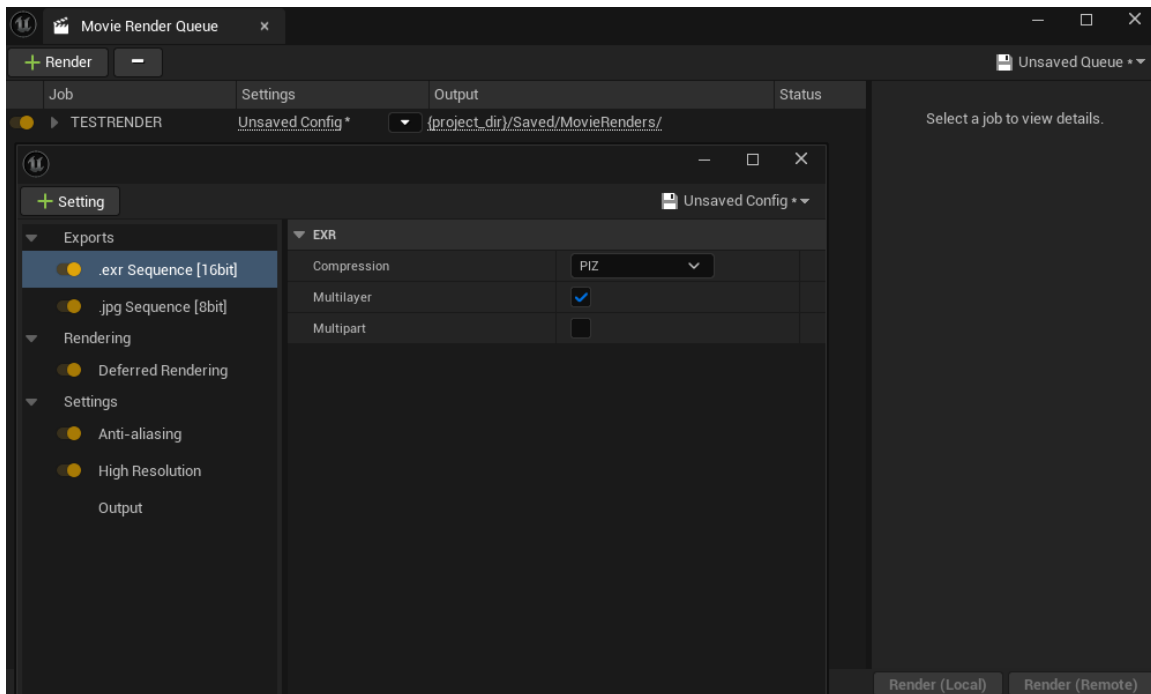


Figure 5.2.8.1: Project Render Setting in Unreal Engine Version 5.6

The rendering pipeline used deferred rendering that is used to render difficult cases of lighting interaction, such as volumetric fog, scattering shadows and physically based reflection, with high fidelity. White, anti-aliased settings were used to remove edged artifacts, and fine details, like the textures of a plant, the structure of the domes, and the dust particles were produced in a clean manner. The High-Resolution option was set to up

sample the result of the shot, making the pictures cleaner with sharper frames in the case of wide landscape shots or when the shot is full of complex geometry.

Directories were set up to store the image sequences to the Movie Renders directory as part of the project so that the file organization of the project would be organized in post-production processes. Conversion to a series of images also ensures that the footage is resilient to crashes or disruption since a single frame can be re-rendered and furthermore these frames will not require a repeat of the whole sequence.

This rendering tool allowed MARS100 to maintain the same level of visual integrity to both interior and exterior settings keeping the same atmospheric lighting, environmental detail and cinematic tone created in the animation and lighting phase. The EXR based working process eventually helped to support the professional compositing workflow with the flexibility required to make the desired documentary-style visual appearance.

5.3 Post Production

a) Compositing and editing (AE, PP) - sewing the collectors together, introducing graphics copy and editing, tight timeline for the final product afterwards.

b) Sound design, mixing, voice over (FL Studios/Audition) - layering of sound, balancing the levels, recording the dialogue in the studio.

c) Music production and audio production - writing a soundtrack that would fit the mood and polishing the audio ill.

d) Grading (DaVinci Resolve) - color correcting, inclusion of LUTs and taking the visual fidelity to standard.

5.3.1 Branding Part: Poster Making

Other than the technical side of the production, I was also part of the visual identity of the MARS100 project as I was creating the official poster and handling the branding aspects. To create a unique identity towards the film, I developed a unique MARS100 typography style, which is based on futuristic and aerospace visual language. The poster was designed with one of our quality rendered scenes to display the Martian landscape and architectural habitats to bring the main theme of humanity on Mars. Color contrasting, arrangement and placement of text was also modified diligently to preserve a film like quality and to fit the aesthetics of the project which were based on active research. This branding effort contributed to the formation of the cohesive way of presentation of the film, documentation, and final showing.

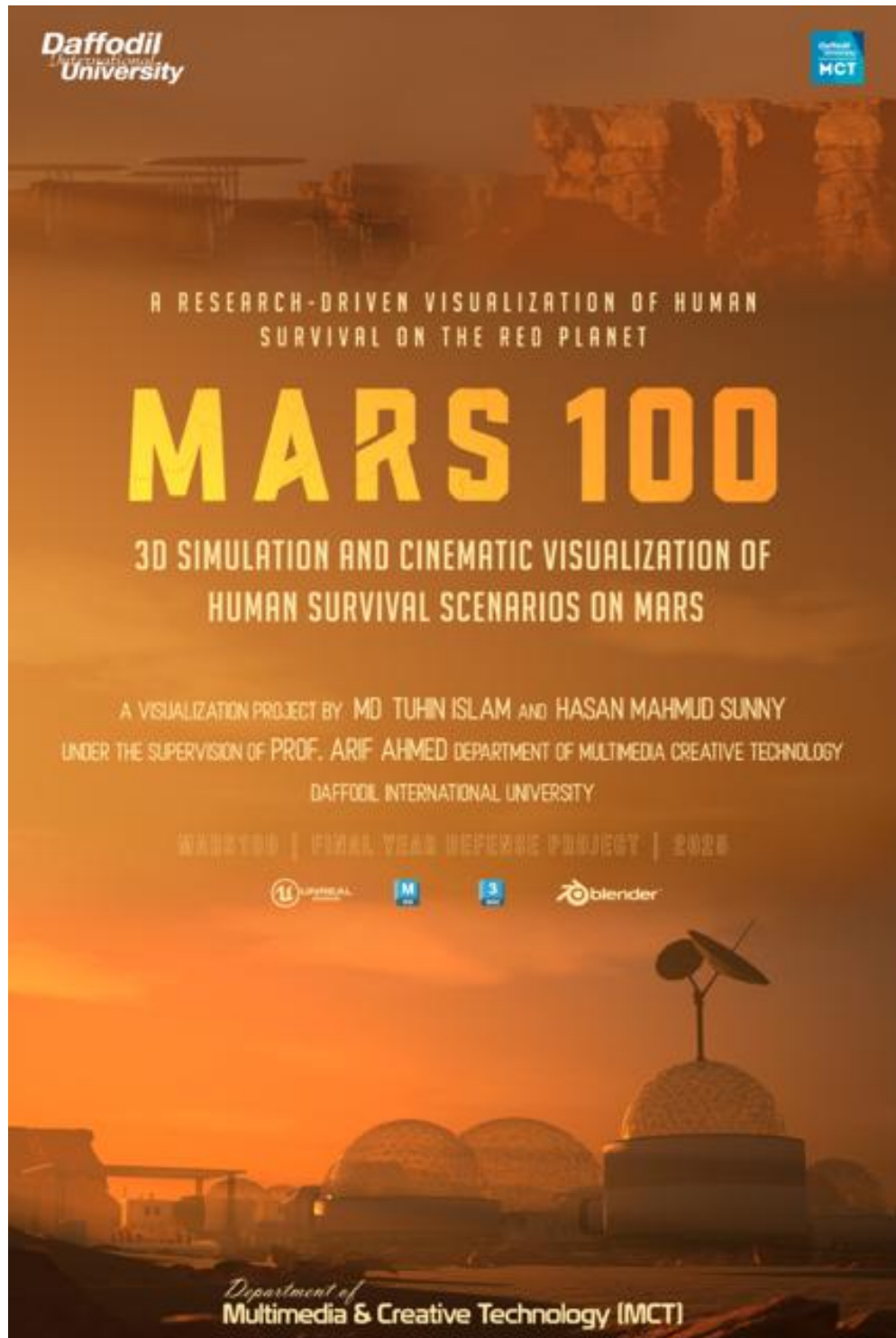


Figure 5.3.1.1: Printable Poster of Mars 100

CHAPTER 6

CONTRIBUTION AND ROLE DISTRIBUTION

6.1 Individual Roles and Responsibilities

The MARS 100 project has been fulfilled in the concerted work of two team members, which focus on different stages of simulation and animation pipeline. Being Student 1, Md. Tuhin Islam, I focused on developing the research-based and technical base of the undertaking. My duties included the transformation of the science literature into the visual effect, development of a simulated Martian setting, building the necessary models, and supervising the cinematographic animation procedure. My overall goal was to ensure that all the visual details were similar to scientifically viable habitat concepts and they could be justified by a movie story and to accomplish the pedagogical and narrative goals of the film. I was able to make the following contributions:

a. Scriptwriting and Story development

I brainstormed and wrote the entire narrative framework of the MARS100 project, wrote the screenplay, descriptions of the scenes, and voice-over sequences which all gave the film the atmospheric character of being cinematic and instructional. It was based on a strict analysis of available scientific literature, thus taking the viewer through the complex survival mechanisms that are likely to be developed in a future Martian colony.

b. Research and Data validation by scholars

I assembled, assessed, and synthesized all scholarly, journals used in the undertaking, including habitat building (JEANNE), in-situ resource-utilization (ISRU) conventions, MOXIE oxygen development prototypes, cryogenic mine modalities as well as photovoltaic power generation prototypes. Every datum was then vetted over the scientific fidelity and converted into aesthetically sensible concepts which guaranteed empirical correctness.

c. Creation of Mood board and Visual Planning

I was in charge of the series of mood boards which predetermined the aesthetic palette, light orientation, aura of a certain space and ambience of the finished cinematographic piece. These visual references acted as a point of reference that was always available and standard consistency in making animation and modeling as well as compositional choices.

3D Modeling and Technical Asset Creation

There were key simulation assets engineered by me, a nuclear reactor model, a MOXIE-inspired oxygen processor, photovoltaic array structures, ancillary greenhouse components, hydroponic racks, and rough scenery using software Maya, Blender, and Unreal Engine. Every model was built based on scientifically presented proportions and functions logic to maintain consistency.

d. Environment Design in 3D

The whole Martian environment was created by Student 1 in Unreal Engine and coordinated the process of landscape creation, material coding, geologic positioning, dome structure, and settlement architecture. The modern research-based historical concepts of habitat plans were manifested through environmental architecture, which realistically supported the narrative.

e. Assigning Materials and Texture

I created UV maps, designed advanced material systems of a range of custom assets in both Maya/Blender and Unreal Engine. Material batching and mixing procedures were used with the main purpose of imitating the appearance qualities of the original Martian regolith and atmosphere surfaces.

f. Project Planning and Management

I managed the schedule of research, arranged the repository of assets, defined the phases of environment-construction, and made the animation pipeline more organized. He made sure that the project was under strict workflows of pre-production, production and post-production.

g. Scene Composition and mixing (Unreal Engine) Animation

I am animated most of the exterior scene's domes, solar farms, reactor arrays, and greenhouse spaces, with the Sequencer tool of the Unreal Engine. Camerawork and lighting, atmospheric effects and transitions of the scenes were carefully written so as to work to the overall cinematic storyline.

h. Presentation Development and Visual Branding

I created graphics, branded, and presentation graphic for submission and defense of his/her academic work. These artifacts were useful to convey project goals, the basis of the research, and the visual plan.

6.2 Coordination and Team Process

MARS100 project was realized with the help of the joint work of two team members, who are me, Md. Tuhin Islam (Student 1), and Hasan Mahmud Sunny (Student 2). We divided our tasks according to our strong points though we continued to have collective work at all the main points so that we could be consistent and precise in our work.

In the first stage of planning, we thoroughly reviewed scholarly articles, discussed the habitat design concept and created the general visual language and narrative structure. I was concerned with making inferences based on empirical results and coordinating the arrangement of the environment and sequences of animation, but Student 2 transformed them into storyboard frames and elaborate modeling plans.

During the production phase, most of the 3D complex models were created by Student 2, and I had the responsibility to add the models in Unreal Engine, manage the layout of the environment, the setting of the light, as well as creation of atmosphere environment, and primary exterior animation scripts by me. We worked together in order to perfect the composition of the scenes, synchronize camera movement and shape cinematic tone.

Since ACES workflows were used during the postproduction, I did my preparation to render the rendered sequences, whereas Student 2 did the compositing, visual effects, color grading, and audio. We also went through all the phases to maintain visual consistency and narrative continuity.

All in all, we reached an efficient and welcoming collaborative process, where every team member delivered vital elements to the project to make a conclusion with a single and research-driven final film.

CHAPTER 7

CHALLENGES

7.1 Technical Challenges

The progress of MARS100 was associated with the range of technical challenges, which could be mostly explained by the reliance of the project on realistic simulation, wide settings, and high-quality rendering. One of the main challenges was performance management and optimization of the Unreal Engine, especially where large terrain files, large textures, volumetric fog and multicolored light sources were concerned. The live preview often was overloading, and Level of Detail (LOD) setting, material complexity, and shadows had to be changed.

The other fascinating challenge was to achieve a clean render through the Movie Render Queue, particularly with the use of EXR image sequences with anti-aliasing, as well as, high sampling rates. The irregularities in form of occasional failures were represented by render failures, frame drops or varying exposure, which necessitated repeated testing. The fact that ACES color pipeline coordinates were not universally compatible between Maya, Unreal Engine, and After Effects made things still more complicated because color spaces which had mismatched brightness or tone mapping might be used.

Additionally, the hybridization of multiple models between various software kits, Maya, Blender, Unreal Engine, was found to be a contributor to scale aberrations, UV mapping, pivot distortions, and had to be repaired frequently by hand. These technical challenges necessitated a long-time workflow optimization and careful assets management in the production process.

7.2 Creative Challenges

In a creative sense, one of the main challenges was to balance the scientific accuracy with the film narrative. The true tone of light and mood of Mars is highly intimate and underapplied, making the images which technically seem one-dimensional. However, the movie required emotionally engaging visuals, which required the meticulous use of color, contrast, and volumetric effects but without going too far as to the side of realism.

The second imaginative challenge was the writing of scenes that would depict the intricate structures of oxygen manufacturing systems, ISRU procedures, and greenhouse activities and maintain narrative integrity. To make sure that the audience could easily understand technical concepts through the use of visual clues, it was necessary to carefully frame camera perspectives, use clear motion-graphic overlay, and take restrained pacing.

The design of assets, such as nuclear reactors, greenhouse machinery, and systems based on MOXIE was also a task that required a creative interpretation of the data since not all scientific references are complete in the visual detail. As a result, the team was required to integrate research-directed reason and artistic intuition to come up with plausible and working models that would be cinematically sound within the MARS100 project.

7.3 Problem-Solving Process and Adaptations

The crew adopted the iterative problem-solving workflow in response to technical and creative problems. Unreal Engine optimization was also an issue and was addressed by turning down the complexity of materials, removing unnecessary foliage, enabling LOD systems, and subdividing large scenes into efficiently manageable subsections. Test renders were periodically performed in order to normalize Movie Render Queue and refine EXR settings to enable the output to fit together more easily in post-production.

To address creative issues, the team used research validation sessions, comparing production to scientific diagrams, habitat diagrams and NASA reference imagery, in order to protect the accuracy and maintain cinematic quality. The editing of the storyboard and the development of shots involved in the storyboard session made it easier to reduce all the complicated concepts into scenes that could be read easily. In the case some of the models were missing in reference, the team came up with some hybrid designs based on scientific concepts but adjusted to make clarity and easy appearance.

Cooperation between Student 1 and Student 2 was extremely useful in hastening the solving of problems. Through sharing opinions about environment building, lighting, timing of animation, and compositing, the team kept on improving the quality of the scenes and handling the problems that appeared during the course of rendering or editing.

These adaptive strategies eventually brought MARS100 to a final but mature visualization of what life will be like in Mars in the future without overcoming the technical and artistic hurdles run across in its production.

CHAPTER 8

DISCUSSION AND ANALYSIS

8.1 Integration of Research with Visual Storytelling

The research gap would be an explanation of the theory behind different phenomena and how they would be conceptualized. The major idea of the MARS100 project was to create a harmonious connection between scientific research and the craft of the film narration, where the complex mechanism of survival which is a prerequisite of living in Mars can be made comprehensible to a broad audience. During the production process, academic text, habitat architectural reports, and NASA reports were used as information in the visual schematics that supported environmental configuration, allocation of systems and sequencing of animation. Instead of just making empirical findings visually, the project re-created them in a form of qualitatively rich narrative, containing ordered scenes, narrated text, and symbolic images.

This synthesizing work required the conversion of scientific information, that on the JEANNE habitat configuration, MOXIE oxygen creation, ISRU water recovery and power infrastructure plan blueprint into a series of cinematic beats to serve both educative goals and sentimental involvement. The fundamental design decisions were based on scientific truth, and the integrity of the narrative was done through storytelling conventions. The coordinated action of movable camera shots, airtight and guided narration, helped them reduce the ideas of closed loop life support and recycles of resources without undermining the science behind it. MARS100 is therefore a good example of how animation can be used in an effective pedagogical process of transforming research findings into an informative interactive visual learning process.

Reality and the ability to think in three-dimensional images emphasize the opposing view, while action-driven cinema puts more importance on the paradoxical cinema within bodily movements and neurological control of mechanisms like perception and attention (Peacock, 2016).

The balance between empirical realism and the use of imagination as an art was a critical creative challenge in MARS100. Data-critical fidelity served to influence the modeling process of subsystems, such as oxygen processors, agricultural modules and power grids, but the artistic domain of animation and cinematography offered a latitude into the aesthetical interpretation. Certain factors light intensity, atmospheric chromaticity, spatial scaling of environmental features was carefully enhanced to enhance clarity and implied feelings on the side of the viewer.

As an example, the Martian light is admittedly very harsh and desaturated; the film, in its turn, added color and regulated the haze of the air to create a mood and focus on the story.

Equally important, camera movements were designed not only to disclose facts of science but also to reveal the settlement in panoramic, sweeping shots, to emphasize quota and grandeur. These aesthetic considerations did not replace scientific reason or obscure it; but served to supplement the factual base, so that the audience can understand how to survive, and can also feel the sense of awe and remoteness that the Martian land causes. The negotiated compromise of realism and imagination became critical in meeting both the two goals: educative effectiveness and cinematic effectiveness.

8.2 Comparison to Existing Scientific Visualizations

Placed next to such modern-day scientific images as those of NASA, ESA, National Geographic, MARS100 will offer a hybrid paradigm of mended research-based simulation and a cinematic approach to documentary style. Traditional scientific visuals tend to put a strong focus on technical accuracy and information integrity, using fixed diagrams, engineering drawing or bare animation. MARS100, on the other hand, uses a narrative approach to its methodology by incorporating cinematic lighting, active camera movement, thought-provoking ambiance, and emotive tone to engage the viewers.

In contrast to the data-driven models of NASA or the rover-centric one, MARS100 provides the overall picture of how oxygen generation, energy distribution, agriculture on a greenhouse scale, and the settlement occupancy of the area are interdependent in one ecosystem of survival. It is more consistent with the documentary dramatizations of science my peers and I interpret such as the National Geographic feature Mars, but it stays squarely fixed in peer-reviewed scientific literature and not in more speculative fiction. The placement makes MARS100 a unique hybrid in the border of scientific communication and cinema storytelling that tries to inspire not only to inform but also trigger curiosity and imagination of what life is like on Mars in the future when humans are already established there.

CHAPTER 9

FUTURE WORK OPPORTUNITIES

9.1 Growth into XR/VR Interactive Experience

The assets, environment, and habitat models created to be deployed to MARS100 have been designed with the prospective growth into XR/VR interactive experience. Since the project already uses real-time technologies like Unreal Engine, the current simulation system can be easily converted into a complete immersion system. The users of such a system could navigate through the Mars habitat, tour through the greenhouse modules, examine the life-supporting systems, and tour the Martian surface. Having the movie translated into a VR game would provide an expanded perception of size, reality and spatial understanding of the ability of humans to live on the planet Mars. This has significant growth possibilities in the museums, science centers, and institutes, in need of interesting ways of conveying the ideas of space travel.

9.2 Scientific Visualization Educational Usage

It is noteworthy that MARS100 initiative is an imperative educational visualization conduit. The dynamic sequences that explain the way oxygen is formed, the engineering of greenhouse, power-generation, schematics, and architecture of the habitat complete a person with an understanding of the complicated principles of Martian dwelling. Through transforming stringent scientific investigation into pictorial engaging plots, the project electrifies the intellectual inquisitiveness, enhances pedagogical education, and experiment and develops a strong base on scholarly discussion. Such translations have the potential to elicit critical thinking about how humans can withstand extremophile environments and can potentially spur new lines of research or even professional work in the area of planetary science, aerospace engineering, or spaceflight exploration.

CHAPTER 10

CONCLUSION

10.1 Overview of Creative Accomplishments

The MARS100 project is a vivid example of the process of a synergistic synthesis of empirical research and cinematic visualization, and, as a result, a high-quality representation of human resilience on the surface of Mars. The project unfolds a consistent and realistic view of the future interstellar use of Martian settlement, using a combination of parametric filming, careful environmental construction work, and high end lighting effects. The main milestones of creativity include the development of a research-based habitat building, the elaboration of complex life-support equipment, namely MOXIE oxygen production equipment as well as indoor hydroponic cultivation, and the accomplishment of an authentic Martian landscape, using the current state-of-the-art capabilities of rendering and atmospheric scattering simulations. All these achievements are merging to create a single visual story that can explain the accompanying difficulties and possibilities of Martian colonization in the way that is suggestive and easily understandable by a widespread audience.

10.2 Reflection on Process of Production

The project required a careful balancing of academic interpretation, technical modelling, composing of the scenes in dramaturgy, and post production processes throughout the production pipeline. It is the lesson of the experience that the necessity of enforcing rigorous scientific fidelity and aesthetic clarity has become especially pressing where the complicated engineering notions are to be rendered into narrative. The problem-solving process and cross-disciplinary nature of exploring modelling, lighting, computational optimization and rendering led to the heightened refinement of the work. Also, the project reflected the pedagogical worth of cyclical design - which consists of refining scenes, characterizing animation forces, and augmenting visual appeal - to deliver emotive appeal and didactic effectiveness. The process of production has therefore strengthened the aspect of competency to work in the area of simulation, animation, environmental design, and scientific visualization, and in this way, the producer has gained significantly in terms of professionalism.

10.3 Significance of Visual Storytelling that is based on research.

MARS100 is an example of how the strong power of research-based visual storytelling can be used to democratize scientific knowledge and motivate the broad population. Turning the academic research into film stories, the project helps in closing the gap between technical research and social interaction. Besides becoming more understanding such visualizations enable the viewers to picture the reality surrounding the practicalities and speculations of future space activities. In this specific case of Martian colonization, where a great number of processes are abstract or unknown, an animated tool is a powerful tool to explain the survival mechanism, the physical environment, and construction design. This project predicts the growing importance of multimedia modalities to scientific communication and predicts 3D animation as an emancipatory medium through which the complexity of future technological possibilities can be understood.

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