MM7: SDG11 SPACE4SDGS SUSTAINABLE HABITATS

SDG11: Sustainable Habitats

- Design a sustainable habitat this could be for the Moon or Mars that could be adapted for extreme environments on earth.

Challenge

Space exploration presents unique challenges, particularly in designing habitats that can support human life in harsh extraterrestrial environments. In this challenge, you will create a habitat that meets the essential needs for human survival while promoting sustainability and adaptability. This habitat must address the needs of human survival and environmental sustainability, utilising minimal Earth-supplied resources. The habitat will be capable of self-sustaining, renewable resource management, and human-centric living conditions under extreme planetary environments. Integrate systems that consider energy, air, water, food production, and psychological well-being. This will require interdisciplinary principles from engineering, biology, environmental science, and design and will also show possibilities for life on earth in extreme environments.

Considerations

- Sustainability and Resource Management
  - Design structures resilient to lunar or Martian conditions such as radiation, low gravity, and extreme temperatures. Ensure that materials can withstand harsh conditions and that the habitat is adequately shielded.
  - Develop closed-loop systems that allow for water recycling, oxygen regeneration, and food production and can function autonomously, minimising maintenance needs.
  - Consider how renewable energy sources like solar power or nuclear batteries can be used effectively in lunar or Martian environments.
  - Utilise biological processes to recycle air, water, and nutrients for sustainable living.
- Environmental Adaptation
  - Design structures resilient to lunar or Martian conditions such as radiation, low gravity, and extreme temperatures.
  - Ensure that materials can withstand harsh conditions and that the habitat is adequately shielded.
- Empathic and User-centred Design
  - Optimise internal space for psychological comfort and operational efficiency, including Design structures that can be expanded or adapted based on requirements and crew size
  - Design layouts that provide space for work, leisure, and rest, supporting crew well-being in a confined, isolated environment.
  - Consider other species and the existing environment

Background

As space exploration pushes beyond Earth, sustainable living environments on the Moon and Mars become critical for human exploration. Lunar and Martian habitats will require highly efficient resource management to minimise resupply missions from Earth and allow for long-duration stays. A habitat's design must integrate life-supporting systems, providing air, water, and food sustainably, and ensuring protection from the harsh conditions of space.

In addition to functional sustainability, creating habitable, psychologically supportive environments is vital. Efficient layouts, ergonomic design, and communal spaces contribute significantly to the well-being of a crew. Effective habitat design will not only make long-term space missions viable but also pave the way for sustainable human presence beyond Earth.

Your Mission

Your mission is to design a sustainable habitat for lunar or Martian environments that supports human life with minimal reliance on Earth-based resources while prioritizing resilience, comfort, and adaptability. Focus on creating resource-efficient life-support systems that ensure the crew's survival in extreme conditions. Design adaptable layouts that cater to the physical and psychological needs of astronauts, addressing challenges such as radiation exposure and extreme temperatures. Consider integrating modular systems that allow for easy expansion, alongside renewable energy sources and bioregenerative life-support systems. Your work will play a crucial role in advancing human exploration beyond Earth, ensuring that habitats are not only functional but also conducive to well-being and long-term sustainability.

Project Objectives

Develop Sustainable Habitat Systems

- Create blueprints that prioritise environmental adaptability and resource efficiency.
- Ensure that habitat design aligns with closed-loop principles, recycling air, water, and waste sustainably.

Human-Centered Structural Design

- Design ergonomic, flexible interior spaces that promote mental health and teamwork in a confined space.
- Emphasise spaces that support varied daily activities, from scientific research to relaxation.

Resource-Efficient Prototyping and Testing

- Encourage the use of sustainable, recyclable materials in physical prototypes.
- Test models to refine system designs, identifying and addressing potential issues in a simulated environment.

Scalability and Modularity

- Develop a design that can expand to accommodate growing crews or increased scientific needs.
- Ensure the habitat can adapt to both lunar and Martian environments with minor adjustments.

Deliverables

- User Profile: Create a profile for an individual who could might be living in the environment as its easier to design for an individual think about how they might interact with the environment. Describe a day in the life experience to help you think about how they might interact e.g work, leisure, carrying our basic needs such as sleeping, cooking etc
- Extreme Habitat Overview: A one-page summary e.g. a blue print that shows the overall

structure, key systems, and adaptability features of the habitat. It should simply outline plans for resource management and your design: human and non-human.

- Prototype or Concept Model: Build a prototype using recyclable or sustainable materials, demonstrating the habitat's key functions, including life-support systems, energy solutions, and modular features for adaptability.
- Prepare a presentation that showcases sustainable habitat design, covering resource systems, modularity, human-centred features, and environmental adaptability. Use visuals to highlight each component's functionality and impact on sustainability.

Questions to Consider

Environmental and Resource Challenges
  - How can resources like water, air, and energy be sustainably managed in an isolated habitat?
  - What systems can support efficient waste management and recycling in a closed environment?

Design for Human Well-being
  - What layout and design features will help alleviate the isolation and confinement experienced by the crew?
  - How can ergonomic and aesthetic considerations improve comfort in an otherwise sterile environment?

Material Selection and Structural Integrity
  - Which materials will provide necessary strength, radiation protection, and durability?
  - How can sustainable and locally sourced materials be used to reduce reliance on Earth resupply?

Adaptability and Modularity
  - What designs would allow the habitat to expand as mission objectives grow?
  - How can the structure be adapted for lunar, Martian and extreme earth environments without major redesigns?

Design Process Overview

Step 1: Introduction: What is available?
- Explore issues of Introduce the challenges of building sustainable habitats on the Moon or Mars or living in sustainable environments

Step 2: Empathy - Who are your users?
- Create user profiles for astronauts, engineers, future settlers and even neighbours, any existing residents / organisms.

Step 3: Defining the Problem
- Define key challenges like resource constraints, environmental hazards, and sustainability

Step 4: Ideate
- Brainstorm habitat designs that use local resources (e.g., 3D printing with lunar soil) and minimise energy use.

Step 5: Ideate 2 – Good Idea / Bad Idea
- Remix and refine ideas to on the habitat designs to improve sustainability and comfort for long-term use.

Step 6: Prototype
- Build a model of the habitat, incorporating renewable energy sources and efficient space use.

Step 7: Test

- Simulate living conditions in the habitat, gather feedback from users, and adjust based on their experiences.
- Share your prototype with others to get feedback. Use their suggestions to make improvements and ensure it's easy to understand for your users

Each step ill take one or more lessons, your teacher will guide you with lessons and resources from 'Space Design Challenge Problem to Pitch' Module and the Future of Space

The United Nations Office for Outer Space Affairs (UNOOSA) works to promote international cooperation in the peaceful use and exploration of space, and in the utilisation of space science and technology for sustainable economic and social development.

VISIT https://www.unoosa.org/oosa/en/ourwork/space4sdgs/sdg1.html

Step 1: Introduction: Understand the the diverse experiences and challenges faced by individuals who may inhabit sustainable habitats on the Moon, Mars, or in harsh, extreme environments on Earth

Consider the realities of living in isolation, where access to resources is limited, and the environment can be unforgiving. Explore the International Space Station and recent space flights e.g. Crew 8 to gain insights into living in space such as communal and mobile living in restricted space and the potential of long-distance travel. Space technology is already supporting sustainable cities and communities on Earth, visit https://www.unoosa.org/oosa/en/ourwork/space4sdgs/sdg11.html to find out more.

Support: Use the resources in MM2,4 and 5 and the Problem to Pitch Space Design Challenge, Lesson 1, Empathy - see supporting links also on the last page

Step 2: Empathy: Explore the perspectives of those impacted by long-term space habitation

Think about their concerns regarding lack of access to technology, mental health challenges due to isolation and physical abilities. By empathising with their perspectives and experiences, you can design solutions that address their specific needs, enhance their quality of life, and create habitats that truly support human flourishing in these extreme settings.

These prompts will help you when thinking about the diverse needs, challenges, and experiences of potential inhabitants of a sustainable habitat on the Moon or Mars. The questions will help you consider the practical aspects of sustainable and human-centric design in space or for life in extreme/harsh conditions and environments. Use the internet to help you research your answers.

Identify Potential Users

- Who will be living in the habitat, think about both specific roles as well as citizens other species?
- Consider individuals with specific roles (e.g., biologist, engineer, or physician) and how the habitat might support their personal and professional needs - see additional role profile prompts at the end of the brief in the support section.
- What unique needs might astronauts or scientists on long-duration lunar or Mars missions have?

Daily Challenges and Pain Points

- What are the most challenging aspects of confined, isolated living in a habitat?
- How would limited access to fresh food, outdoor spaces, or natural light impact
- crew well-being?

- How would they manage the limited access to Earth-based resources and conserve/preserve these resources?

Technology Access and Comfort Level

- Outline and consider the user's familiarity with essential technology, noting their comfort with tools like habitat monitoring software, resource management interfaces, or virtual reality platforms for mental well-being.
- Mention any adaptive tools they may require, like voice-activated systems or visual alerts, for managing life-support systems or communication.

Role of Resource Accessibility

- How could efficient access to water, energy, and waste systems streamline daily activities?
- How might different crew members' needs for space and comfort influence the habitat's design?
- The need for environments that support human life under extreme conditions

Specific Needs and Goals Related to Sustainable Habitat Living

- How would they ensure reliable bio-regenerative life-support systems?
- How might they access regular mental health resources or communication channels with Earth?
- Do they need training or upskilling in environmental control systems or emergency protocols for safe and sustainable living?

How They Would live and work in the habitat

- How might an engineer use modular energy systems to manage and monitor power distribution efficiently?
- How might a biologist work on closed-loop ecosystems to ensure food and oxygen recycling?
- How might a mental health officer might create dedicated spaces and activities for well-being to support the crew's morale and mental health?

Creating User Profiles

After exploring the prompts above, create a user profile for an individual who would

- Name, age, and location of the user and perhaps role e.g., astronaut, environmental engineer, mission biologist, mental health officer, resident, family member etc.
- Personal Comfort and Social Needs: Detail how layout, private spaces, and communal areas meet their psychological and physical needs.
    - Outline their daily challenges and pain points, such as limited access to reliable life-support systems, including oxygen and water recycling, earth-based resources and the pressure to use resources conservatively as well as psychological stress due to isolation, confinement, and limited interaction with nature
    - Technology they have access to and comfort level with learning essential technology, e.g. tools like habitat monitoring software, resource management interfaces, or virtual reality platforms for mental well-being
    - Their specific needs or goals related to inclusive space exploration e.g. adaptive tools they require, (e.g. voice-activated systems or visual alerts for communication or managing life-support systems
- Describe the day-to-day life experience within the habitat, including aspects of resource use (heating, lighting cooking, hygiene), workspaces (roles/activities), and leisure areas/activities.

Support: Use the resources in MM7: Problem to Pitch Space Design Challenge, Lesson 2 Empathy - see also the roles and profiles in the supporting links section on the last page

Step 3: Define the core issue your project addresses. For example the need for environments that support human life under extreme conditions

Use a problem tree to explore root causes like limited technological resources, environmental challenges, and socio-economic disparities. Identify the effects of these issues, such as restricted access to sustainable living practices, inadequate training opportunities, or lack of community engagement. This will help you see the interconnected challenges and focus on designing inclusive, resilient habitats.

Support: Use the resources in MM7: Problem to Pitch Space Design Challenge, Lesson 2 and 3,

Step 4: Ideate Brainstorm various solutions that can make your habitat design adaptable for extreme environments

- Consider features like renewable energy systems, advanced water recycling technologies, and modular construction methods that can be easily expanded or modified. Explore how these solutions can also apply to sustainable living on Earth, making them relevant for a broader audience and promoting inclusivity in habitat design.

Step 5: Refine your ideas, selecting the most impactful and feasible concepts for your habitat

- Prioritise designs that are not only sustainable and environmentally friendly but also culturally sensitive and accessible to various user needs. Think about partnerships with organisations focused on sustainability and community development, ensuring your design encourages collaboration and knowledge sharing among diverse groups.

Support: Use the resources in MM7: Problem to Pitch Space Design Challenge, Lesson 4 and 5, Ideate

Step 6: Prototype Create a model or sketch of your sustainable habitat, highlighting energy-efficient systems, adaptable layouts, and methods for resource management

- Include elements that demonstrate how your habitat can support different user groups, such as spaces designed for collaboration, education, and community activities, ensuring that all individuals can thrive in the environment.

Support: Use the resources in MM7: Problem to Pitch Space Design Challenge, Lesson 6 Prototype

Prototypes can be 3D or 2D if using wireframes for software / apps. You can read this article to help you https://www.figma.com/resource-library/what-is-wireframing/

Mock-ups can help you imagine how a user might interact with your satellite data -based app or system. The following links in Canva to create prototypes for any platform

- https://www.canva.com/prototypes/templates/
- https://www.canva.com/prototypes/

Follow the steps in Canva to create a user interface (UI) Mock-up for a mobile interface or explore Canva's Mock-up app to show a range of prototypes for different aspects of your programme

Steps in Canva:

- Open a New Project:
  - Create a Custom Size project, 1080x1920 pixels - mobile screen format.

    - Ensure it's optimised for mobile accessibility and readability.
- Set Up a Mobile Background:
    - In Elements, search for "mobile screen" to find a blank phone outline. Place it in the centre of the canvas.
    - Choose a background colour that is easy on the eyes, such as soft blue or light gray, ensuring good contrast for text and icons to improve readability
- Design the App's Home Screen:
    - Inside the mobile frame, add a rectangle at the bottom for the primary navigation bar. Include essential menu items, such as "Habitat," "Resources," "Crew," and "Health." These tabs provide quick access to vital resources, habitat data, and social interaction spaces.
    - Near the top, add a circle or square for the main icon or app name to establish a welcoming, inclusive feel for the app.
    - Title the screen with engaging text, like "My Habitat" or "Mission Hub," to foster a sense of connection and belonging within the habitat community.
- Add Buttons or Icons for Key Functions:
    - Design large, clear buttons or icons for primary functions like "Environment," "Energy," "Crew Health," and "Supplies." These should be prominently positioned, ensuring easy access to crucial data.
    - Label each button with specific text, such as "Air Quality," "Power Levels," or "Nutrition," and consider including alt-text or audio labels for crew members with varying visual needs to enhance navigation.
    - Ensure icons are placed logically within the screen, with spacing between buttons to make tapping easier and reduce accidental clicks.
- Add a Dynamic Data Preview:
    - Place a rectangle in the middle of the screen to serve as a data preview area. This section can display changing information such as "Current Power Levels," "Water Usage," or "Upcoming Maintenance Tasks."
    - Use smaller text to create a realistic UI look, but offer an option for enlarging text or enabling voice narration. This will ensure accessibility for all crew members, including those who might prefer auditory information or need larger text.
- Enhance with Colours and Borders:
    - Add borders around each button/icon for a polished, organised look. Choose colours that align with an inclusive theme, such as a friendly blue and white colour scheme that gives a "tech" feel while ensuring all elements are visually accessible.
    - Use high-contrast colours to ensure that icons, text, and buttons are easy to see, and consider adding visually-friendly options or themes for additional accessibility.
- Review, Download, and Save:
    - Carefully review the design to ensure that all elements are aligned, readable, and accessible. Verify that labels, icons, and buttons are intuitively placed to guide users effectively through the app.
    - Once satisfied with the design, download and save the mock-up as a finalised version, ready to be tested and refined based on user feedback.

You can also use cardboard - Cardboard Prototyping | Techniques,
Cal Maritime Makerspace see https://www.youtube.com/watch?v=qxXj2RhKjZY

Or Paper Mobile Application Design: Paper Prototype Video,
Cor-mac https://www.youtube.com/watch?v=y20E3qBmHpg

Step 7: Present your design to classmates, teachers, or industry experts to gather feedback.

- Ask questions to determine if the habitat feels inclusive, sustainable, and adaptable to various needs. Use this feedback to improve your design's effectiveness and accessibility, ensuring it meets the diverse requirements of those who will inhabit these environments, whether on the Moon, Mars, or in extreme locations on Earth.

Support: Use the resources in MM7: Problem to Pitch Space Design Challenge, Lesson 7 Test

Supporting links to help you define your inhabitants and their needs and test your initial solutions and what you may need to consider in developing your sustainable habitat

- Eden Project. Available at: https://www.edenproject.com/visit (Accessed: April 12, 2023).
- Halley VI Antarctic Research Station (2021) SpaceArchitect.org | SpaceArchitect.org. Available at: https://spacearchitect.org/portfolio-item/halley-vi-antarctic-research-station/ (Accessed: April 12, 2023).
- Rethinking the Future (Designing for Extreme Environments https://www.re-thinkingthefuture.com/architectural-styles/a9978-designing-for-extreme-environments/
- NASA (2024) Living in Space collection https://www.nasa.gov/humans-in-space/living-in-space/
- Tech Vision (2021) Life Inside The International Space Station [11:13 mins] https://www.youtube.com/watch?v=-Y04Zic1-r4
- United Nations (2024) SDG11 Targets and Indicator https://sdgs.un.org/goals/goal11#targets_and_indicators
- UNOOSA (2024) Decent Work and Economic Growth https://www.unoosa.org/oosa/en/ourwork/space4sdgs/sdg11.html

Additional Role Profiles to support designing your sustainable habitat

Astronaut Profile

- Name: What would be a suitable name for a future astronaut?
- Background: What is their training and experience in space exploration? Consider their educational background and any specialised skills (e.g., engineering, biology, robotics).
- Daily Life: What does a typical day look like for them in the habitat? What tasks do they prioritise?
- Challenges: What specific challenges do they face living in a lunar or Martian habitat? Consider issues like resource scarcity, psychological effects of isolation, and environmental hazards.

Scientist Profile

- Name: Create a name for a scientist working on a Mars or Moon mission.
- Field of Study: What is their area of expertise (e.g., geology, astrobiology, environmental science)?
- Goals: What are their main objectives in conducting research on the Moon or Mars?
- Needs: What resources or tools do they require to effectively carry out their work? How can the habitat be designed to support their research activities?

Engineer Profile

- Name: Imagine an engineer's name who specialises in habitat construction.
- Skills: What skills do they bring to the team (e.g., structural engineering, renewable energy systems)?
- Responsibilities: What specific tasks are they responsible for in maintaining and improving the habitat?

- Innovations: What innovative solutions would they want to implement to address challenges in habitat design?

Medical Officer Profile

- Name: Choose a name for the medical officer on the mission.
- Duties: What are their primary responsibilities regarding the health and well-being of the crew?
- Health Concerns: What health issues might arise in an extreme environment, and how would they be addressed?
- Design Needs: What features in the habitat would be crucial for maintaining crew health and safety (e.g., medical facilities, exercise areas)?

Family Member Profile

- Name: Create a name for a family member of a crew member who may be concerned about their loved one's well-being.
- Concerns: What worries do they have about their family member living in a habitat on the Moon or Mars?
- Support: What support systems or communication methods would they find helpful to stay connected with their loved one?
- Impact of Isolation: How might the long-term absence affect their relationship, and what design features could help mitigate that impact?

Educator Profile

- Name: Envision a name for an educator involved in training future astronauts or scientists.
- Curriculum: What kind of training programs do they offer to prepare individuals for life in a lunar or Martian habitat?
- Engagement: How do they engage students from diverse backgrounds in space exploration?
- Challenges in Education: What challenges might students face in accessing education related to space missions, and how can habitats be designed to facilitate learning?

Robotic Assistant Profile

- Name: Come up with a name for a robotic assistant that helps with habitat maintenance.
- Functions: What tasks can the robot perform to assist the crew (e.g., resource management, repairs, data collection)?
- User Interaction: How do crew members interact with the robot? What user interface would be intuitive for them?
- Adaptability: How can the robot be designed to adapt to unexpected situations or challenges in the habitat?

Sustainability Advocate Profile

- Name: Create a name for a sustainability advocate on the mission.
- Mission: What is their primary goal regarding sustainability in the habitat?
- Community Engagement: How do they involve the crew in sustainable practices?
- Design Priorities: What specific features would they prioritise to ensure the habitat minimises waste and uses resources efficiently?