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Towards a Lunar Generation Workshop 2021

Summary

Sponsors and Partners

LOCKHEED MARTIN

SPACE GENERATION ADVISORY COUNCIL

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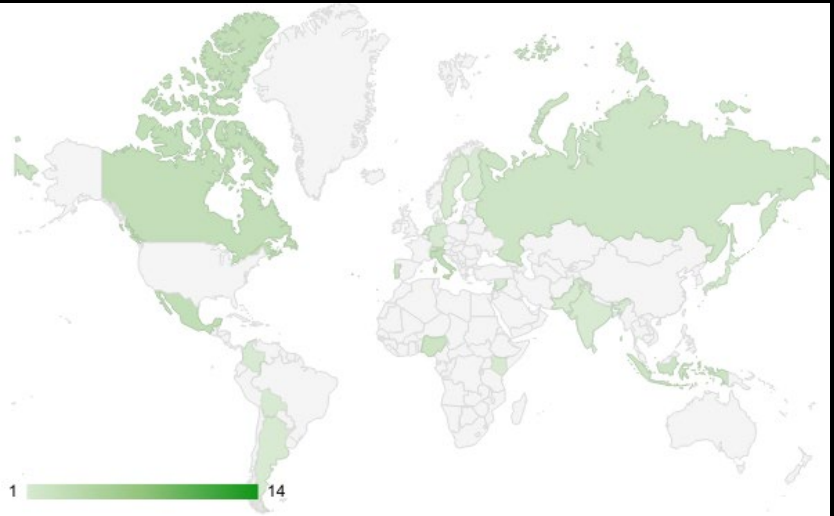
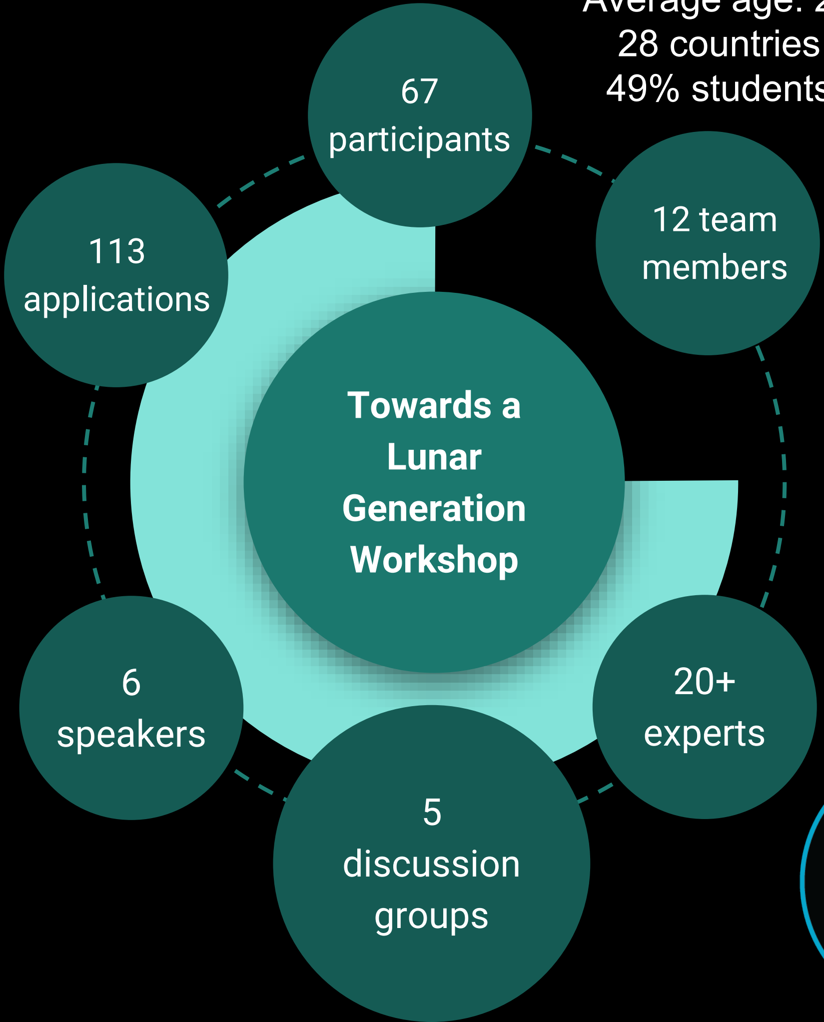
TLG 2021 Overview

Average age: 26
28 countries
49% students





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Organizing Team


Ali Nasseri


Ariann Duncan


Bas Krijnen


Georges Antoni Moubayed


Ioana Simona Rosca


Jorge Rubén Casir Ricaño


Kaori Becerril


Katerina Kobrlova


Leonard de Guzman


Marco Lavazza


Molly Silk


Swetha Kotichintala

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Keynote Speakers

Introduction to the Moon Village and MVA

John C. Mankins

MVA Vice President

Innovation and Entrepreneurship towards a Lunar Economy

Manny Shar

Head of Analytics at BryceTech

Lunar Medical Autonomy

Dr. Kris Lehnhardt

Element Scientist for Exploration Medical Capability at the NASA Johnson Space Center

Science on the Moon

Bernard Foing

Executive Director of International Lunar Exploration Working Group

Legal and Policy Ramifications of Moon Resource Utilization

Mark J. Sundahl

Director, Global Space Law Center, Cleveland-Marshal College of Law

Technologies for a Sustainable Moon Village

Kathleen Coderre

Systems Engineer, Lockheed Martin

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Subject Matter Experts: Lunar Medical Autonomy

Anthony Yuen, MD

Emergency medicine physician and space medicine researcher at Weill Cornell Medicine

Rochelle Velho

Medical doctor specialising in Acute Medicine and Intensive Care Medicine

Ashfaq Gilkar

Lead Senior Clinical Business Analyst

Kristi Ray, MD

Aerospace Medicine resident at UTMB/ NASA and completed a fellowship in Undersea and Hyperbaric Medicine

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Subject Matter Experts: Law and Policy

Christopher D. Johnson

Space Law Advisor, Secure World Foundation

Mark J. Sundahl

Director, Global Space Law Center, Cleveland-Marshal College of Law

Christopher D. Johnson

International Business Development / Government Relations Manager, I. M. Systems Group Inc. (IMSG)

Subject Matter Experts: Innovation and Entrepreneurship

Chantelle Dubois

Avionics & Software Systems Engineer at Canadian Space Agency

Carlos Mariscal

Computer Engineering and CEO at Dereum Labs

Jenna Tiwana

European Business Development and Partnerships Officer at Ispace Inc.

Derek Webber

Co-Chair of the Working Group on LCE of MVA.

Nadeem Gabbani

Director and Principal Engineer at Exobotics

Andrea Jaime

Institutional Business Developer at Isar Aerospace

Charlotte Neyret-Gigot

European Development Director chez Thales Alenia Space

Timothy Cichan

Space Exploration Architect at Lockheed Martin

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Subject Matter Experts: Science on the Moon

Melissa Battler

Chief Science Officer at Mission Control Space Services Inc.

Ian Crawford

Professor in Planetary Science & Astrobiology

Madhu Thangavelu

Conductor ASTE527 Graduate Space Concept Synthesis Studio

Gordon Osinski

Professor and Industrial Research Chair in Earth and Space Exploration

Bernard Foing

Executive Director of International Lunar Exploration Working Group

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Subject Matter Experts: Technologies for a Sustainable Moon Village

Chantelle Dubois

Computer Engineer, Canadian Space Agency

John C Mankins

Vice President, Moon Village Association

Kathleen Coderre

Systems Engineer, Lockheed Martin

Koorosh Araghi

In-Situ Resource Utilization (ISRU) & Surface Power (Fuel Cell & Electrolysis) Domain Manager, NASA Johnson Space Centre

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Presentations of Discussion Groups

Discussion Group 1:
Lunar Medical Autonomy

Discussion Topics

- What type of infrastructure is needed for medical autonomy on the Moon?
- What are high risk medical emergencies, and how can they be tackled on the Moon? What needs to be evacuated back to Earth?
- What are major human factors (including mental health) challenges on the Moon?
- Role of analogues in exploring medical autonomy: How could these be tested?
- What would medical autonomy on the Moon look like in the next 5, 10 and 50 years? What role can the MVA play in this regard?

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Our Team

Kateřina Kobrlová
Czech Republic

Mark Rosenberg
United States

Betania Tapia
United States

Izzy Cory
UK

Rachelle Moawad
Lebanon

Yeritza Gómez Martínez
Mexico

Amri Ramadhan
Indonesia

Daan van den Nieuwenhof
Netherlands

Aarón Garduño Rodríguez
Mexico

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Keynote, Speakers, Subject Matter Experts

Kris Lehnhardt, MD
Element Scientist for Exploration Medical Capability for the Human Research Program at the NASA Johnson Space Center

Anthony Yuen, MD
Emergency medicine physician and space medicine researcher at Weill Cornell Medicine

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Main challenges & Medical Issues for Lunar Activities

- Dependence on Supplies - Costly, Pharmacy, Tools, Medical Emergencies
- Microgravity - Difficult for CPR, Surgeries
- Radiation Exposure - Difficult for testing in Analogs, Sickness
- Infection Risk - dysregulation of the immune system, virulence of microbes
- Physiological issues: Cardiovascular, Musculoskeletal, Nutrition,
  Space Motion Sickness
- Psycho-Social Changes & Circadian Rhythm - Closed loop environment, Remoteness and communication access, work load, sleep habits
  → stress and mental related disorders

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Risk Medical Emergencies - Requires Mitigation

- Adverse **Cognitive** or **Behavioral Conditions** and **Psychiatric Disorders**
- Adverse **Health** and **Performance Effects** of **Celestial Dust Exposure**
- Adverse Outcome Due to **Inadequate Human Systems Integration Architecture**
- **Impaired Control** of Spacecraft/Associated Systems and **Decreased Mobility** Due to **Vestibular/Sensorimotor Alterations** Associated with Spaceflight
- **Performance Decrement** and Crew **Illness** Due to **Inadequate Food** and **Nutrition**
- **Performance Decrements** and **Adverse Health Outcomes** Resulting from Sleep Loss, Circadian Desynchronization, and Work Overload
- **Injury** and **Compromised Performance** Due to **EVA Operations** & from **Dynamic Loads**
- Spaceflight **Induced Cardiovascular Disease**
- **Decompression Sickness**

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Risk Medical Emergencies - Accepted

- Adverse Health Event Due to **Altered Immune Response**
  - Moon: Short (<30 days): Accepted with monitoring
  - Moon: Long (30 days-1 year): Requires mitigation
- Adverse Health Outcomes & **Decrements in Performance** due to inflight Medical Conditions
  - Moon: Short: Accepted
  - Moon: Long: Requires mitigation
- **Ineffective/Toxic Medications** During Long-Duration Exploration Spaceflight
- **Renal Stone Formation**
- **Radiation Carcinogenesis**
- **Orthostatic Intolerance** During **Re-Exposure to Gravity**
- **Spaceflight-Associated Neuro-ocular Syndrome** (SANS)

- Accepted with monitoring:
  - **Performance** and **Behavioral Health Decrements** Due to Inadequate Cooperation, Coordination, Communication, and Psychosocial Adaptation within a Team
  - Reduced Crew Health and Performance Due to **Hypobaric Hypoxia**
  - Reduced Physical Performance Capabilities Due to **Reduced Aerobic Capacity**
- Accepted with optimization:
  - **Bone Fracture** due to Spaceflight-induced Changes to Bone
  - Impaired Performance Due to **Reduced Muscle Mass, Strength & Endurance**

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Infrastructure

5 years

- 3D Printing: Printed Tools & Replacement Parts
- Health Sensors - pulls, heart beating, pressure, temperature, oxygen + notifications
- Automated Miniaturized Computerized Tomography [CT] & Magnetic Resonance Imaging [MRI]
- AI - Ejenta, VisualDX, take notes, medical scans, diagnosis, treatment
- Dust measurements & Contamination Monitors - Radiation - Dosimeter
- Surgical Tools: Defibrillator, Reusable Devices
- Suits/Clothes - antibacterial Technology + physiological measurement

10 years

- 3D Printing - Food & Medications
- Medications (Tablets) developed on the Lunar Base
- Hydroponic Plants - included medications, vitamins, important nutrition
- Closed Unit/Module
- Restricted number of plants can be grown hydroponically - tomatoes, spinach (with iron), cabbage, potatoes, spirulina (Vitamin C), mushrooms (Vitamin D), mold/fungi (Penicillin)
- Surgical Robots

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Infrastructure

50 years

3D Printing:
- Bio-printing: Tissues/organs
- Disposable Surgical Tools - no requirement for sterilization

Surgical robots:
- Surgery without the help of people
- Surgery on different patients

Suits/Clothes with Technologies that detect medical problems before symptoms occur

Brain Stimulation being able to increase astronauts mood and performances

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System-Based Approach

- Evaluated different systems to determine emergencies including:
  - Neurologic, gastroenterologic, genitourinary, cardiovascular, orthopedic, ophthalmologic, pulmonary and endo/heme
  - Determined best diagnostic modalities including imaging, labs and other modalities
  - Determined best therapies including minimally invasive procedures, pharmacologic management and other supportive care
    - Requires antibiotics, anticoagulants, anti-hypertensives, pressors in the event of shock, etc.
- Will require (in its infancy) an ACLS-trained healthcare professional who can adequately triage patients to determine if they are stable enough for the transit home vs must be treated on the Moon
  - Will also require a clinic with capabilities to take care of an astronaut in the event they are in critical condition

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Analogs

What is already tested

- Places: Utah, Mexico, Antarctica, Desert Oman, Israel, Altitude Chamber
  - ESA Caves - no natural light, remote capabilities
  - Russia - long-term tests
- Psycho-emotional status in isolation and confinement
- Help to decide which tools, methods can be used
  - Capabilities of optical images from UAS & terrain-classified optical images from the rover for decision making and path planning
- Regolith & Dust - minor hardware difficulties to overall mission failure
- Training scenarios - Terrestrial climate change, human land and water usage
- How to distribute tasks between crew members & if humans are able to perform in higher workload since microgravity

What should be tested

- Utilization of different **garments** for **biometric purposes**
- **Medical emergency simulation labs**
- Clothes/Space suit - affected by **dust** & environment & health sensors
- Surface **Telerobotics**: Development & Testing of a Crew Controlled Transport
- **Higher workload tests**
- First aid, Simple **medical procedures**, Telesurgery
- Production of medications

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Future Moon explorers should...

- **Crew members** - **basic life support training** (e.g. handling allergic reactions, stemming bleeding, basic sutures)
- **Ultrasound** instead of MRI or CT - smaller, more portable
- **Universal donor** (crew member with O negative blood)
- 3D Printed Equipment
- **Prevention** of **Infection Risk**:
  - **Vaccination** and rigorous **screening**
  - Technologies for safe environment, e.g.:
    - Ventilator-associated bacteria
    - Preventative medication regimen
    - Psych crises-padded unit
- Robust imaging modalities
  - Initially: Point-of-care ultrasound with transition to higher fidelity like MRI and CT
- **Telesurgery**
  - 5 - 10 years: Possibly person with **basic surgery training** will be able to do surgery
  - 50 years: Telesurgery - without the help of people, Robot could do **surgery on different patients**

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Conclusions and Recommendations

For Government

- **New** ways of **detecting** and **treating diseases**
- Research and development of **corrosion-resistant coatings** and **materials** with **improved properties**
- Provide **new jobs** → better economy, strengthening cooperation with organizations, businesses & countries
- How Moon **Mission** will **support development** of **country**:
  - **Water recovery and management** - Improving access to clean water in less developed places
  - **Measure pollution** and **protect** against it → less allergies and diseases
  - Growing **plants** in **harsh conditions** & remote locations
  - **Heat resistance suits and life support technology** → useful for development of suits for firefighters
  - Providing **medical assistance** to people in remote areas: AI, digitalization, portable miniaturized devices, health sensors

For Industry

- Cordless tools
- **Digital Imaging**
- **Hydroponic systems** for growing plants
- **Robots** - autonomous image processing, assistants, location tracking
- Clothes - **antibacterial**, **measuring** characteristic **parameters**, **notifying** about **symptoms** of diseases or higher temperature

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MVA should...

- A **collaboration** between all the types of **organizations** for **sharing knowledge** by having access to multiple expertise
- **Identify hydroponically grown plans** which can be used for daily dose of vitamins, minerals and plants which can be used for production of medication
- Identification of **most common medical emergencies and treatments**
- Emphasis on **3D printing technology** development for purpose of **medication**, disposable **medical devices/materials** and **nutrition** creation
- Create new **materials** that can help shield astronauts from exposure to **radiation**

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Discussion Group 2
Legal & Policy Issues
Of using Lunar Resources and Infrastructure

Moon Village Stakeholders

INITIAL MISSIONS

- States:
  - Space Faring States
  - Emerging Space States
  - States w/o Space Capabilities
- International Organizations (i.e. United Nations)
- Private Industry
- Scientific Institutions

\+

ESTABLISHED MISSIONS

- Private actors (investors, billionaires)
- Non-profit organizations
- Unions & Associations

Existing Legal Framework

- Outer Space Treaty
  - Moon shall be exclusively peaceful.
  - Space activities shall be carried out for the benefit and interests of all countries.
  - Outer space is not subject to national appropriation.
  - States shall retain jurisdiction and control over their space objects.
- The Moon Treaty
  - Similar to OST but specific to the Moon - Ratified by 11 states. Language prevented success.
    - E.X. Moon is common heritage of mankind && Dictates an international regime
- Space Liability Convention - OST
  - Must prove fault - including intention.
  - States shall be responsible for national space activities (govt & non-govt). States shall be liable for damage caused by their space objects. States shall avoid harmful contamination of space and celestial bodies.
- Notable Mentions:
  - Astronaut Rescue Agreement - mentioned in OST
  - Scientific & Future Generations Protection (OST & MT)

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Potential Conflicts & Pitfalls

Existing legal framework provides a basis, but has flaws and are up for interpretation which could lead to negative conflicts in the future Moon Village.

- General Conflicts
    - Non-physical attacks - cyberattacks, jamming, etc.
    - Physical attacks
    - Technological espionage
    - Infrastructure Claim/Ownership (Race to, Stealing of, Rights to resources)
- State vs State Conflicts
    - Shared versus exclusive benefits (space faring vs non-space)
    - Political conflicts - Spillover from Earth conflicts.
- Other Pitfalls:
    - Private actors' responsibility is vague under the law.

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Potential Options

1. International Judicial Body
    a. Pros: Neutral body. Cons: International bodies have failed. States prefer to work directly with other states. Conclusion: Ideal in theory. Difficult to enforce/provide incentives in practice.
2. First Come, First Serve
    a. Pros: Initial States set the precedence. Cons: Initial States set the precedence. Conclusion: Absence of established Moon Village. Most likely to create conflict.
3. Initial State Alliances & Stakeholder Agreements
    a. Pros: Establish stakeholder limitations & assignments to prevent Lunar monopoly. Cons: Consensus is difficult. May not benefit or harm excluded Stakeholders. Conclusion: Good if done well. Most likely to occur with exclusions.

Other:

- Create a model similar to the IMF (International Monetary Fund) Model: Central fun ensure mutual benefits (i.e. Tax the profits coming from the Moon) to increase spac access inclusion.

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MVA Recommendation

Focus: Collaborative Resource Utilization & Infrastructure Protection

MVA should be the forum for stakeholders to proactively set the initial guidelines for Option 3. Initial State Alliances & Stakeholder Agreements and prevent the con of exclusions by ensuring the MVA forum is open to all.

- Begin the group on researching the existing international collaborative platforms. Analyzing what has been successful, what has been unsuccessful, and improving upon the existing systems for future Lunar Missions. Such as:
    - Analyzing the International Space Station (ISS) as a model for collaboration and infrastructure/resource division.
    - Analyzing the International Monetary Fund (IMF) as a model to promote incl across stakeholders.

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Thank You to MVA, Moderators, & SMEs!

Moderator: Molly Silk

Subject Matter Experts:

- Mark Sundahl - Cleveland Marshall College of Law
- Chris Johnson - Secure World Foundation Space Law Advisor
- Stephanie Wan - I. M. Systems Group Inc. (IMSG) The George Washington University

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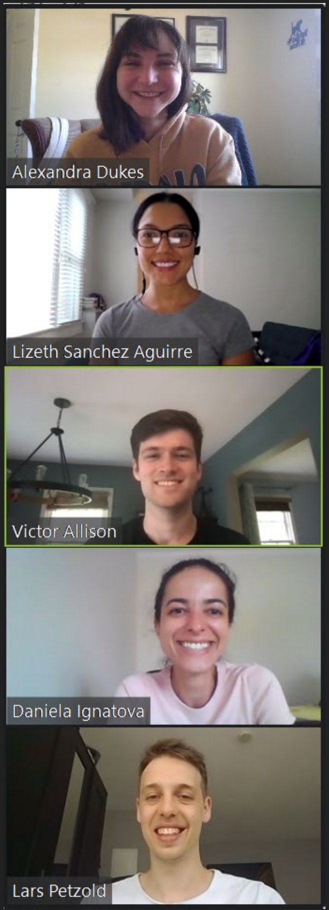
Discussion Group 2: Legal & Policy



Denver, CO, U.S.
Software Engineer, Lockheed Martin Space.

United States/Mexico

Law Student

Lexington, Kentucky, U.S.

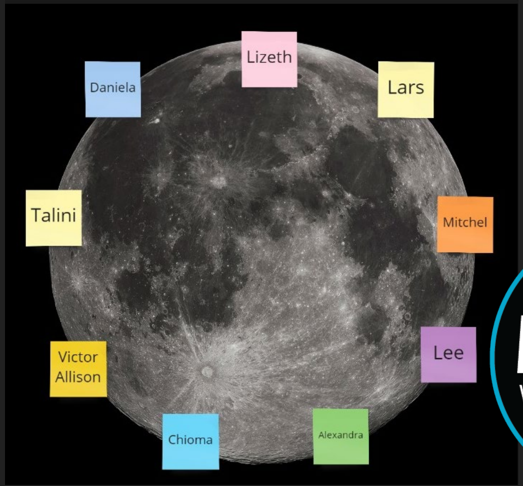
Senior at Vanderbilt University

Luxembourg/ Bulgaria

Political Scientists, Space Entrepreneur

Cologne, Germany
Student of Political Science and Student Assistant at German Aerospace Center

Other Team Members:
Chioma Ezeigbo
Itzel Rocillo
Lee Simonds
Talini Pinto Jayawardena
& others.



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Discussion Group 3: Entrepreneurship towards a Lunar Economy

Innovation Craters

Entrepreneurship towards a Lunar Economy!

Hackathon

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Team 1

Arun Radhakrishnan

Nidhi V

Team 2

Stefano Brunelli

Alice Pais de Castro

Alessio

Team 3

Gracio Joyal Lobo

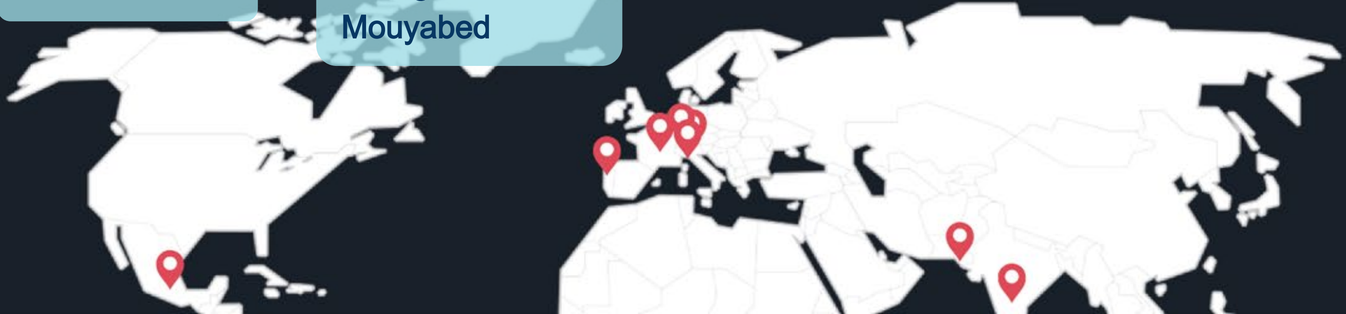
Mario Ortega Pérez

Muhammad Rayan Khan

Moderators

Kaori Becerril

Georges-Antoni Mouyabed



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Checkpoints

Subject Matter Experts

Chantelle Dubois

Avionics & Software Systems Engineer

Canadian Space Agency

Carlos Mariscal

Computer Engineering and CEO

Dereum Labs

Jenna Tiwana

European Business Development and Partnerships Officer

Ispace Inc.

Derek Webber

Co-Chair of the Working Group on LCE of MVA.

Former Vice-Chair of the Judging Panel for the Google Lunar XPRIZE

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Presentation Day

Jury

Nadeem Gabbani

Director and Principal Engineer at Exobotics

Andrea Jaime

Institutional Business Developer at Isar Aerospace

Charlotte Neyret-Gigot

European Development Director chez Thales Alenia Space

Manny Shar

Head of Analytics at BryceTech

Timothy Cichan

Space Exploration Architect at Lockheed Martin

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Presentation Day

Evaluation

Category 1

Jury Selection

Category 2

Popular Choice

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ISRU Challenge

Team 1

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INNOVATION CRATERS

TEAM 1: InSitu Resource Utilisation

NIDHI & ARUN

THE PROBLEM: HOW do WE setup a recurring logistics network to initiate an Interplanetary economy

How it is a problem?

The amount of fuel that is required to make an interplanetary mission makes no economic incentive

Root cause of the problem.

The volume and useable mass is limited. This prevents launch vehicles and satellites from fully generating useful revenue since much of the additional propellant is dead weight. Additional mass carried will prevent useful payload being loaded and increase cost thereby negating access to space.

What is the purpose of solving this problem?

The purpose is to establish the seeds of a cis lunar economy. Exploration always requires an economic incentive. Current technologies are unfeasible economically towards initiating a cislunar logistics network.

Why is it critical that we solve this problem?

There will be no interplanetary exploration and access to space will be constrained. Kesler Syndrome and Crowding of LEO

To enable stakeholders to facilitate political and economic development.

To provide economic incentives that lay groundwork for an cislunar economy, to establish a long term presence with the moon, and gateway to Deep Space Exploration

To create new technologies that use sustainable fuels and to make insitu resource utilization viable.

THE IDEA

The context of the idea

The creation of a propellant processing depot that breaks down the lunar regolith into components such as hydrogen, oxygen, methane.

The processed lunar soil can be sintered to allow for creation of habitats on the Moon, and also allow for exotic arts that can be sold back to Earth.

Liquid hydrogen, oxygen and methane created can be used for rocket fuel that would allow for return missions and long term deep space exploration.

Elements of the idea

In-situ resource Utilisation, electrolysis, cryogenic tanks and management, additive manufacturing, Propellants

Competitive advantage

Lower launch costs from Earth

Economic incentive for launch

High power EP for faster Missions

Bigger and Better Deep space missions

EUREKA!!

How does our idea work?

Moon is the stepping stone for Mars

Ideal locations mapped on the moon rich in water ice →	Lander and ISRU Plant setup. →	Processed regolith is sent towards additive manufacturing. ↓
Processed Regolith is used to make exotic stuff, and can be sent back to earth, rest can be used to make habitats.	← Part of the processed fuel is converted for propellent and ascent vehicle can transfer this to gateway. This is the main product	← O2, H2 extracted is recombined to form methane, water and liquid H2 and O2.

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THE SOLUTION

1. The customer initiates a request for propellant: For ex: NASA
2. The team analyses the mission parameters and optimizes the solution
3. Algorithms ensure best price to performance
4. Customer Space vehicle reaches the Moon and refuels, proceeds to Deep space.
5. Exotic moon art is sent back on Space vehicle.
6. Processed regolith used for habitat construction is sold and credited
7. Moon art sold generates additional revenue.

The Business Plan

Identify all stakeholder and conduct survey on technologies, TRL advancing

Standardize hardware and software interfaces, initiate legal discussions for multilateral treaties.

2025

Send In-situ plant to Moon

Setup supply chain for regolith process and transfer

2030

Orbital depot in operation, Orbital refueling will enable DEEP SPACE MISSIONS

Additional regolith used to create habitats

2035

Customer sends rocket, receives fuel and artwork

TRL Maturity, Additional revenue generated to bring down unit cost.

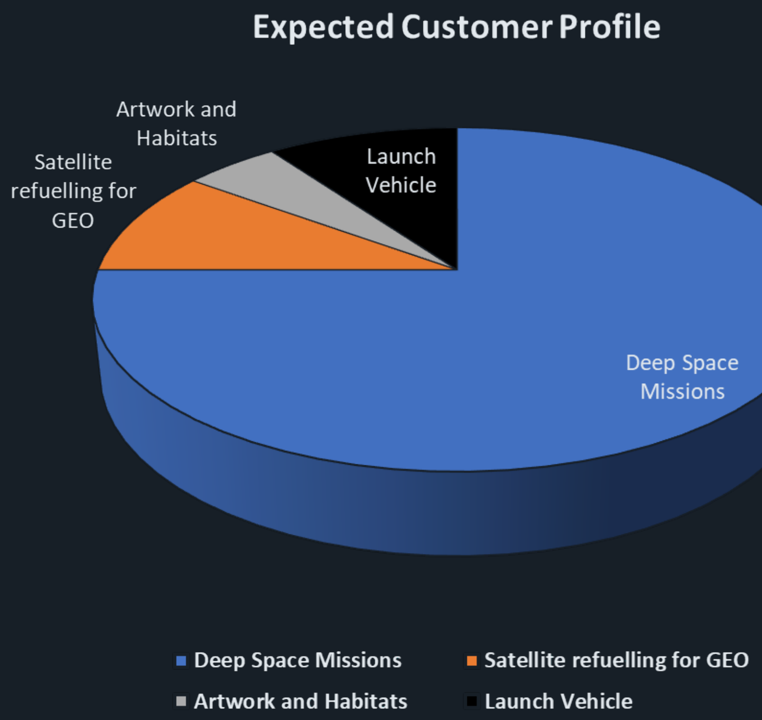
2040

The Value

- NASA requires 650 T of Fuel to Mars for supporting Habitats.
- Space X Falcon Heavy can carry 16.8T to Mars.
- To support, 650 T requirement, it would cost 39 Launches = 5.8 Billion @ $ 150 M per launch
- In-situ plant costs $ 20 Billion in setup & ops, and can generate 350 MT of propellant / Year
- 650 MT requirement for NASA can be sold at $ 5 Billion
- Overall lifecycle, we can generate 13.6 Billion in net profit.
- ROI is expected to be 5.7 Years.
- ISRU plant is expected to work for 12 years with minimal Human interaction.

CUSTOMERS AND MARKET

- Deep space Mission providers
- Satellite refueling providers
- Space Tugs
- Launch vehicle providers
- Satellite operators
- Art Work



Recommendation to Observer organizations

Initiate an in-depth industry consultation to study and map all the stakeholders including academia, Private and Governmental stakeholders

Act as a bridge in ensuring legal and export compliance towards all stakeholders and ensure that innovation is not stifled due to regulatory deficiencies.

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THANK YOU

ISRU Challenge

Team 2

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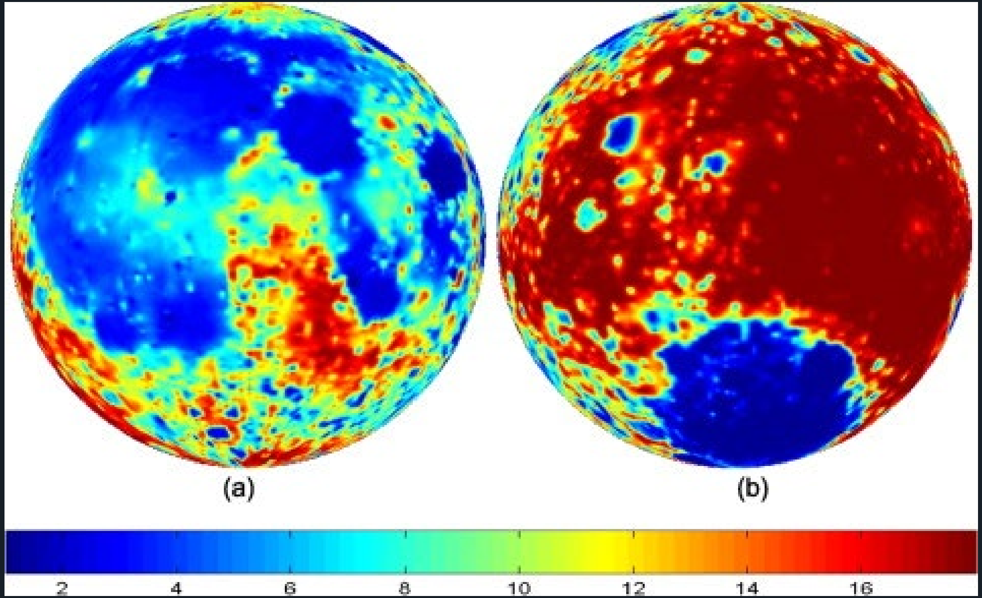
Mining Helium-3 to solve Earth's energy crisis

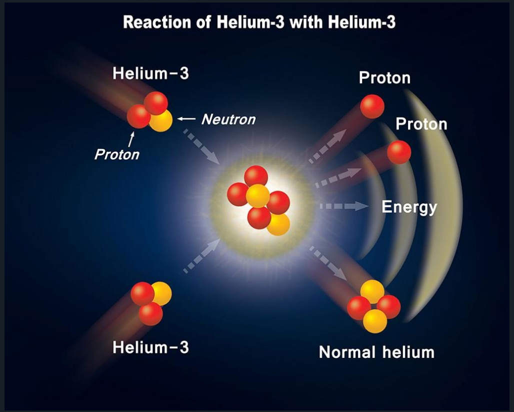
By: Stefano Brunelli, Alice Pais de Castro, Alessio Pedullà

What is Helium-3? (Earth vs Moon)

- Helium-3 is an isotope of helium created by the nuclear reactions in the Sun.
- It does not naturally appear on Earth because its the atmosphere.
- It is most abundant in the poles of the moon



What are the applications of He-3?



- Fusion energy
- MRI scans
- Quantum computers

A world with and without He-3

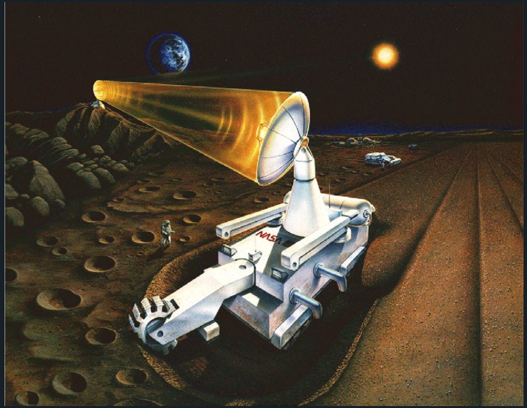
Lack of Helium-3

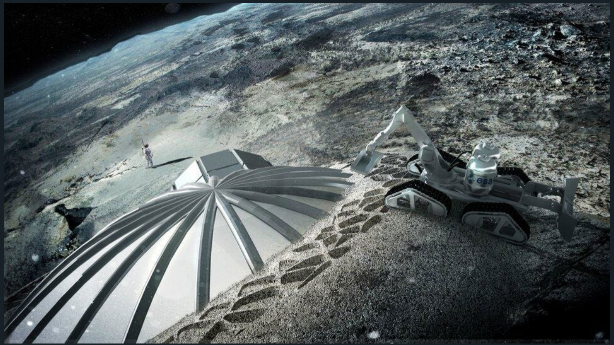
- Difficult to transition away from fossil fuels to clean and sustainable energy
- Traditional forms of renewable energy are inefficient, unreliable, and unsustainable in the long run

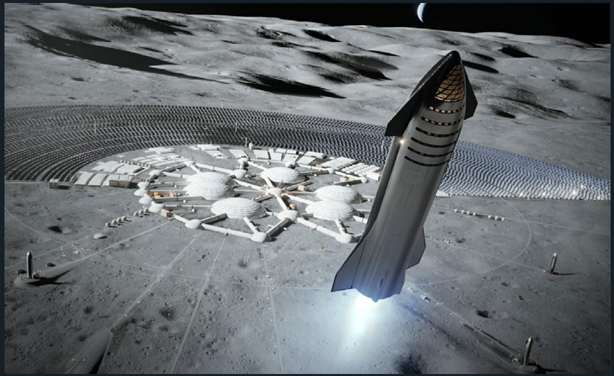
Abundance of Helium-3

- Ability to produce large amounts of clean energy close to areas of high energy demand
- Scalable technology capable of satisfying growing energy demand anywhere in the wrld.

How can He-3 be extracted?

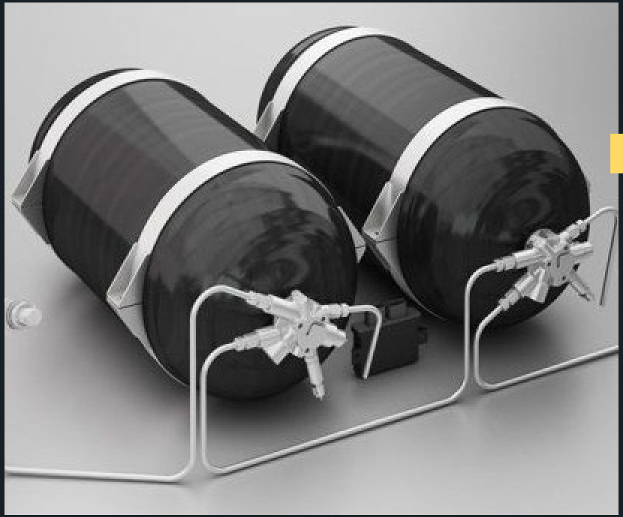




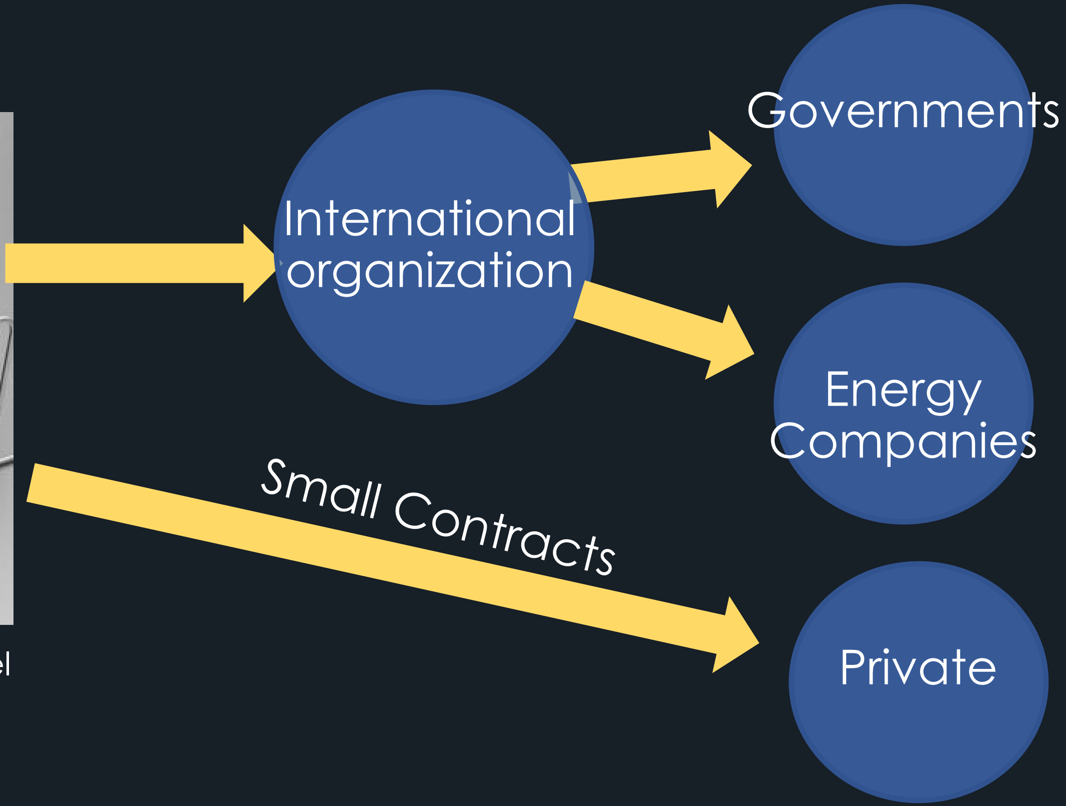


Mine and collect regolith using rover → Process and extract resources → Transport back to Earth

Customers

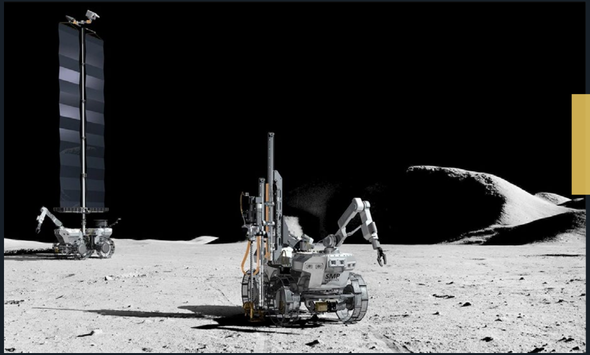


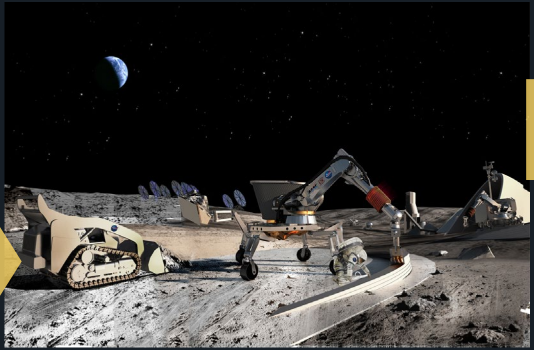
Helium-3 in a standardized pressure vessel

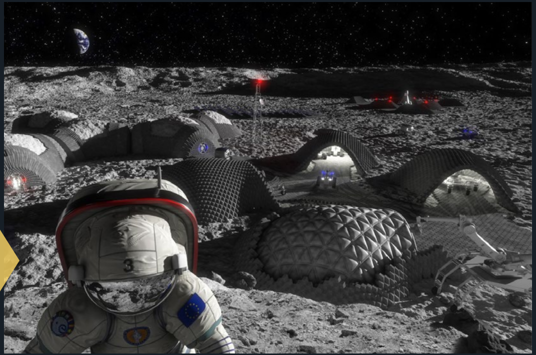


Business Roadmap

"Commercializing the value chain at every step"







2025-2030 Timeframe

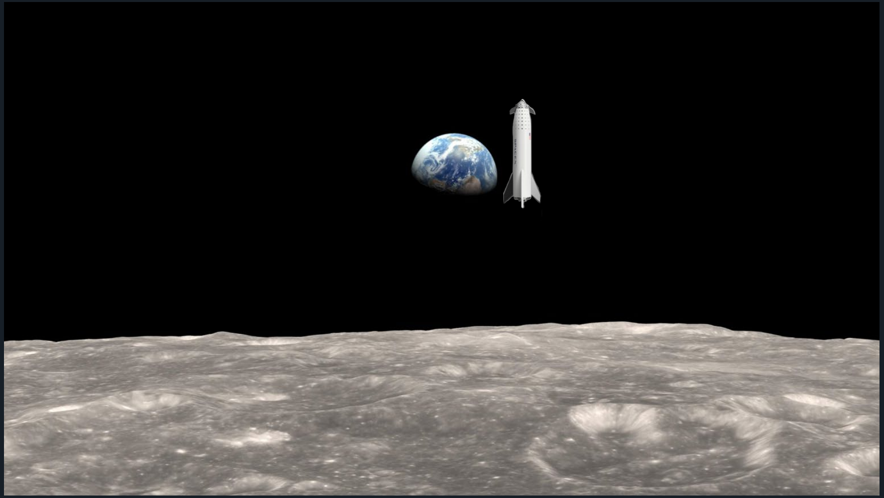
2025 → **2030**

2025

- Test the rover on earth
- Partner with space institutions

2030

- Send rover to the moon and begin mining.
- Bring the unprocessed regolith back to earth to sell



2035-2085 Timeframe

2035

- Build the lunar infrastructure
- Improver rover
- Sell regolith on earth

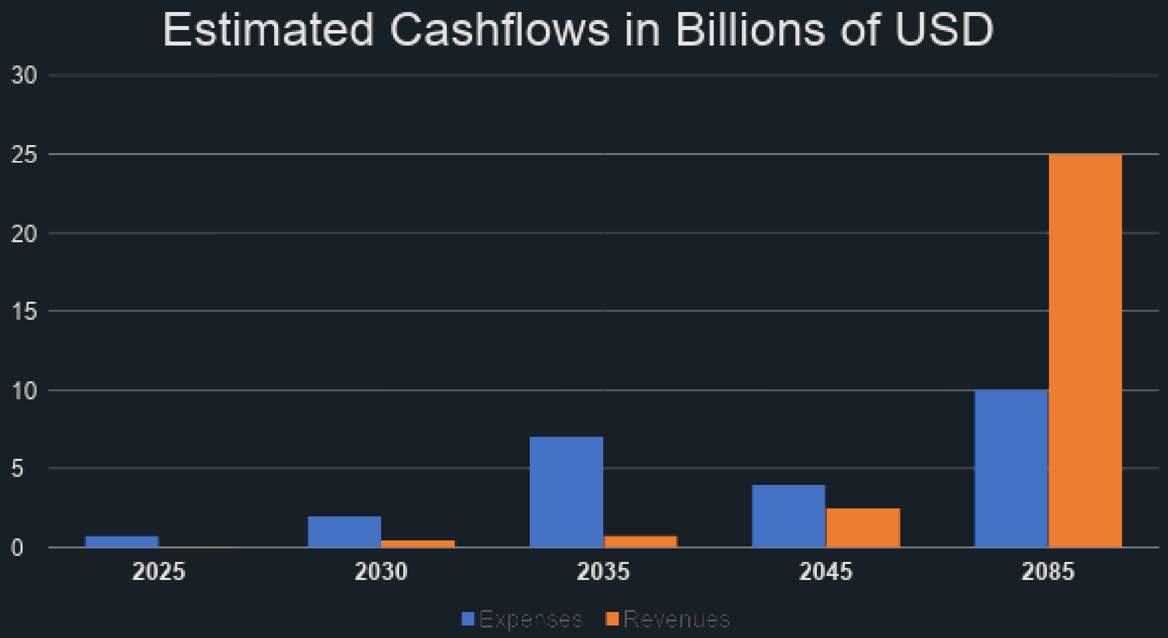
2045

- Extract resources (He-3, H, C) on the moon.
- Sell He-3 on earth
- Sell and use the other resources on the moon

2080

- Increase rover capacity
- Create EoS
- Vertically integrate the value chain

Financial Viability



- Breakeven is estimated to be in 2050

- 220lb (100kg) of He-3 is estimated at a price of $141 Million
- 1 rover can mine about 165lb (75kg) of He-3 per year

Lunar Orbit Challenge

Team 3

MOON
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TOWARDS A LUNAR GENERATION WORKSHOP 2021

Discussion Group 3

INNOVATION CRATERS: TOWARDS A LUNAR ECONOMY

LUNAR CLOUD

Covering all your backup needs on cloud...

Problem

Venezuela’s only telecoms satellite is lost in space


Venezuela's only telecoms satellite is lost in space

By MANUEL RUEDA March 27, 2020

BOGOTA, Colombia (AP) — Venezuela's only telecommunications satellite has veered off its orbit and stopped working, creating a logistical headache for the cash-strapped South American nation.

The Chinese-built satellite was launched among much fanfare in 2008 under the watch of former President Hugo Chavez, who said that the six-ton machine would help to "construct 21st century socialism" and contribute to Venezuela's "independence and sovereignty."

But as Chavez's socialist revolution decays under U.S. sanctions and years of economic mismanagement, the nation's prized satellite is tumbling in space and has become useless three years before its planned expiration date of 2023.

Click to copy

RELATED TOPICS

International News
South America
General News
Latin America

Satellite Traffic

01

By 2030, 100,000 satellites will be orbiting LEO and Geostationary Orbit.

Collision and Failures

02

Possiblility of Kessler Syndrome due to Satellite Traffic.

Loss of Communication

03

Users on earth can't communicate or access data due to satellite collisions.

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Covering all your backup needs on cloud...

Solution

We're providing cloud services over the moon covering all your back-up needs!

01

In case of emergency

Lunar Cloud Emergency Response Center will automatically get activation notice in case of emergency.

02

Loss of satellite

Costumers will get premium access to critical data in case of loss of satellite.

03

Insurance of your data

Providing an insurance to your critical data.

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Market Size

$312 Billion

in 2020

WORLDWIDE PUBLIC CLOUD SERVICES MARKET IN TOTAL

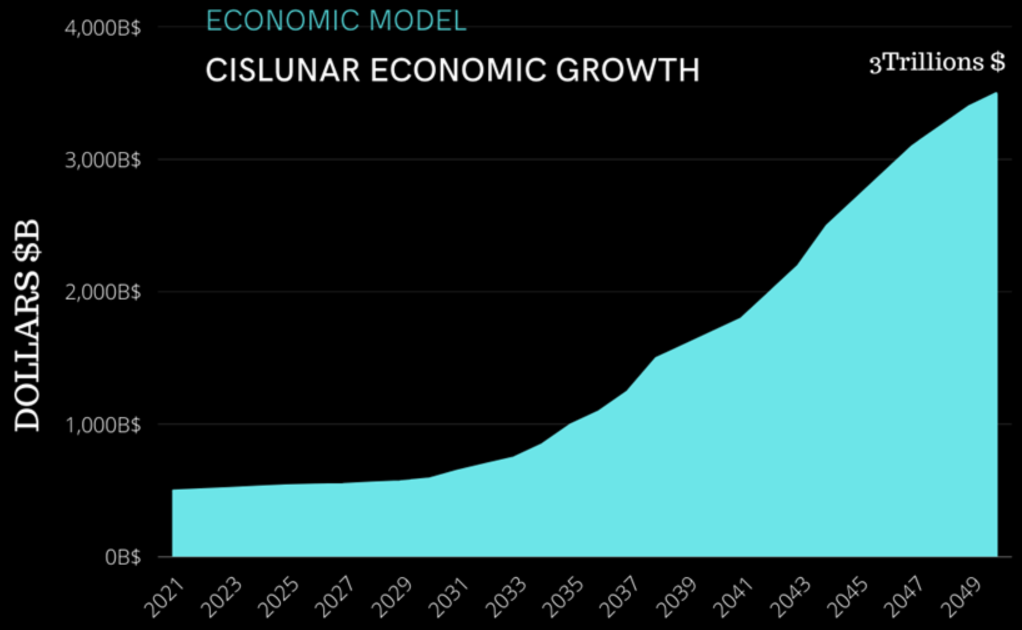
800 Services Provider

MORE THAN 800 SERVICES PROVIDERS IN CLOUD INDUSTRY

35% Growth

in 2020

MARKET CONTINUES TO GROW EVERY YEAR



Mercill Lynch:Bank of America (2018).The Space industry will be worth nearly $3 Trillion in 30 Years

USG INVESTMENT OF 20B$ STIMULATES A $3T PER YEAR ECONOMY

LUNAR CLOUD

Covering all your backup needs on cloud...

Business Roadmap

PARTNERS

- INTERNATIONAL SPACE UNIVERSITY (isu)
- esa business incubation centre
- SPACE GENERATION ADVISORY COUNCIL
- UNITED NATIONS Office for Outer Space Affairs UN-SPIDER
- SPACE4SDGS

PRE-SEED FUNDING	SERIES A FUNDING	PRIVATE FUNDING	PRIVATE FUNDING	FUTURE
2021	2025	2030	2035	2050

STAGES

ALPHA PHASE	PHASE 1	PHASE 2	PHASE 3
Develop technology through a collaborative University Network	Provide the Past Back-up of Satellite Data	Provide Real-time Data based on requirement	Provide Predictive Analytics based on requirement

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Who are our Customers?

Satellite Manufacturers

To provide insurance to the satellite manufacturers in-case there is loss of data from a satellite.

Cloud Service Providers

To provide data backup's for the Cloud Service Providers

Research Establishments

To provide insightful predictive analytics of forthcoming scenarios back on Earth.

Why Moon?

CLIMATE CHANGE

Earth will face a lot of Climate-Change phenomenons which will disrupt the current cloud service industry on Earth.

PEACE-BUILDING

Our aim is to resolve injustice in peaceful ways as the Moon is not governed by politics, religion or racial boundaries.

INNOVATION

Inspire next generation to innovate and develop new technologies and come up with business ideas in lunar orbit.

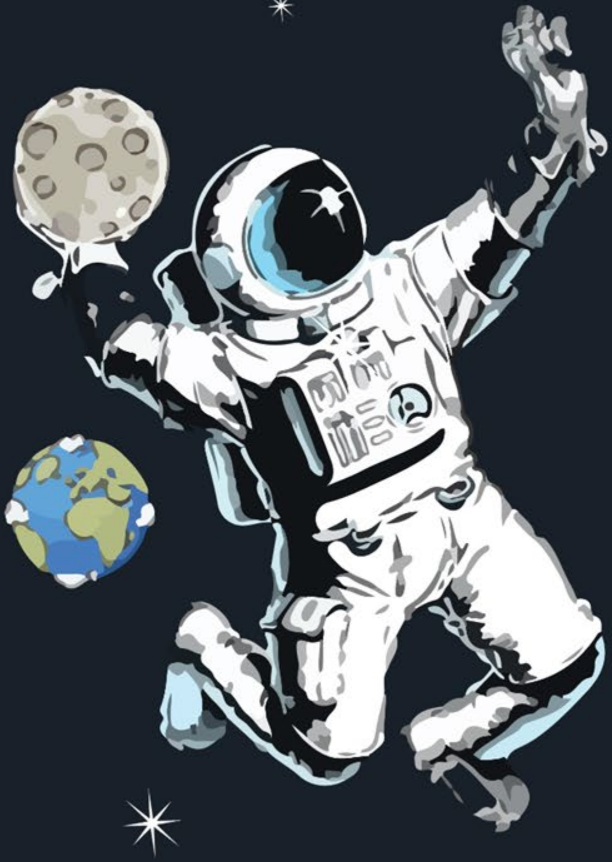
Competitors

Direct Competitors

- Amazon Web Services
- Microsoft Azure
- Google Cloud Platform (GCP)

Indirect Competitors

- Starlink
- Planet Labs
- Digital Globe



Innovation Craters

Entrepreneurship towards a Lunar Economy!

Hackathon

Q&A

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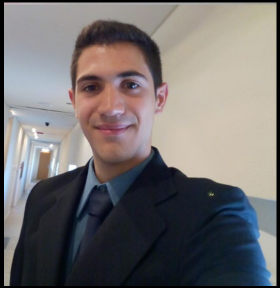
Discussion Group 4: Science on the Moon

Khushi Shah



Alexis Caratozzolo

Adamu Bala

Sahba El-Shawa

Harini Shanika Wijeratne

Hassan Sarfraz

Abhishek Prem

Ruhi Shaik

Gatot Susilo

Robert Jomphe

Steven Barber

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Discussion Group Questions

What scientific objectives can be identify beyond ones stated in the reading materials?

Which scientific objectives should be reached using crewed missions and which using robotic missions?

What scientific objectives require human settlement on the Moon, such as the Moon Village, and why?

What is the role of the Moon in advancing science?

What will scientific activity on the Moon look like in the next 5, 10 and 50 years? What role can the MVA play in this regard?

WHAT? — Science Objectives

HOW? — Humans / Robots Settlement

WHY? — Moon in advancing science

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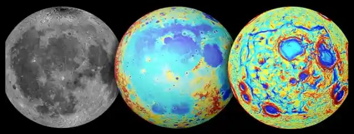
Scientific Objectives

Science of the Moon



- Moon History
- Geology
- Environment Science

Science from the Moon

- Astronomy
- Analogue bases
- Energy production

Science on the Moon

- Biological research
- Environmental research
- Communications

Science for the Moon

- ISRU
- Safety and reliability
- Robotic development

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What are we going to do on the Moon ?

Near Future

- Low gravity and radiation on terrestrial processes
- Advanced regolith processing
- Human psychology and physiology study.
- Study bio sensors
- Studying and testing self-healing materials
- Acoustic levitation

Future

- Exploring cryogenic material storage in PSR
- Wireless modes of energy transfer
- Soft robotics.
- Low-Frequency Radio Astronomy
- Early warning system

Far future

- Influence of biophilia
- Study quantum technology
- Moon as an extraterrestrial launchpad
- Next Gen propulsion system.

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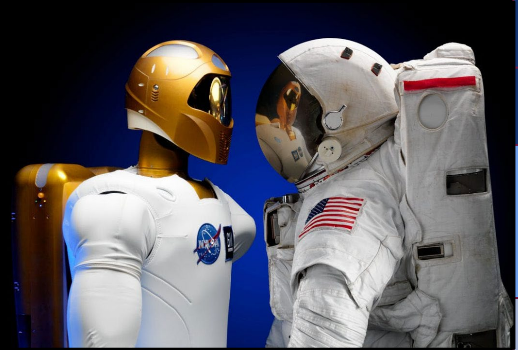
How are we going to do science on the moon?

Robot	
Pros	**Cons**
Surveying and prospecting landing sites	Navigation / obstacle avoidance
For maintenance purposes	Not self-repairable
Long and repetitive work periods	Relatively slow
Access Difficult terrain	Harsh environment can reduce life
Dependable + Economical	Teleoperation - latency of 2.5sec (earth to moon)



Credits: NASA's Robonaut 2 squares off with a human astronaut

Humans	
Pros	**Cons**
Adaptability	Vulnerable
Design/next steps	Expensive
Relatively fast general decision making	Prone to error
Quick learners	Small reach
Innovative	Need tools and technology
Multifunctional	Weak (lifting/endurance)

Scientific Objectives that require a Human Settlement on the Moon

- Study of human physiology & psychology for long duration missions.
- Study of plant behaviour in low gravity & experimentation with cell growth & multicellular reproduction.
- Installation of a human observatory on Moon to improve deep space astronomy.
- Outpost for long term crewed service and surveillance of equipment.
- Establishment of research station to reduce transportation costs.
- Preservation of lunar ice cores & regolith cores.
- Establishment of an extraterrestrial launchpad on the Moon.
- Fetching records about history of the Solar System.

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Conclusions

High Priority Objectives

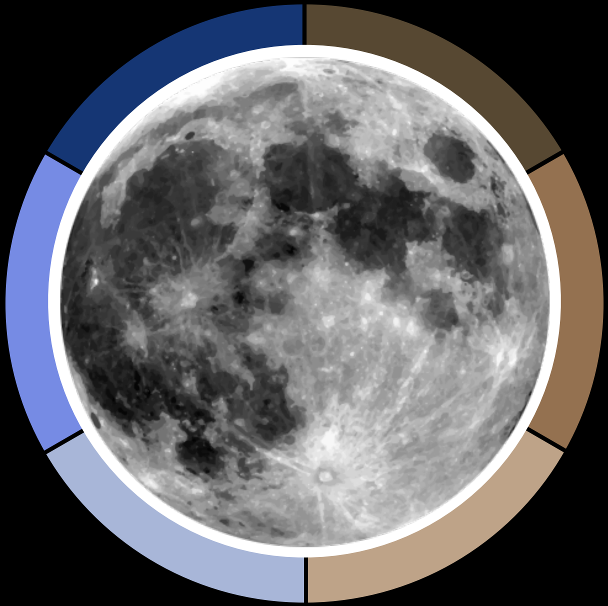
Quantum science/technology
Analogs on Earth and Moon
Moon-Earth ecosystem

Humans ~~vs.~~ *and* Robots

Each has a role to play
Human-robot collaboration

Role of Moon Village

Human physiological research
Sustainable community



International Collaboration

Standardization of interfaces and goals
Safety protocols and regulations

Emerging Space Countries

Build on national priorities
Identify scientific strengths

Role of MVA

Foster international collaboration
Create standardization working group

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Additional Recommendations: Science and Culture

Sustainable Development

Focus on research to understand Earth's changing climate, and technologies that will help us mitigate it and live more sustainably

Indigenous Communities

Involve and respectfully learn from indigenous peoples who have always lived in harmony with their environment for thousands of years

Inclusive Language

Discourage the use of gendered or language with negative connotation
"manned" → human
"colonization" → habitation/expansionism

Accessibility and Outreach

Decouple defense and space, include all countries and people of all backgrounds in space exploration and science

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Discussion Group 5: Technologies for a Sustainable Moon Village

Our Team


Sarah Fox
United States


Sapna Rao
United States


Sneha Manimurugan
Singapore


Nitya Jagadam
India

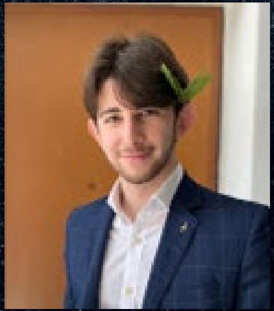

Gagandeep Kaur
India


Keerthi G
India


Luis Zacatelco
Mexico


Jordan Lerner
United States


Marcel Frommelt
Germany


Marco Giugliarelli
Italy


Bintang ASWAM
Indonesia

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Subject Matter Experts and Moderators

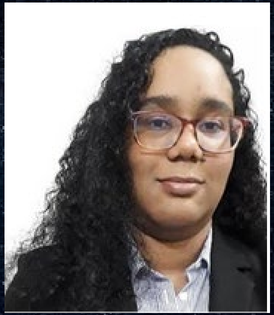
Kathleen Coderre
Lockheed Martin

John C Mankins
Moon Village Association

Chantelle Dubois
Canadian Space Agency

Koorosh Araghi
NASA

Jorge Rubén Casir Ricaño
Moon Village Association



Ariann Duncan
Moon Village Association

Ali Nasseri
MVA, UBC, SGAC

Overview

- Introduction & Challenges
- The main enabling technologies for operation on the moon
- The role of emerging technologies in the next 5/10/50 years and related TRLs
- Emerging space countries can contribute to the development of those technologies
- Recommendation for Stakeholders (including MVA/SGAC)

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Introduction & Challenges

- Moon Village → contributes to future human settlements on the Moon by emphasizing the **planned**, **potential** and **prospective diverse lunar activities** including science, engineering-technology, policy-law, and economics for the improvement of future human civilization.
- Many challenges arise for establishing a settlement on the Moon, such as technology limitations, international cooperation, and economic feasibility.

Enabling Technologies

Crew Support

The technology needed to keep inhabitants healthy both physically and psychologically

Includes:
- Habitation Systems
- Food production
- Power supply
- Communication with Earth
- Radiation and micrometeoroid protection

Scientific advancement

The technology needed to make scientific progress and perform research

Includes:
- EVA and spacesuits
- Training for future space missions
- Monitors for human health in low gravity
- Lunar Robotics and Rovers
- Regolith Processing System
- Search for potential life

Economic sustainability

The technology needed to make the Moon Village profitable

Includes:
- Lunar ice mining
- Fuel production
- Tourism

TIMELINE VS READINESS LEVEL

	~2026	~2031	~2071
TRL 1-2	Artificial atmosphere, AR, VR	Dust protection, Surviving the lunar night	Tourism, Mining, artificial gravity
TRL 3-4	Material recycling, aeroponics, Luna Net	3D printing, solar power, lab grown meat	Surface habitat, ISRU,spacesuit design
TRL 5-6	Nuclear Fission, Hydroponic Farming	Complete Autonomous Vehicles, Nanotechnology	Regolith processing, Nuclear fusion, inflatables for lunar re-entry
TRL 7-8	Reusable Lunar Landers, GPS	Geotechnical analysis, seismic detection	Evacuation rooms, sensors
TRL 9	Robotics and Rovers	Radiation/solar flare protection	Navigation, communication network

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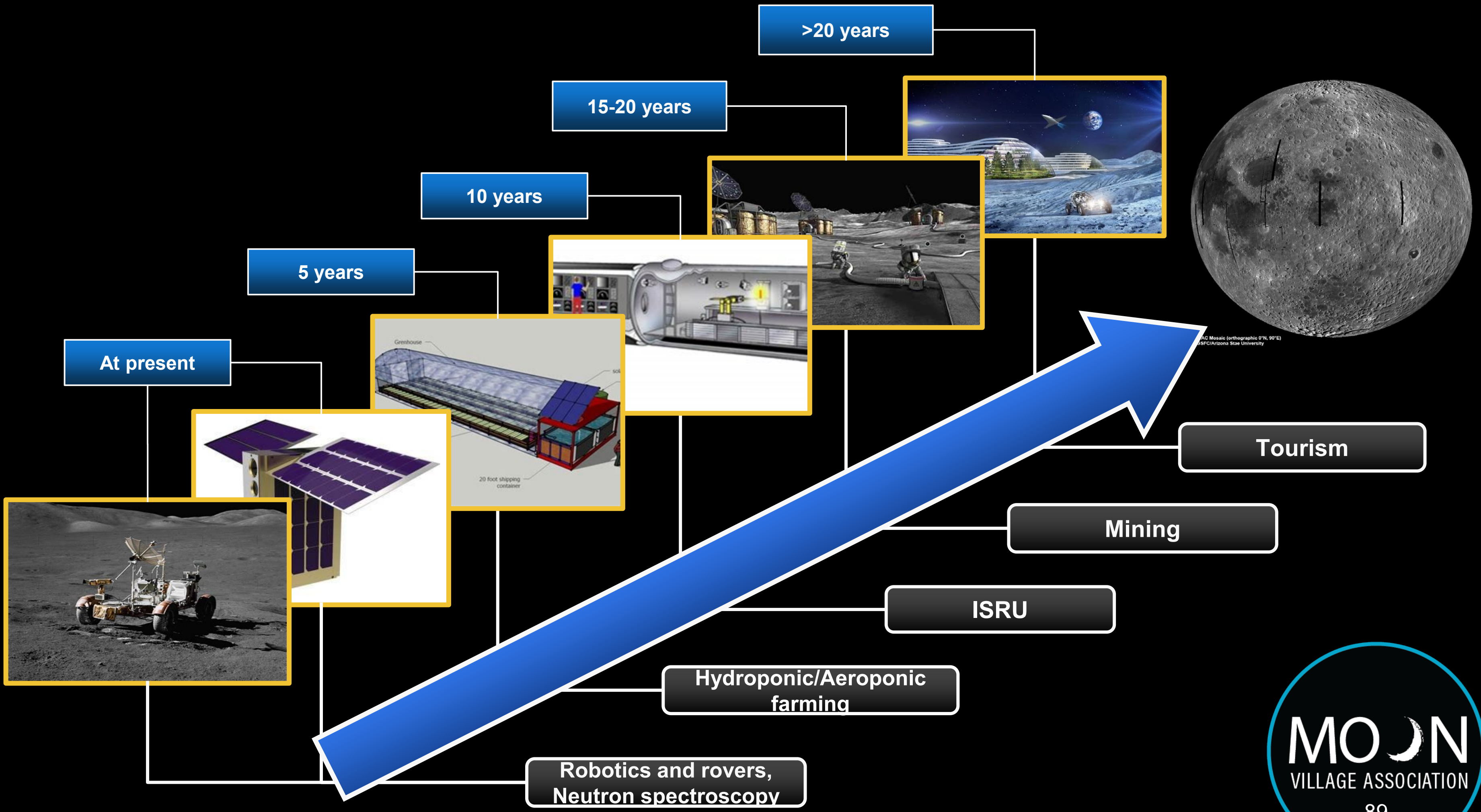

Image credit:
https://photojournal.jpl.nasa.gov/jpeg/PIA13516.jpg

Contribution by Emerging Countries

Near-term (tactical):

ride-share/piggy-back

More strategical
(time scale: 20-30 years)

Various players needed for Moon village.
Emerging space countries could specialize,
-develop academic programs,
-Longer-term framework for education.

Technology Maturation:

Moon itself will become testbed (once regular transport ensured)

Just like with **cube sats** today, it might become sensible to just send hardware there and test it in place.

⇒ No expensive test infrastructure on Earth needed!
Good opportunity for emerging space countries!

Time

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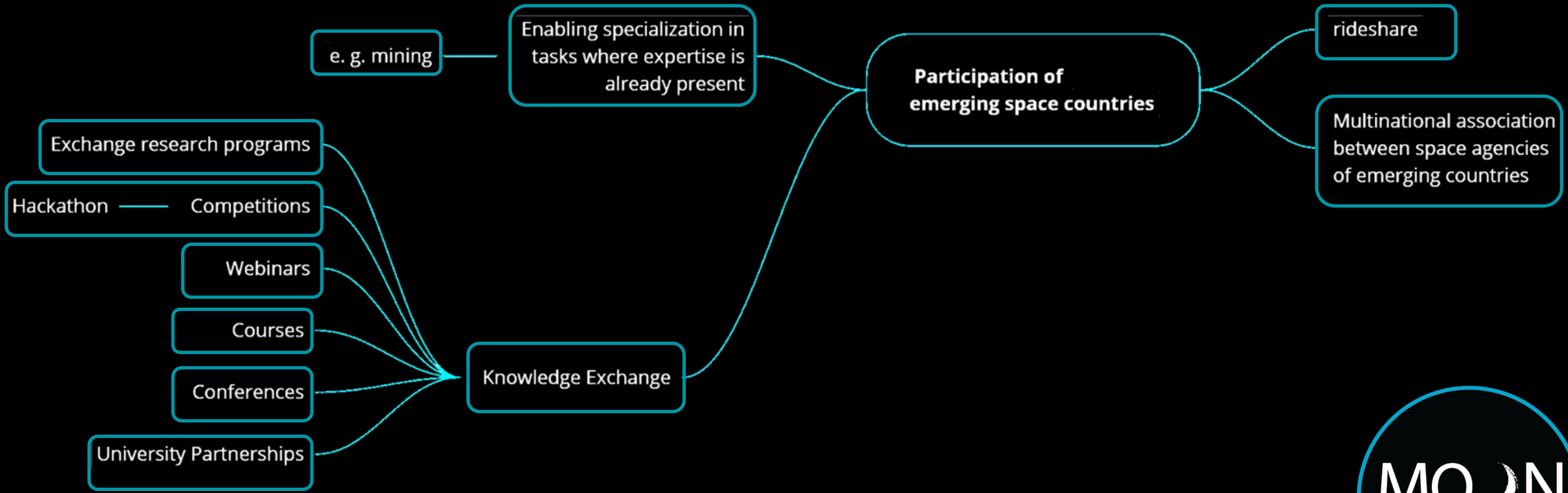
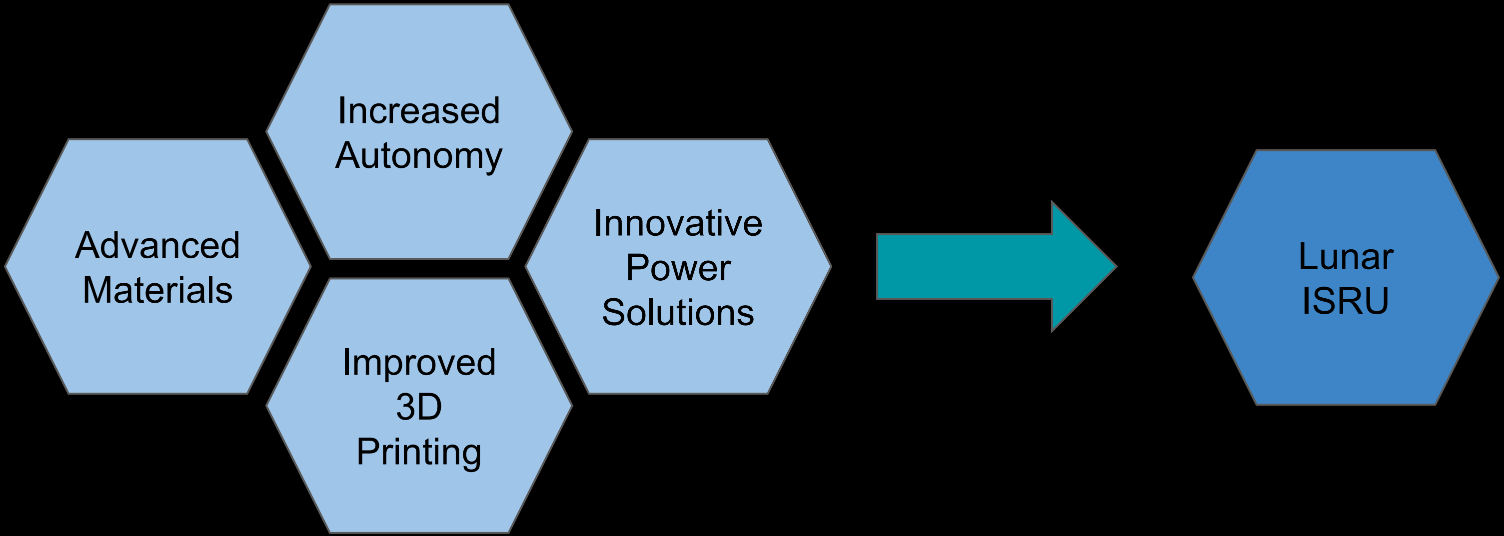
Contribution by Emerging Countries



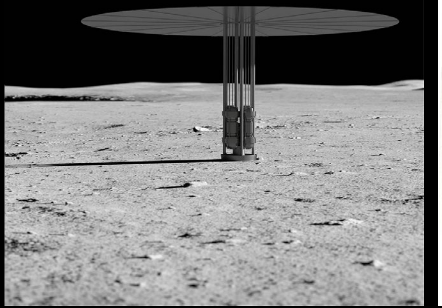
Sustainability

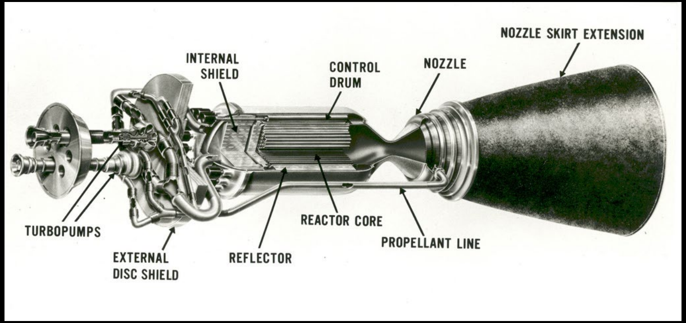


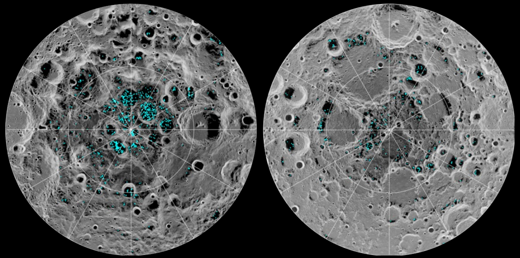
Enabling Technologies

Recommendation for Stakeholders (including MVA/SGAC) in general

Start developing Enabling Technologies for ISRU such as Nuclear Surface Power and Cryo storage







Images courtesy of NASA.gov

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Recommendation for Stakeholders (including MVA/SGAC) in particular

01 EDUCATIONAL

- Working groups (in the form of workshop and interactive-engaging discussion) on current space issues
- Internship/apprenticeship opportunities to youth space enthusiast
- Exchange research program meanwhile the research project should be focused on resolving the current barriers in the sub-topics of lunar or mars mission.

02 COMPETITIONS

- Hackathons/ competitions aligned to current space topics, e.g. data
- startup competitions for non space focused countries
- Poster/Video competitions to showcase their ideas

03 OTHERS

- Country Specific Activities
- International partnerships focused on outsource
- build research centers in non-space countries to help in different topics
- Organise space conferences including space community development within smaller regions of the world (eg. Asia etc)

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Thank you for making TLG2021 possible!

Towards a Lunar Generation Workshops to continue!

- Bi-monthly half to one day workshops
- Next topics will be
  - Role of Emerging Space Countries
  - Science Communication and the Role of the Arts
  - Equity, Diversity and Inclusion in the Moon Village
- Stay tuned for more information!

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