MM7: SDG12 SPACE4SDGS SPACE DEBRIS

SDG12: Space Debris and Recycling in Space

- Develop a system for cleaning up space debris and recycling materials in space.

Challenge
As we continue to explore and use space, the growing amount of space debris—abandoned satellites, broken spacecraft parts, and other discarded materials—poses serious risks to future missions, active satellites, and even Earth. In this challenge, you are tasked with designing an innovative system for cleaning up space debris and recycling materials in space. Your solution should address both the cleanup of existing debris and the recycling of materials for potential reuse, and how it could be prevented, making space safer and more sustainable for future exploration

Considerations
- Safety: Your system must avoid causing more damage or creating additional debris while in operation.
- Sustainability: Consider the use of renewable energy sources and closed-loop recycling systems.
- Feasibility: Your design should be adaptable for use in a zero-gravity environment and be efficient with limited resources.
- Durability: Space is a challenging environment with extreme temperatures, high radiation levels, and microgravity, so your system needs to be resilient.

Background
Space debris is a growing issue for all space-faring nations and organizations. When debris collides with functional satellites or spacecraft, it can cause severe damage, potentially leading to more debris in a chain reaction known as the "Kessler syndrome." Space debris also threatens the safety of astronauts, and the accumulation of this waste could one day prevent safe travel beyond Earth's atmosphere. Recycling materials in space presents an opportunity to repurpose debris, turning it into useful resources like construction materials, spare parts, or even fuel.

Environmental sustainability is critical not only on Earth but in space as well. By developing a system to clean and recycle debris in space, we can contribute to more sustainable exploration practices, reduce the risk of debris collisions, and conserve resources. In line with SDG 12, your project will focus on ensuring responsible consumption and production practices in space, aiming to reduce waste and protect the space environment.

Your Mission
Your mission is to design a system that captures, processes, and recycles space debris to make it

useful for ongoing or future missions. Your design should incorporate sustainable practices, emphasise safety, and use innovative technologies to create a practical solution for a cleaner, safer space environment. By doing so, you'll contribute to a more sustainable future for space exploration and address the pressing issue of waste in orbit.

Project Objectives

- Design a system that effectively captures and removes space debris from orbit.
- Develop a recycling process that repurposes captured materials for use in space missions or other applications.
- Ensure that the system operates efficiently with minimal human intervention and can withstand the harsh conditions of space.

Deliverables

- Detailed Design Proposal: An outline of your debris capture and recycling system, including sketches or diagrams.
- System Description: An explanation of how each part of the system works and its purpose.
- Sustainability Report: An analysis of how your system supports sustainable practices in space, focusing on resource efficiency and recycling.
- User Experience Plan: A description of how astronauts or ground operators will interact with your system, with safety and ease of use in mind.
- Prototype or Concept Model: Build a prototype using recyclable or sustainable materials, demonstrating the key functions, energy solutions, and modular features for adaptability.
- Prepare a presentation that showcases your design solution and process. Use visuals to highlight each component's functionality and impact on sustainability.

Questions to Consider

- What methods could be used to capture space debris effectively?
- How could the system avoid creating new debris or damaging active satellites?
- What processes could recycle the debris into useful materials in space?
- What sources of energy (e.g., solar power) would best support your system in space?
- How would the system be controlled or monitored from Earth?
- What are the challenges of recycling materials in a zero-gravity environment, and how can your design address them?

Design Process Overview

Step 1: Introduction: What is available?

- Introduce the growing problem of space debris and its dangers to future missions.

Step 2: Empathy - Who are your users?

- Create user profiles for satellite operators, astronauts, and space agencies.

Step 3: Defining the Problem

- Define the problem of space debris accumulation and the challenge of recycling in space.

Step 4: Ideate

- Brainstorm ideas for debris cleanup (e.g., robotic arms, magnetic collectors) and recycling space materials.

Step 5: Ideate 2 – Good Idea / Bad Idea

- Iterate on the best ideas, exploring cost-effective and energy-efficient methods.

Step 6: Prototype

- Create a prototype of a space debris collection tool or recycling system.

Step 7: Test

- Test the system in a simulation and refine the design based on performance.
- 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 will 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:

Visit https://www.unoosa.org/oosa/en/ourwork/space4sdgs/sdg12.html to find out about projects that are engaged in more responsible production processes and reducing consumption.

Support: Use the resources in MM2,4 and 5 and the Problem to Pitch Space Design Challenge, Lesson 1,

Step 2: Empathy: Understand the needs and experiences of those affected by space debris
Consider the daily challenges in space—limited resources, microgravity, and constant exposure to debris risks—and design a system that effectively addresses these realities. Think about who might be engaged in the issue of space debris such as mission engineers who maintain satellites, astronauts facing collision risks, and scientists interested in reusing materials.

Identify Potential Users

- Who might directly use or rely on a space debris cleanup and recycling system? Describe what their role could be (e.g., astronaut, mission control engineer, space scientist, environmental advocate) and what motivates them.
- What organisations or groups would be invested in the success of this system? Think about space agencies, satellite companies, and environmental organisations. How might they benefit from a cleaner space environment?
- Who are the people on Earth whose work or daily life might be impacted by space debris removal? Describe how this system could make a difference for researchers, satellite operators, or communication services.

Daily Challenges and Pain Points

- What specific challenges do space engineers or astronauts face due to space debris? Consider safety, collision risk, and communication issues. Describe how the presence of space debris might impact their work routines and responsibilities.
- How would a space debris system make daily operations in space easier or safer for the user? Think about ways the system could improve safety or reduce stress for astronauts, engineers, or scientists.
- What difficulties might astronauts encounter while operating or monitoring this system in space e.g. potential challenges posed by zero-gravity, limited resources, or monitoring from Earth.

- How does space debris currently impact scientists and environmental advocates concerned with sustainability?
- Consider their frustrations with growing debris and how this system could ease those concerns.

Impact on Environment and Space Exploration

- What are the long-term risks of space debris for users involved in space missions? Describe how a cleaner space environment could benefit astronauts, satellite operators, or space agencies in the future.
- How would a successful space debris system help environmental advocates and researchers? Think about the environmental and scientific impact and describe the benefits of a debris-free orbital space.
- What positive impacts on global space exploration would a cleaner, more sustainable space environment have? Describe how this might change the experiences of space agencies, researchers, and engineers in the future.

Skills and Training Needs

- What specific skills would an astronaut or engineer need to operate this debris cleanup and recycling system? Consider technical expertise, like robotics, problem-solving, and resource management, and how it relates to the user's role.
- What unique training might users need to safely and effectively work with a debris management system in space? Describe how training would be essential for handling zero-gravity operations or repairing the system.
- What problem-solving abilities would help these users handle any unexpected challenges or system malfunctions? Think about how quick thinking and adaptability would be key in space.

Global Benefits and Impacts

- How could a debris recycling system positively impact people on Earth who rely on satellites for daily needs? Describe potential benefits for users connected to global communications, navigation, and research.
- What environmental benefits could result from cleaning up and recycling space debris?
- Consider how this system would support environmentalists, scientists, and the global community, creating a safer, sustainable space environment.
- How might this system inspire other industries or organizations on Earth to focus on sustainability? Describe how users in industries beyond space exploration could be motivated by the project's success.

Creating User Profiles for Space Debris and Recycling

After exploring the prompts, create a user profile for an individual who would benefit from a space debris cleanup and recycling system. This could be an astronaut facing daily challenges from space debris, an environmental scientist working to reduce human impact on space, or an engineer developing systems to make space exploration safer. The profile can include:

- Name, age, and location of the user
- Describe the user's background, including their role or connection to space exploration (e.g., "Maya, a 32-year-old engineer from the European Space Agency," or "Leo, a 29-year-old astronaut on a lunar mission").
- A description of their daily challenges and pain points
- Outline the specific struggles they encounter related to space debris. For instance, a satellite technician may face disruptions in equipment performance, or an astronaut may experience safety risks during missions due to floating debris.

- Technology they have access to and comfort level with system tools Describe the systems or tools they currently rely on, like orbital tracking software or debris management technology, and their comfort level with these tools.
- Consider if they need more user-friendly or resilient technology to enhance their daily work.
    - Their specific needs or goals related to a space debris system
    - Identify how the user could benefit from an improved space debris and recycling system, such as reliable safety protocols, easier debris monitoring, or improved recycling methods for spacecraft materials.
- Describe how this system would help the user achieve their objectives. For instance, an astronaut could use the system to maintain safer orbits during missions, while an environmental scientist might use it to study the reduction of debris and promote global sustainability efforts in space exploration.

You can use these key roles to help you create a user profile of someone engaged with the challenge of space debris.

- Mission Engineer
    - Background: What skills does this engineer need to ensure the system operates effectively in space?
    - Tasks: What specific tasks will they perform to monitor and maintain the system?
    - Challenges: How will they address challenges like remote monitoring, limited power, and possible malfunctions in space?
- Space Scientist
    - Field of Study: What background in space science or materials engineering would be valuable for working on this system?
    - Goals: What are their goals regarding the scientific and environmental impact of debris cleanup?
    - Tools Needed: What specific tools or instruments would they need to analyze and process space debris?
- Environmental Advocate
    - Mission: How do they contribute to promoting sustainable practices in space exploration?
    - Public Awareness: How might they use data from the system to inform and educate the public about space debris and sustainability?
    - Design Priorities: What aspects of sustainability and minimal waste generation would they prioritise in the system?
- Astronaut
    - Daily Interaction: How often would an astronaut need to interact with or check on the system?
    - Safety Needs: What safety features are necessary to protect the astronaut while operating the system?
    - Efficiency: How can the system minimize the astronaut's time and effort in debris management?

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

Step 3: Define the core issue your project addresses. For example the lack of an efficient, sustainable way to capture and recycle space debris.

- Break down the challenges, such as debris detection, capture mechanisms, recycling processes,

and energy needs. This will help you focus on creating a safe, resource-efficient, and adaptable solution.

Step 4: Ideate Brainstorm various solutions for capturing and recycling space debris.

- Think about different technologies, like nets, robotic arms, or magnetic capture devices, and ways to recycle debris into useful materials. Generate ideas on how the system can power itself sustainably, whether through solar panels or alternative energy sources.

Step 5: Refine your ideas by selecting the best solutions for capture and recycling.

- Focus on ensuring that your system is durable, safe, and effective in a zero-gravity environment. Consider user feedback and prioritise features that make the system easy to monitor from Earth, sustainable, and resilient against damage.

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

Step 6: Prototype Create a model or digital prototype of your system, showing how it captures debris and processes materials for recycling.

- Highlight key features, such as energy sources, capture mechanisms, and storage for recycled materials. Emphasise ease of use and adaptability for real-world testing in space.

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/

Explore Canva's Mock-up app to show a range of prototypes for different aspects of your programme

Follow the steps in Canva to create SDG 12: Space Debris and Recycling Challenge - Creating a Mobile Interface Mock-up for a Space Sustainability App

Steps in Canva:

Open a New Project:

- Create a Custom Size project, 1080x1920 pixels - mobile screen format.
- Ensures the design will be optimised for mobile access, readability, and ease of use for all users.

Set Up a Mobile Background

- In your design tool, search for a "mobile screen" frame or outline and place it in the centre of the canvas.
- Choose a background colour that's easy on the eyes, like a light blue or grey, to provide good contrast for icons and text, improving readability.

Design the App's Home Screen

- Inside the mobile frame, add a rectangle along the bottom for a main navigation bar.
- Include menu items like "Debris Tracker," "Recycling Tips," and "Innovation Hub" to give users easy access to information about space debris, recycling methods, and sustainability. Near the top, place a circle or square for the app's icon or logo to create a welcoming first impression. Label the screen with a title like "My Space Sustainability" to encourage engagement with the app.

Add Buttons or Icons for Key Functions

- Create large, clear buttons or icons for each primary function. Examples might include "Learn" for resources about space debris, "Connect" for forums or expert profiles, and "Innovate" for users interested in developing new solutions for space recycling.
- Label each button clearly, with accessible text and alt-text descriptions or audio labels to aid users with visual impairments. Arrange buttons logically on the screen with ample spacing for easy tapping and to prevent accidental selections.

Add a Sample Data Preview

- In the centre of the screen, use a rectangle to create a "data preview" area where live information can appear, such as "Latest Recycling Technologies," "Upcoming Webinars," or "Noteworthy Space Initiatives."
- Ensure the text in this preview is clear but consider adding an option to enlarge the text or enable voice narration for accessibility.

Enhance with Colours and Borders

- Add borders around each button and icon for an organised, professional look. Choose colours that align with the theme of sustainability and accessibility, like friendly blue and white shades with high contrast to make text, buttons, and icons easier to read.
- Consider adding themes that accommodate users with colour blindness or low vision.

Review, Download, and Save

- Review the mock-up to check alignment, readability, and ease of navigation.
- Ensure that labels and icons are accessible and that the layout naturally guides users to explore the app's features.
- Once complete, download and save the mock-up as your final version, ready for feedback and potential adjustments.

Step 7: Test

- Share your prototype with classmates, teachers, or potential users to gather feedback.
- Ask if the system is user-friendly, effective in managing space debris, and sustainable.
- Use feedback to improve design features, refine debris capture and recycling processes, and ensure the system's reliability and safety in space conditions.

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

- Hitchcock Project for Visualizing Science (2024) Space Debris is a Threat to Earth's Environment [1:54 mins] https://www.youtube.com/watch?v=HqUuwXBZ6TM
- United Nations (2024) SDG11 Targets and Indicator https://sdgs.un.org/goals/goal12#targets_and_indicators
- UNOOSA (2024) Decent Work and Economic Growth https://www.unoosa.org/oosa/en/ourwork/space4sdgs/sdg12.html