



MM4: Space Innovation and Enterprise

Experimentation and Exploration

Lesson 1 Introducing the Commercialisation of Space

Subject Areas: CSPE/ SPHE, Design, English and Communication, Science, Sustainability, Technology

8 DECENT WORK AND ECONOMIC GROWTH



10 REDUCED INEQUALITIES



12 RESPONSIBLE CONSUMPTION AND PRODUCTION



17 PARTNERSHIPS FOR THE GOALS



Lesson Title and Summary: Introducing the Commercialisation of Space

In this lesson, learners are introduced to the commercial space industry, its key players, and ventures in space entrepreneurship and explore space as a marketplace for goods, services, and innovation.

The lesson will support learners to define and explain the concept of the commercialisation of space exploration, and begin to identify the motivations behind companies' interest in investing in space ventures.

Through this lesson, learners will develop an understanding of the commercial aspects of space exploration and begin to explore the diverse career opportunities available in the space industry.

Vocabulary: Commercialisation, Emergent Impact, Innovation, Ventures

In this lesson, the learner will:

- develop an understanding the concept of commercialisation in space exploration:
- identify key players and ventures in the commercial space industry
- understand the contributions to advancing space exploration
- begin to explore space and the emerging opportunities and implications for developing goods, services and innovation in space
- will develop their creativity, innovation, and critical-thinking skills

Materials

- Worksheet: Commercial Space Sectors Overview
- Worksheet: Space Venture Remix Grid
- Teacher's Guide: Space Commercialisation
- Paper / pens
- AV equipment
- Computers with internet access

MM4: Space Innovation and Enterprise

L1 Introducing the Commercialisation of Space



Activity Instructions

Activity 1: What is the Commercialisation of Space? (25 mins)

1. Write on the board or project the following definition of commercialisation - 'as the process of introducing a new product or service into the market to make a profit'.
2. Explain that now private companies have enough money, space exploration is no longer only possible for government, military or academic institutions, this has opened up opportunities for private companies. This means more opportunities for governments and private companies to work together to make space profitable and ideally equitable.
3. Watch Video: 'Commercialisation of Space' [3:26 mins]
4. Working in pairs, ask learners to come up with two reasons why companies are interested in investing in space exploration ventures.
5. Ask pairs to share one of their two reasons, and add their reasons to a circulating piece of paper. One of the pair can share while the other is writing down their reasons and ask learners to try to keep all the answers on 1 page
6. Go around the class, asking for new reasons until all pairs have given one reason or their reasons have been covered by someone else.
7. Ask the class to add any reasons not yet shared.
8. Use an overhead projector or photograph and upload to the class computer for projection

Activity 2 Introduction to the Commercial Space Industry (25 min)

1. Project the findings from activity 1, and working in pairs, ask learners to complete Worksheet: 'Commercial Space Sector Overview' using the learning from activity 1 and internet searches.
2. Ask learners to work with another pair to share and discuss their findings.
3. Learners will continue working in groups of four, and using their shared ideas from the Worksheet: 'Commercial Space Sector Overview' complete the Worksheet: Space Venture Remix Grid'
4. Ask for four of the groups to each share an answer for one of the boxes.
5. Use the 4 answers to brainstorm, as a class an additional or potential goods, services, or innovations that could be offered in the space marketplace. See Teacher's Guide for instructions

REFLECTIVE EXERCISE: 3-2-1 (10 mins)

- Three things they feel they have learnt from the tasks
- Two things they found most interesting and would like to explore more
- One – their opinion they have about the tasks

Use Post-its or a mentimeter survey - www.mentimeter.com to gather reflections

MM4: Space Innovation and Enterprise

L1 Introducing the Commercialisation of Space



EXTENSION / REDUCTION ACTIVITIES

Reduction: For a shorter lesson: complete Activity 1 only and have learners upload their reasons to a shared document in the e-class room for this module as well as to their e-portfolios in Microsoft Teams or other class repository

Extension: For a longer lesson: as a class, summarise the key concepts covered in the lesson and encourage learners to reflect on what they have learned about the commercialisation of space and the opportunities it presents. Ask learners to consider the social, environmental and economic implications of space exploration and begin to identify positive and negative impacts. See Teacher's Guide for example discussion questions. Resources from MM2: Space Leadership for the 21st Century can also support this activity.

If not doing lesson 2, the Space Venture Remix Grid can be using different needs to complete worksheet e.g. completing the four boxes using different needs and then use step 4 and 5 of activity 2 to define the parameters that learners can then will work on in their own groups. This introduces learners to ideation while they can see how many possibilities can be generated with one set of variables. - see also media box video: 'Design Thinking Ideate'

MEDIA BOX: (materials, online video links, extra resources, case studies etc)

Commercialisation of Space [3:26 mins] https://www.youtube.com/watch?v=N7hKPnHwf_A

Space Foundation - Non-Profit <https://discoverspace.org/about/about-the-space-foundation/>

Article: The commercialisation of outer space

<https://www.nortonrosefulbright.com/en/knowledge/publications/102a426e/the-commercialisation-of-outer-space#section3>

Design Thinking Ideate [4:03 secs] <https://www.youtube.com/watch?v=zbLxs6te5to>

Local Trip / Expertise / Additional Work and Assessments

For a larger assessment project, use resources from Lesson 11 and 12 or MM7: Space Design Problem to Pitch to support learners to develop a venture idea that emerged in the Space Venture Remix Grid and present to the class.

For a smaller project, use the questions in the Teacher's Guide to create a research project for the class - allocating the questions across small groups. Learners can present their findings using SDG 12 Future of Innovation and Enterprise, MM7: Media Communication module 1 - 4.



Activity 2 Overview of Space Commercialisation

INDUSTRY	SHORT DESCRIPTIONS
Satellite communications	The use of satellites to transmit data, voice, and video across long distances for global telecommunications networks.
Launch services	Companies that provide the technology and logistics to send spacecraft, satellites, and payloads into space
Satellite imaging	Capturing Earth's surface and space imagery through satellites for applications such as mapping, environmental monitoring, and security.
Space-based manufacturing	The production of goods and materials in microgravity environments, offering unique advantages like precision and efficiency.
Space tourism	Commercial space travel experiences for private individuals, allowing non-astronauts to visit space.
Asteroid mining	The extraction of valuable minerals and resources from asteroids for use on Earth or in space-based industries.
Space Food and Nutrition	The development and provision of sustainable, nutritious food systems to support human life in space environments
Space Tech: Travel and Transportation	Innovations in spacecraft and propulsion systems to enable human and cargo transport in space
Space Clothing and Personal Protective Equipment (PPE)	Specialised attire and protective gear designed to safeguard astronauts from the harsh conditions of space
Space Shelter and Habitats	Structures and habitats designed for sustaining human life during space exploration, whether on spacecraft, the Moon, or Mars



INDUSTRY	DESCRIPTION
Space Technology - Data Services / Communication	Advanced technologies for handling data transmission, storage, and communication between space and Earth.
Space Healthcare / Medical Services	The development of medical technologies, treatments, and protocols tailored to the unique health challenges faced by humans in space.
Space Tech: Energy / Power Generation	Technologies for generating and harnessing energy in space, such as solar power and nuclear energy for spacecraft and space colonies
Space Tech: Environmental Monitoring and Resource Management	Technologies to monitor and manage environmental conditions and resources, both on Earth and in space, for sustainable exploration.

ACTIVITY 2 SPACE VENTURE REMIX GRID

Instructions for Using the Worksheet: Space Venture Remix Grid

Explain learners will use generate the answers to the boxes using the completed table for activity 1 to understand how to develop ideation skills and creative problem-solving skills

1. Organise learners into groups of 4 and ask learners to complete the worksheet: Space Venture Remix Grid by brainstorming to place an answer in each box

- Select one of the industries from the table they completed in activity e.g Space Food and Nutrition
- Write their selection in the Space Industry / Challenge theme box and think about what are the challenges to this industry e.g. food production in space, alternative production such as hydroponics or aquaponics - they can use the internet to find out what these are,
- Once they have selected their industry and challenge theme they begin to complete the other boxes answering the questions in the worksheet boxes -
- Finally, once they have completed the boxes e.g. they should devise a product, service or innovation for Space Exploration.

Using the example of fSpace ood and nutrition, this could be

- What Are the possible challenges for the selected challenge theme, challenges could be no sun / water, long distances, dead seeds
- Obstacles to developing solutions e.g. minimal space and trying to reduce weight for transportation
- How would you overcome the obstacles e.g. vacuum packing or dehydration to reduce size and weight

MM4: L1TG SPACE VENTURE REMIX GRID



ACTIVITY 2 SPACE VENTURE REMIX GRID

Our service uses new technology to ensure the long life of seeds and transport them in space by vacuum packing and a unique seed dispersal system designed to be small and light yet durable, making it suitable for long-distance space exploration.

2. Once the learners have completed their boxes ask four random groups for input from the grid e.g. “Group one, tell me what’s written in your ‘Space Industry and Challenge theme’ box, group 2 tell me what’s written in your ‘Challenges’ , write their answer on the board. Repeat until all the boxes are filled.

3. Ask the groups to start coming up with possibilities for a business, activity or service that include the 4 variables, the more random the variables the better to push their creativity.

These emergent needs reflect the multifaceted challenges and opportunities associated with space exploration, highlighting the importance of interdisciplinary collaboration and innovation in addressing the complex requirements of future space missions.

You can use the table below to support them thinking about their challenges and obstacles as you circulate the room.

NEEDS	POSSIBLE ANSWERS
Food and Nutrition	<ul style="list-style-type: none">• Development of sustainable food production systems for long-duration space missions.• Creation of nutrient-rich, shelf-stable foods that can withstand the rigors of space travel.• Exploration of alternative food sources such as hydroponics, aquaponics, and cellular agricultural
Travel and Transportation	<ul style="list-style-type: none">• Advancement of propulsion technologies for faster and more efficient interplanetary travel.• Development of reusable spacecraft and spaceplanes to reduce the cost of access to space.• Implementation of advanced life support systems to ensure the safety and well-being of crew members during extended space journeys.
Clothing and Personal Protective Equipment (PPE)	<ul style="list-style-type: none">• Design of lightweight, durable, and protective space suits for astronauts working in harsh environments.• Development of smart textiles and materials with built-in sensors to monitor astronauts' health and performance.• Exploration of 3D printing technologies for on-demand production of clothing and PPE in space.



NEEDS	POSSIBLE ANSWERS
Shelter and Habitats	<ul style="list-style-type: none"> • Design of modular habitats and inflatable structures for lunar and Martian colonies. • Integration of sustainable and self-sufficient systems for water recycling, air purification, and waste management. • Implementation of radiation shielding technologies to protect astronauts from cosmic radiation and solar flares
Data Services and Communication	<ul style="list-style-type: none"> • Establishment of high-speed, reliable communication networks for real-time data transmission between Earth and space. • Development of autonomous navigation systems for spacecraft and satellites to enable precise positioning and maneuvering. • Implementation of secure data storage and encryption protocols to protect sensitive information transmitted in space.
Healthcare and Medical Services	<ul style="list-style-type: none"> • Research into preventive healthcare measures and countermeasures to mitigate the effects of microgravity and space radiation on astronauts' health. • Exploration of telemedicine and remote diagnostics technologies for providing medical care to astronauts on long-duration space missions. • Development of pharmaceuticals and medical treatments tailored to the unique challenges of space travel, such as bone density loss and muscle atrophy.
Energy and Power Generation	<ul style="list-style-type: none"> • Advancement of renewable energy technologies such as solar panels and nuclear reactors for powering spacecraft and habitats. • Exploration of in-situ resource utilisation (ISRU) techniques for extracting and utilising resources such as solar energy, water, and regolith on planetary surfaces. • Development of energy storage systems for storing excess energy generated during periods of high solar activity or daylight.
Environmental Monitoring and Resource Management:	<ul style="list-style-type: none"> • Implementation of remote sensing technologies for monitoring planetary environments and assessing resource availability. • Integration of AI and machine learning algorithms for analysing environmental data and predicting potential hazards or anomalies. • Exploration of sustainable resource extraction and utilisation techniques to minimise the environmental impact of human activities in space.



Extension Activity

Lesson 1 Extension Activity: Use these questions to facilitate a discussion on the social, environmental, and economic implications of space exploration, along with positive and negative impacts:

Key Concerns / Issues: Generated from Emergent needs

Social Implications:

- Discussion Questions:
 - How does space exploration inspire and engage people around the world?
 - What are some potential benefits of space exploration for society, such as inspiring innovation, fostering international collaboration, and promoting STEM education?
 - How might space exploration contribute to addressing global challenges such as climate change, resource scarcity, and sustainable development?
 - What ethical considerations should be taken into account in space exploration, such as ensuring equitable access to space resources and protecting cultural heritage sites on other planets?
- Positive Impacts:
 - Inspiring future generations to pursue careers in science, technology, engineering, and mathematics (STEM).
 - Fostering international cooperation and diplomacy through collaborative space missions and partnerships.
 - Stimulating technological innovation and spin-off technologies that benefit society, such as GPS, medical imaging, and water purification systems.
- Negative Impacts:
 - Exacerbating existing social inequalities by diverting resources away from pressing societal needs such as poverty alleviation and healthcare.
 - Generating space debris and environmental pollution in Earth's orbit, posing risks to satellites and spacecraft.
 - Potentially leading to geopolitical tensions and competition over space resources, such as rare minerals and water ice.

Environmental Implications:

- Discussion Questions:
 - What are the environmental impacts of space exploration on Earth and beyond?
 - How does space debris affect the sustainability of space activities and the safety of spacecraft and satellites?
 - What are the potential risks and benefits of resource extraction and utilization on celestial bodies such as the moon and asteroids?
 - How can space exploration contribute to environmental monitoring and protection efforts on Earth, such as tracking climate change and natural disasters?



Extension Activity

- Positive Impacts:
 - Advancing our understanding of Earth's climate and environment through space-based observation and remote sensing technologies.
 - Facilitating the development of sustainable technologies and practices for resource utilisation in space, such as in-situ resource utilisation (ISRU).
 - Providing opportunities for environmental monitoring and protection efforts on Earth, such as tracking deforestation, pollution, and natural disasters.
- Negative Impacts:
 - Generating space debris and orbital debris that pose risks to operational spacecraft and satellites, as well as to future space missions.
 - Potentially disrupting ecosystems and geological formations on other celestial bodies through resource extraction and human activities.
 - Introducing contaminants and biological hazards to other planets and celestial bodies, potentially compromising scientific research and astrobiology studies.

Economic Implications:

- Discussion Questions:
 - How does space exploration contribute to economic growth and development on Earth?
 - What are the economic opportunities and challenges associated with commercial space activities such as satellite communication, space tourism, and asteroid mining?
 - How can space exploration stimulate innovation, entrepreneurship, and job creation in industries such as aerospace, technology, and manufacturing?
 - What are the potential economic risks and benefits of investing in space exploration compared to other priorities such as healthcare, education, and infrastructure?
- Positive Impacts:
 - Stimulating economic growth and investment in high-tech industries such as aerospace, telecommunications, and satellite imaging.
 - Creating new opportunities for job creation, entrepreneurship, and innovation in space-related sectors and downstream industries.
 - Generating revenue and economic value through commercial space activities such as satellite launches, space tourism, and space-based services.
- Negative Impacts:
 - Diverting resources and funding away from pressing societal needs such as healthcare, education, and poverty alleviation.
 - Exacerbating income inequality and social disparities by benefiting primarily wealthy individuals and corporations.
 - Potentially leading to economic instability and speculative bubbles in space-related industries, particularly in the absence of clear regulatory frameworks and oversight.

MM4: L1WS SPACE COMMERCIALISATION OVERVIEW

9 INDUSTRY, INNOVATION
AND INFRASTRUCTURE



Activity 2 Overview of Space Commercialisation

INDUSTRY	DESCRIPTION
Satellite communications	
Launch services	
Satellite imaging	
Space-based manufacturing	
Space tourism	
Asteroid mining	
Space Food and Nutrition	
Space Tech: Travel and Transportation	
Space Clothing and Personal Protective Equipment (PPE)	
Space Shelter and Habitats	



INDUSTRY	DESCRIPTION
Space Technology - Data Services / Communication	
Space Healthcare / Medical Services	
Space Tech: Energy / Power Generation	
Space Tech: Environmental Monitoring and Resource Management	

ACTIVITY 2 SPACE VENTURE REMIX GRID - INSTRUCTIONS

Emergent (arising or developing) needs reflect the multifaceted challenges and opportunities associated with space exploration, highlighting the importance of interdisciplinary collaboration and innovation in addressing the complex requirements of future space missions.

Using the information from the table you completed for activity 1 you will complete the boxes in the worksheet Worksheet: Space Venture Remix Grid.

1. Select one of the industries from the table above - e.g. Space Food and Nutrition
2. Write your selection in the challenge box and think about what are the challenges to this industry e.g. food production in space, alternative production such as hydroponics or aquaponics - you can use the internet to find out what these are,
3. Once you have selected your industry and your challenge begin to complete the other boxes answering the questions in the worksheet boxes -
4. Finally, once you have completed your boxes - what is your product service or innovation for Space Exploration.

Using the example of fSpace ood and nutrition, this could be

- What Are the possible Challenges for the selected Space Challenge, challenges could be no sun / water, long distances, dead seeds
- Obstacles to the solutions - minimal space and trying to reduce weight for transportation
- How would you overcome the obstacles - vacuum packing or dehydrating to reduce size and weight

Our service uses new technology to ensure the long life of seeds and transport them in space by vacuum packing and a unique seed dispersal system designed to be small and light yet durable, making it suitable for long distance space exploration.

MM4: L1WSb Space Venture Remix Grid

Team Name _____

9 INDUSTRY, INNOVATION AND INFRASTRUCTURE



This worksheet will help you play with ideas for Space Ventures using your work from activity 2 Space Ventures Remix Grid

Fill in the boxes - we will then work with the whole group to develop a number of possible ideas.



WHAT IS YOUR SELECTED SPACE INDUSTRY AND CHALLENGE THEME



LIST THE POSSIBLE CHALLENGES FOR YOUR SELECTED SPACE THEME



OBSTACLES TO DEVELOPING SOLUTIONS TO THE CHALLENGE



HOW WOULD YOU OVERCOME THE OBSTACLES