

Architecture and Energy Systems for Moon and Mars Settlements



Applications for Earth



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India Smart Grid Forum, India Smart Utility Week
March 2nd, 2023
Lalit Hotel, New Delhi





India SMART UTILITY Week 2023

28 February - 04 March 2023

The Lalit Hotel, New Delhi

ORGANIZER



ISUW 2023

9th Edition of
India Smart Utility Week
An International Conference
& Exhibition on
Smart Energy & Smart Mobility

www.isuw.in

28 February 2023

Tuesday

Special Workshops
& Master Classes

01 March 2023

Wednesday

Conference &
Exhibition

02 March 2023

Thursday

Conference &
Exhibition

03 March 2023

Friday

Conference &
Exhibition

04 March 2023

Saturday

Technical Tours,
Demonstrations &
Cultural Tours

ISGF INNOVATION AWARDS : 03 MARCH 2023

SUPPORTED BY



नीति आयोग

Ministry of Environment, Forest and Climate Change



Ministry of External Affairs
Government of India



Ministry of Electronics &
Information Technology
Government of India



Ministry of Jal Shakti
Government of India



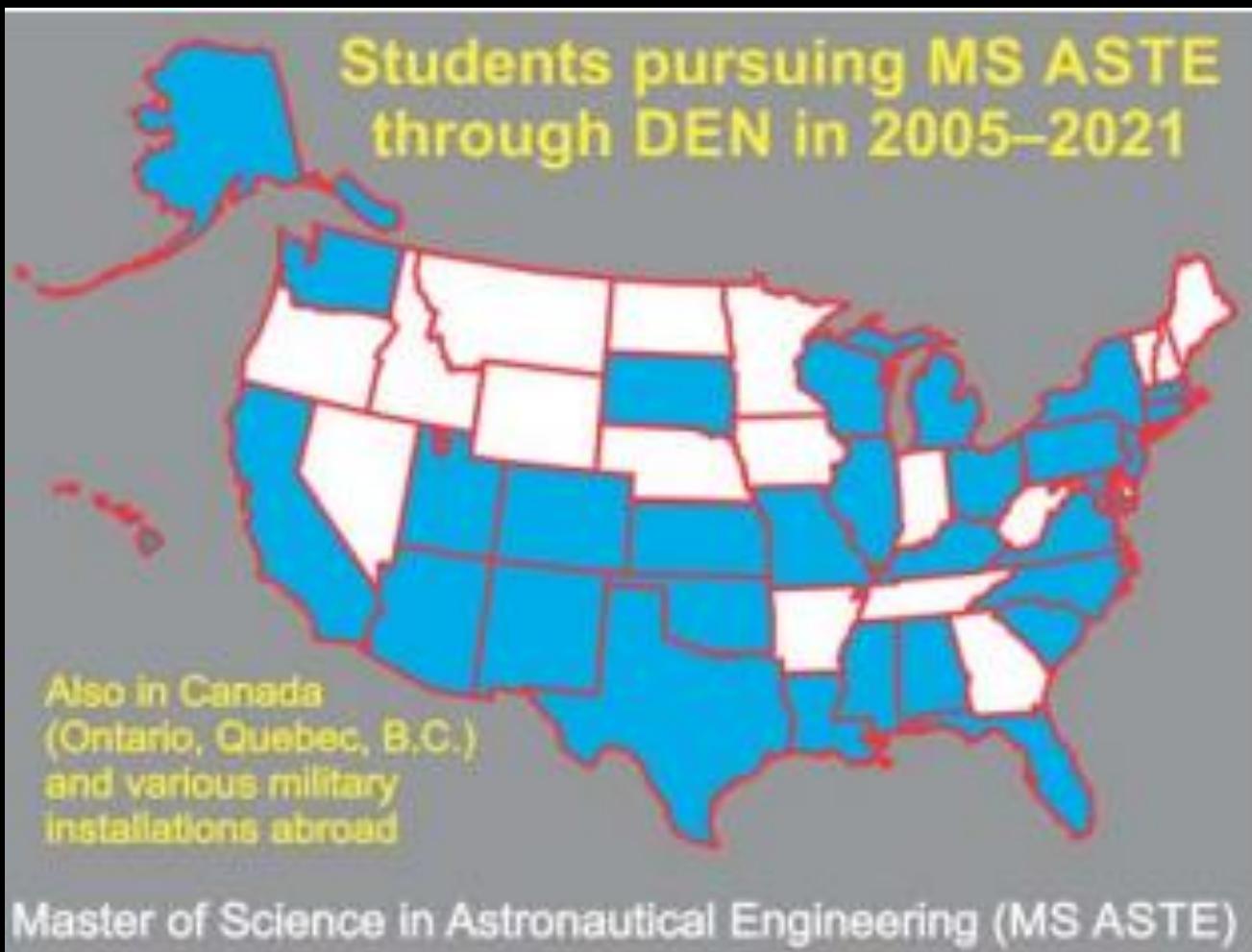
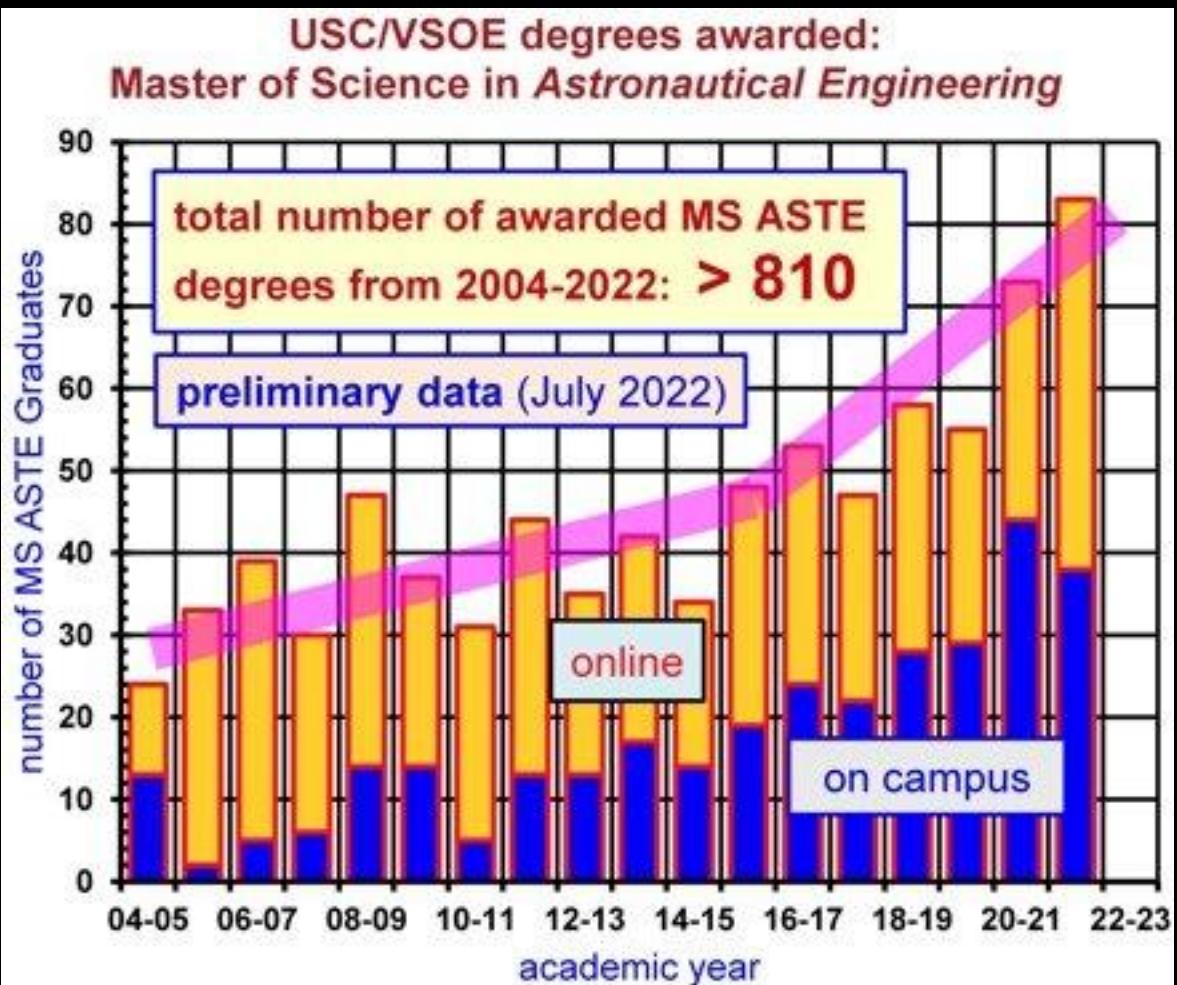
MINISTRY OF POWER
GOVERNMENT OF INDIA

CENTRAL ELECTRICITY AUTHORITY



Ministry of Environment, Forest and Climate Change

USC ASTE Astronautical Engineering



USC ASTE527 Studio

- 3-Unit graduate class
- **Focus on Imagination & Creativity**
- Concept Creation - Rapid Visual Representation
- Originality
- Academia – Independent of Agency or Industry

USC ASTE 527 Site [ASTE 527 \(google.com\)](#)

- Several Lunar Concepts
- 2018-2021 ADAM, MAXIM, TWINS, CHASE
- Public Appeal: PLANET MOON !
- [ASTE 527 \(google.com\)](#)



[1999 - The Exploration of Mars: Crew Surface Activities \(PDF\)](#)

[2004 - Hercules - Human Earth Moon Rover Competition To Upgrade Lunar Exploration Vehicles](#)

[2008 - Return to the Moon - Looking Glass 204](#)

[2009 - Evolution of ISS Part 1](#)

[2010 - Evolution of ISS Part 2](#)

[2011 - The US Department of Space](#)

[2012 - Cosmic Synergy - Administration-Enterprise Alliance](#)

[2012 - ASTE 527 Midterm Presentations](#)

[2013 - Eden Shield - Concept and Strategies for Planetary Defense](#)

[2014 - Tipping Point - The Future of Astronaut Activity and Human Spaceflight](#)

[2015 - LunaRevolution - Role of the Moon in the Future of Human Space Activity](#)

[2016 - SeleneOption : High Fidelity Simulations and Analogs on the Moon](#)

[2017 - Renaissance - Commercial Space & The Promise of Self-Sustaining Human Space Activity](#)

[2018 - ADAM](#)

[2019 - USC ARTEMIS: MAXIM](#)

[2020 - ARTEMIS: TWINS](#)

[2021 - CHASE :Commercial Human Spaceflight Expeditions](#)

[PLANET MOON](#)

[Miscellaneous](#)



USC

USC Astronautical Engineering, Viterbi School



USC Architecture School – Space Architecture

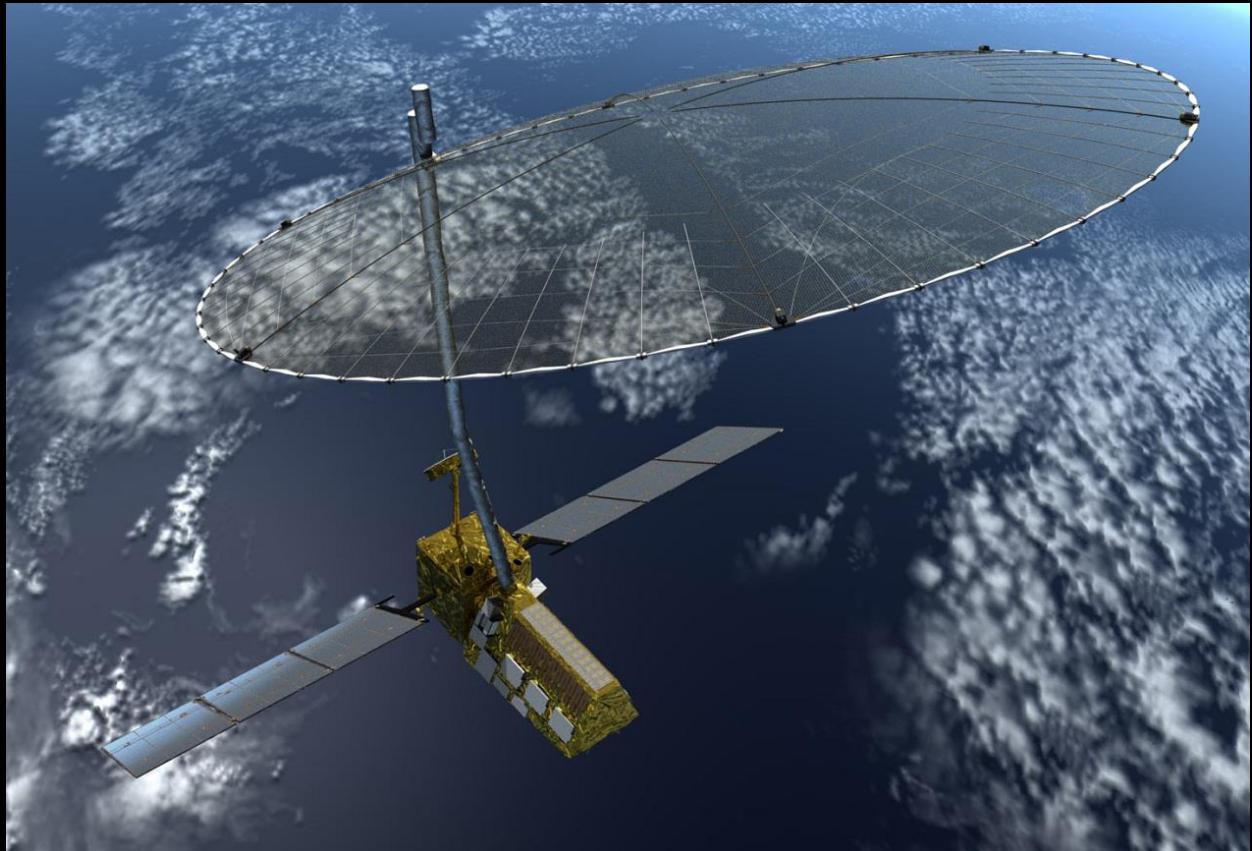


Space Technology for Smart City Utility

- Net Zero Clean Energy – Hydroelectric & Gravity, Solar, Wind, Tidal, Geothermal, Nuclear
- Potable Water – Reuse and Recycle, H₂+O₂ Fuel Cell by product
- Air Revitalization – ECLSS, CO₂ scrubbers, PM2.5 filters
- Food Growth Chamber – pesticide free, hydro/aquaponics LED
- Broadband Comm – Laser links – Remote Education - YouTube
- Robotics – Transportation and Logistics, Artificial Intelligence
- Underground Infrastructure – Utilities, Factories, Habitation
- Health and Hygiene - Telemedicine
- Waste Products – Reduce, Reuse, Recycle
- Satellites – Earth Observation, Climate Change, Weather, Agriculture, Emergency Alerts
- UN Sustainability Goals & India PMO

NASA India Relations

- NASA India Synthetic Aperture Radar – NISAR
- Human Spaceflight Collaboration
- US State Department



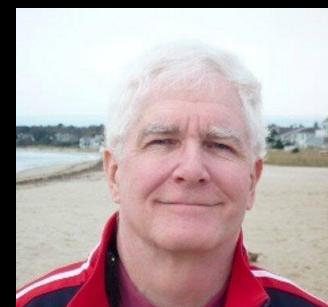
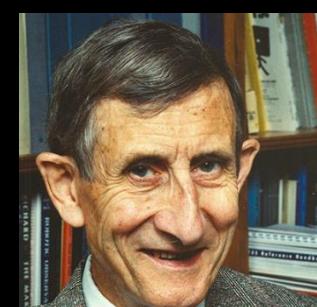
Himalayas and Climate Change

- Monsoons
- Rivers – Lifeblood of Civilization
- India, Pakistan, China, Nepal, Bhutan, Bangladesh
- Floods- Reservoirs, Hydroelectric Projects
- Foothill Regions in India affected
- Himachal, Uttarakhand - Joshimath
- Lithium Deposits
- Kerala & Tamil Nadu



New Space Paradigms

- Elon Musk - Settle other planets –human survival insurance
- Jeff Bezos - Protect and make Earth beautiful
- John Marburger III - Economic sphere of influence
- Joseph Campbell - Return of the Hero
- Freeman Dyson - Beautify our Universe
- Frank White - Overview Effect
- Michelle Hanlon - Preservation of Species Cultural Heritage
- ?



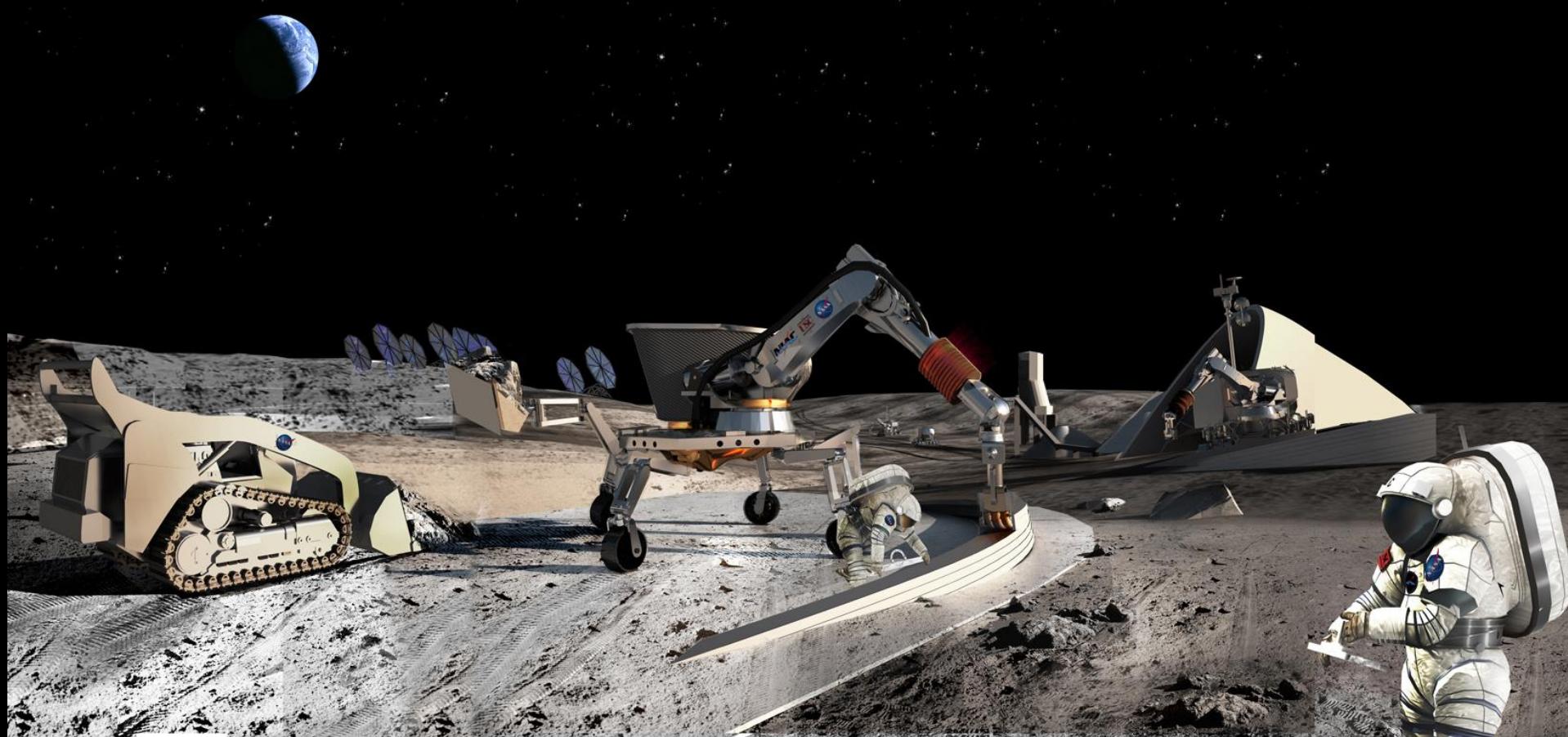
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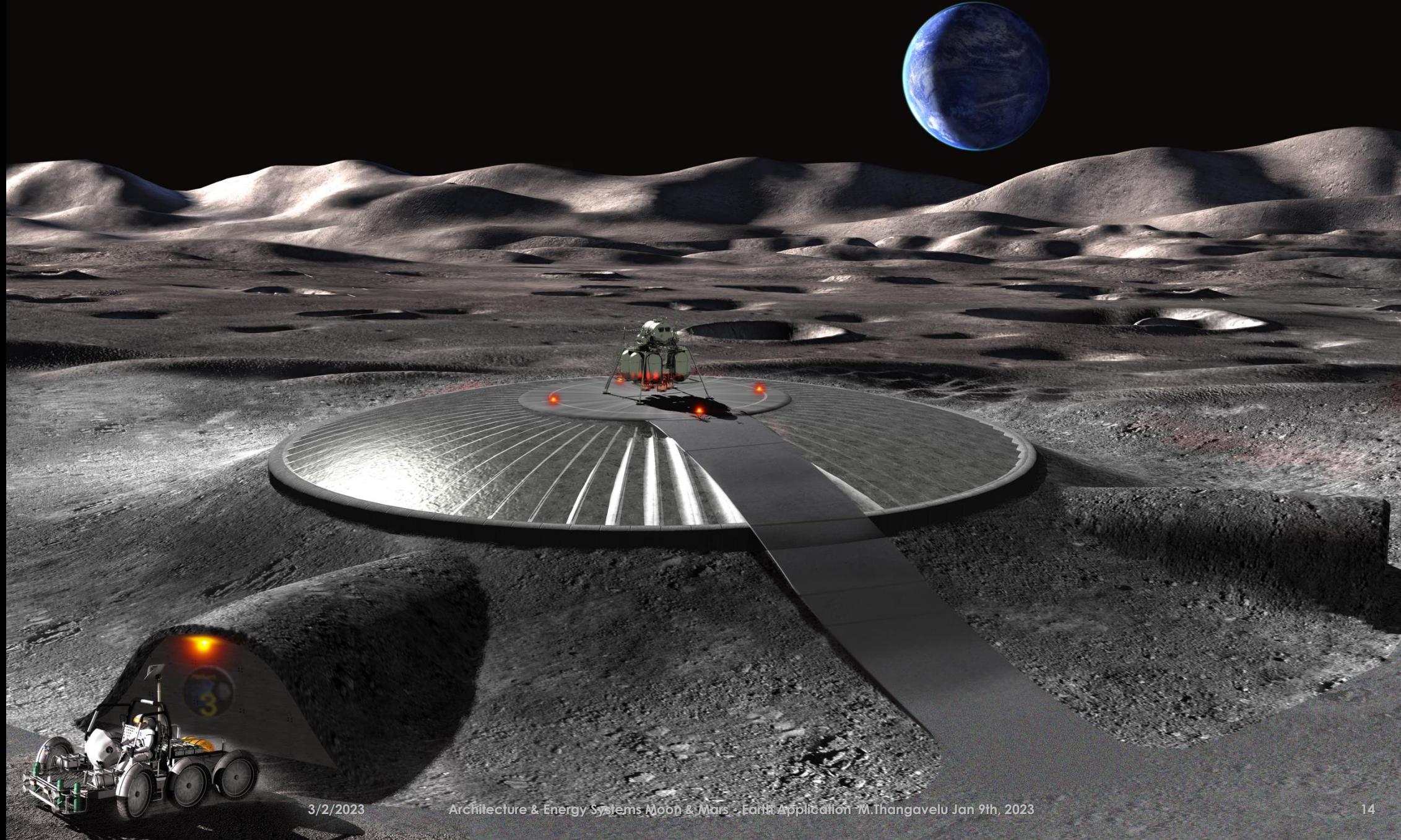
Space Philosophy for Earth -Vasudhaiva Kutumbakam

- Space Philosophy is Whole Earth Philosophy
- Cosmopolitanism
- Holistic Approach and Interdisciplinary

- C-19 Experience
- E Pluribus Unum
- Kant

Robotic Construction





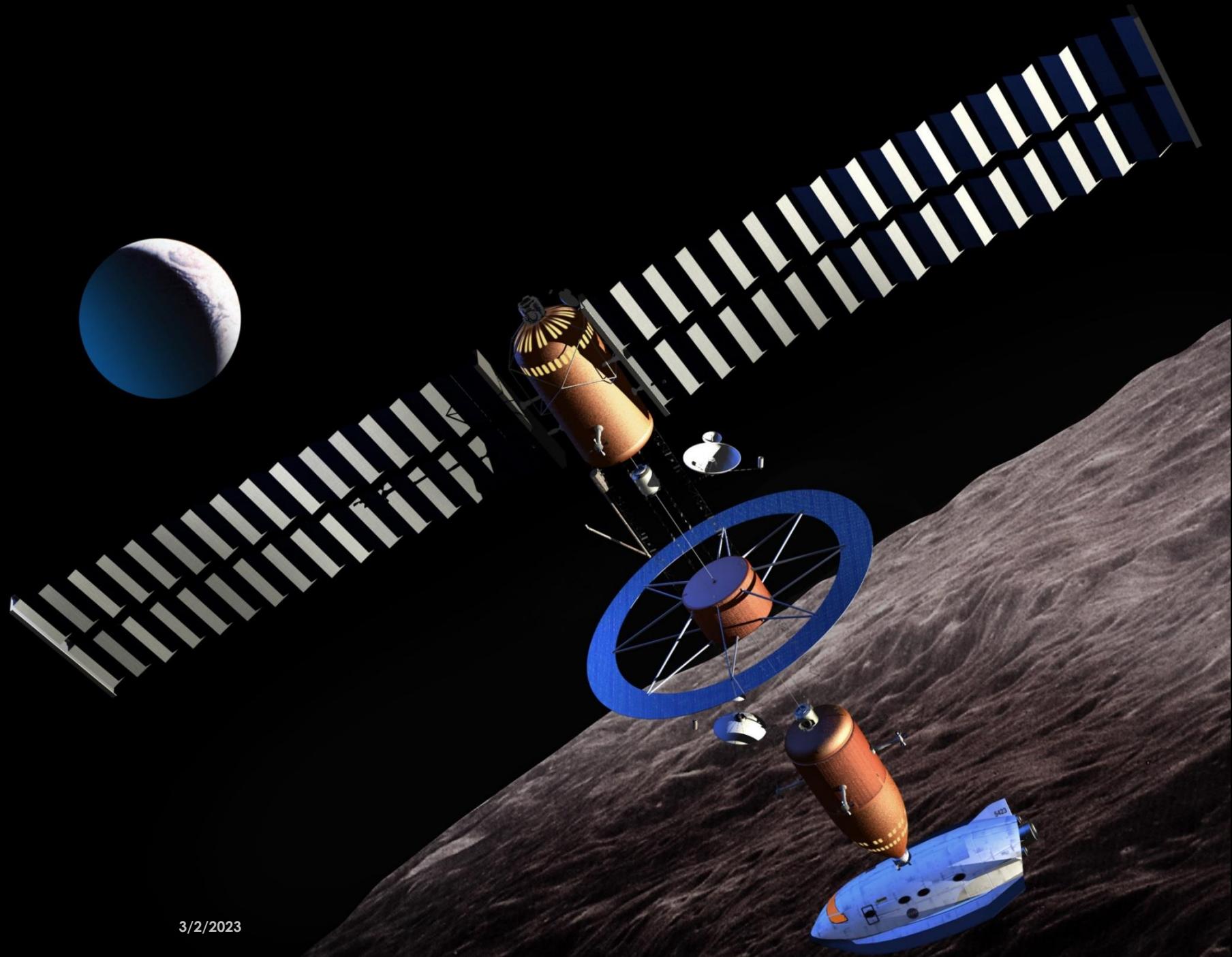
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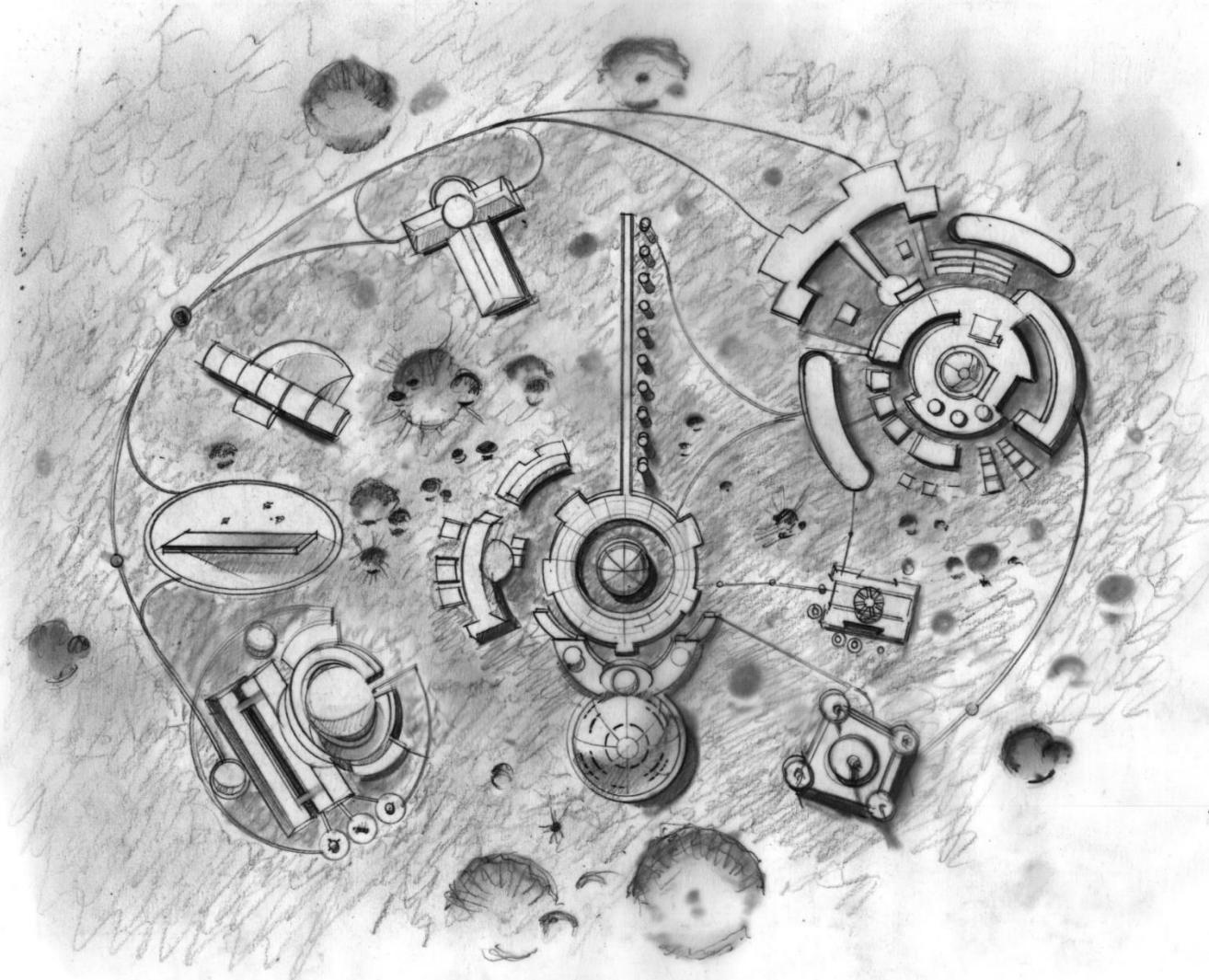
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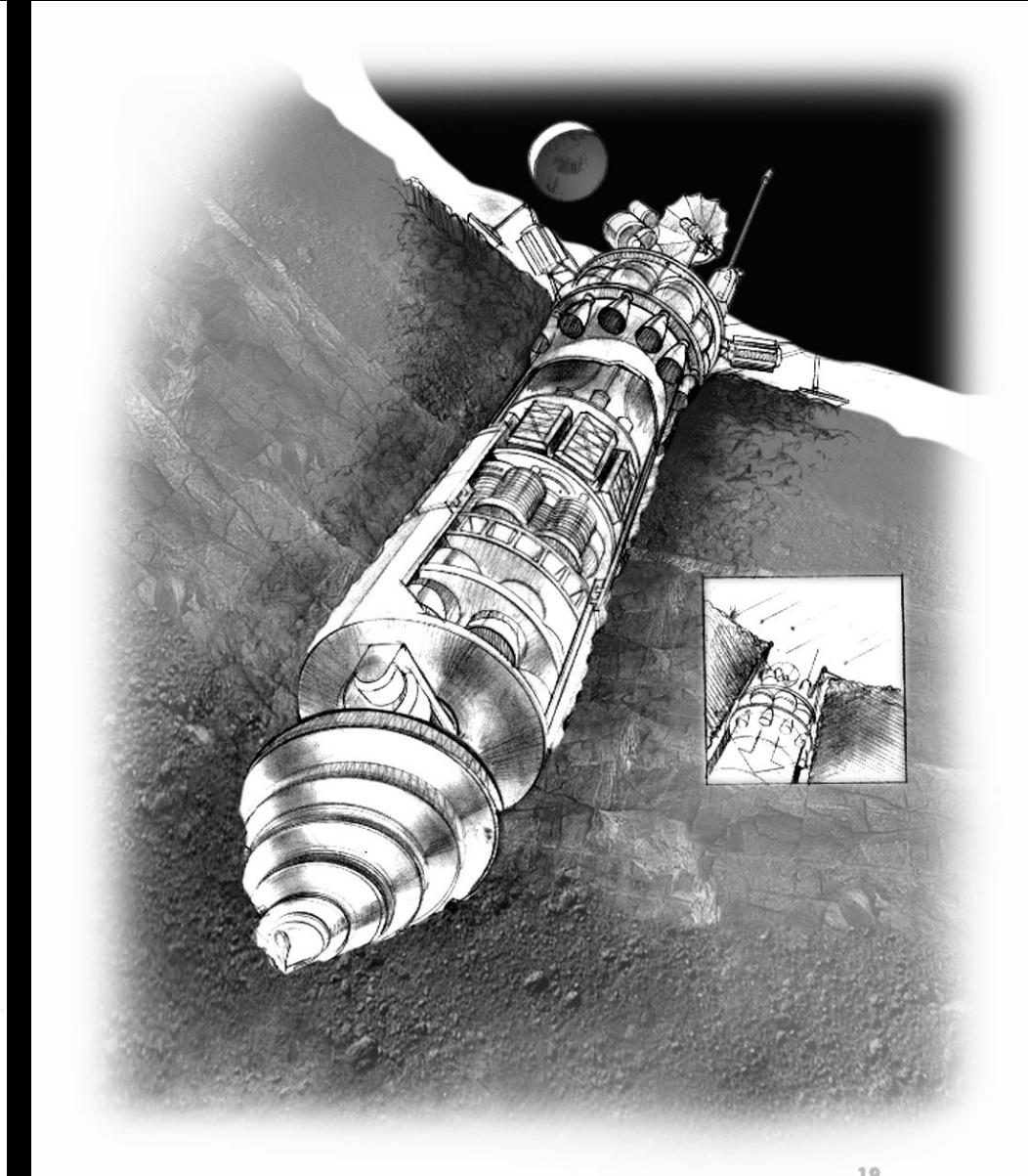
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Lunar UN Summit Hq. & Humanities Nexus



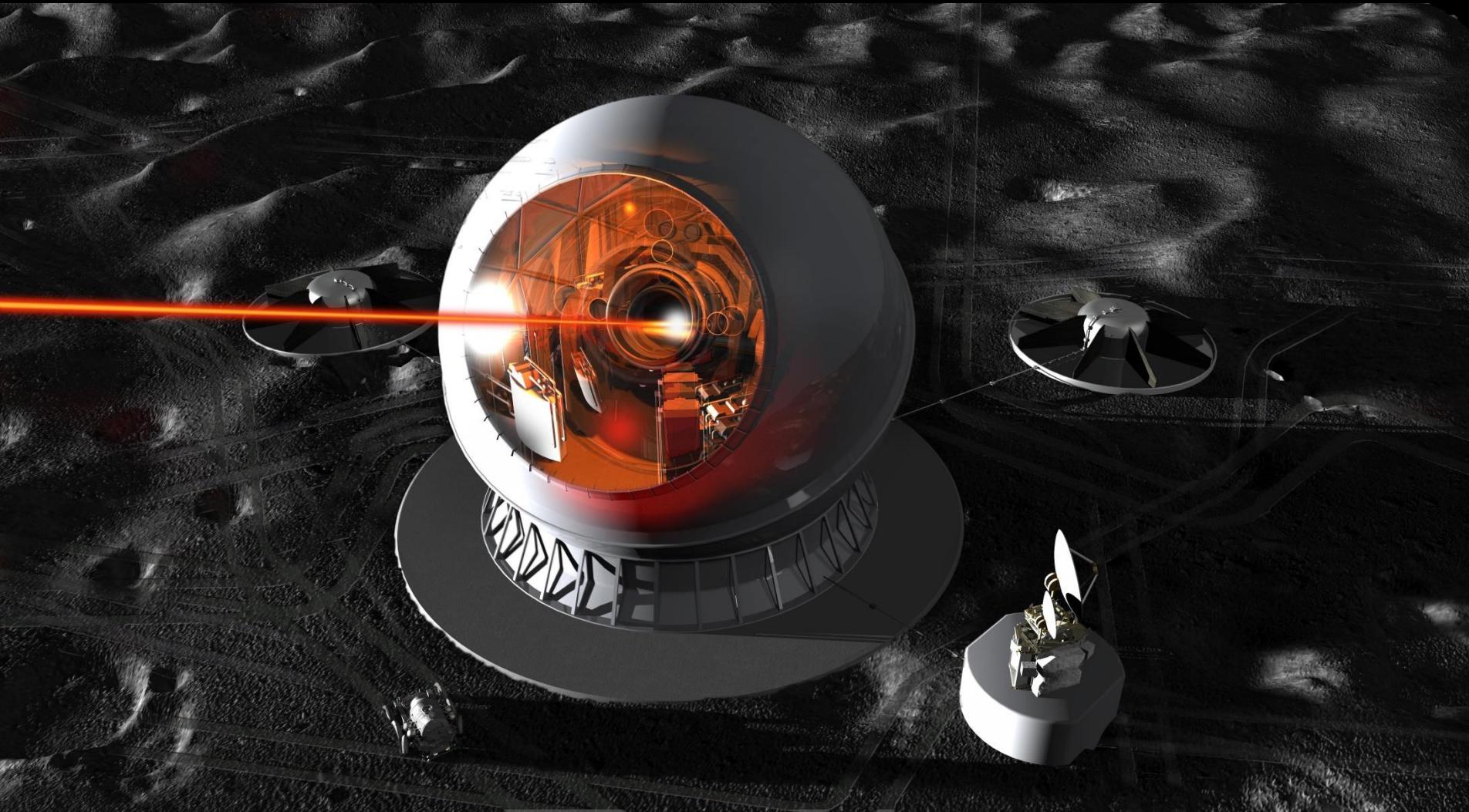
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Lunar High Energy Laser(HEL)



We create and shape our surroundings.
Thereafter, our surroundings shape and steer us.

- Measure twice....
- Simulations
- Pilots
- Evolution, much less Revolution in complex systems

Space Technology Refines and Redefines

- Efficiency
- Safety
- Responsible Use of Energy and Material Resources
- Global Unity

PMO Vision

- Make In India
- One World, One Family, One Future – Vasudhaiva Kudumbakam
- E Pluribus Unum
- Sankara – Tat Tvam Asi

USC Architecture + Engineering

- USC Astronautics
- Engineering +

Size Comparison of Inner Rocky Planets in Our Solar System – Gravity Matters

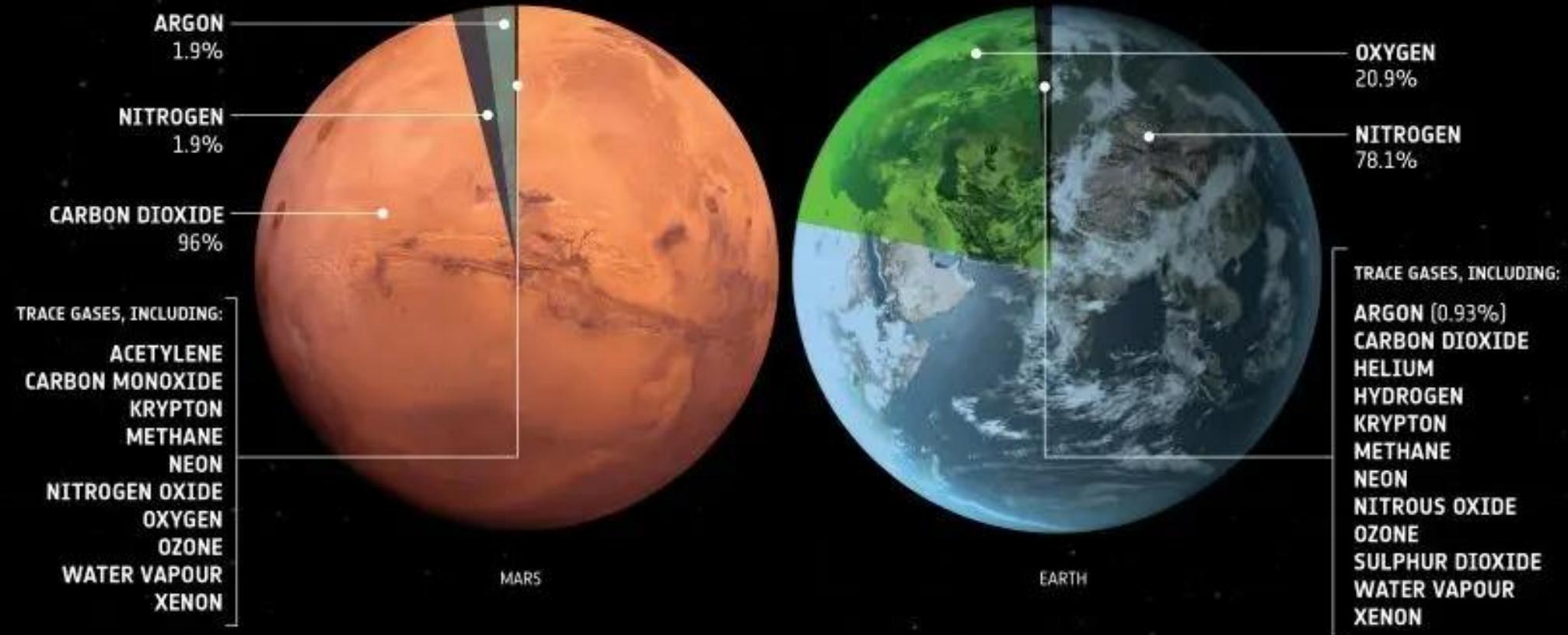


Astronautics v Aerospace Curriculum ?

- Alien Environment
- Space and Extraterrestrial Bodies
- Gravity, Vacuum, Extreme Temperatures, Radiation, micrometeorites..
- Radiative Thermodynamics
- Orbital Dynamics
- Entry Descent and Landing
- Human Factors and Performance
- Human Crew – Safety **OVERRIDING #1 CRITICAL Priority**

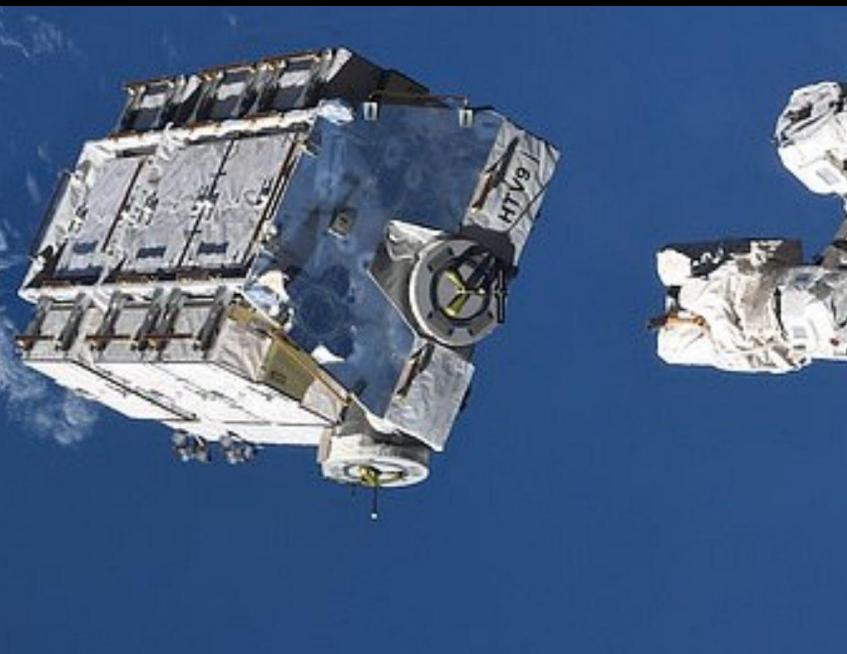
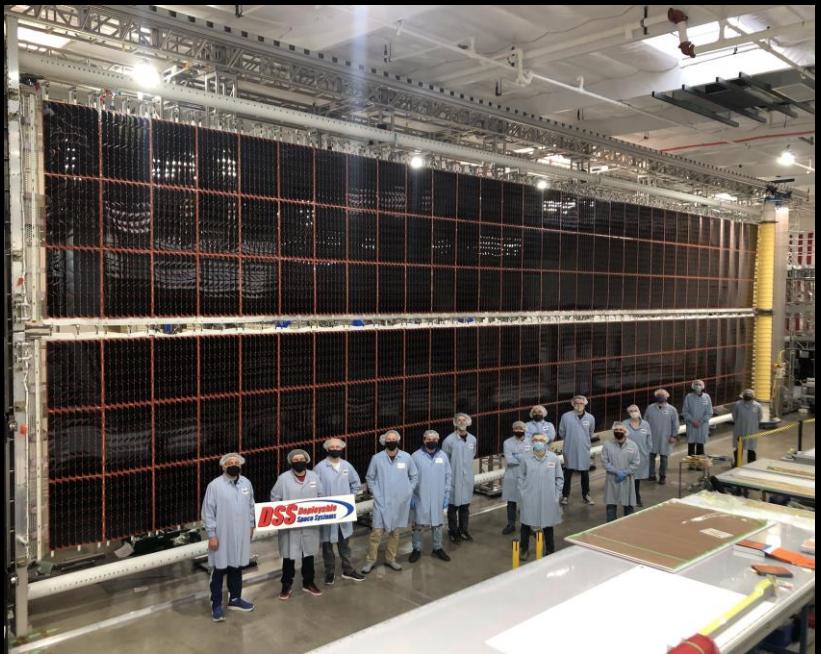
	Gravity (g)	Temperature range (°C)	UV range (nm)	Ionizing radiation dose (average, mGy/year)	Dominant ionizing radiations	Atmosphere (hPa and dominant gases)
Earth	1	-90 to +60	>300	~1	muons, neutrons, electrons	10 ¹³ at sea level (N ₂ , O ₂)
ISS in LEO	0	-160 to +120	>10	~240	electrons, protons	10 ⁻⁵ – 10 ⁻⁵
Moon	0.16	-180 to +130	>10	~100	GCRs, SEPs, neutrons	10 ⁻¹² – 10 ⁻⁸
Mars	0.38	-150 to +30	>190	~90	GCRs, SEPs, neutrons	0.6 – 1.2 (CO ₂ , N ₂ , Ar)

→ COMPARING THE ATMOSPHERES OF MARS AND EARTH



[Atmospheric composition by volume](#) | [Planets not to scale](#) | Atmosphere of Mars is less than 1% of Earth's | Trace gases listed alphabetically

Energy Propulsion & Power

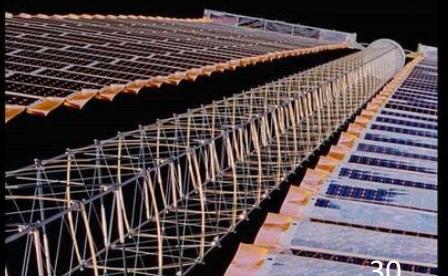


Strengths

- High blanket packaging density, (300 kW/m^3)^{*}
- Efficient structural form (single support beam)

Weaknesses

- Low structural packaging density, (12 kW/m^3)^{*}
- Heavy aluminum canister and truss

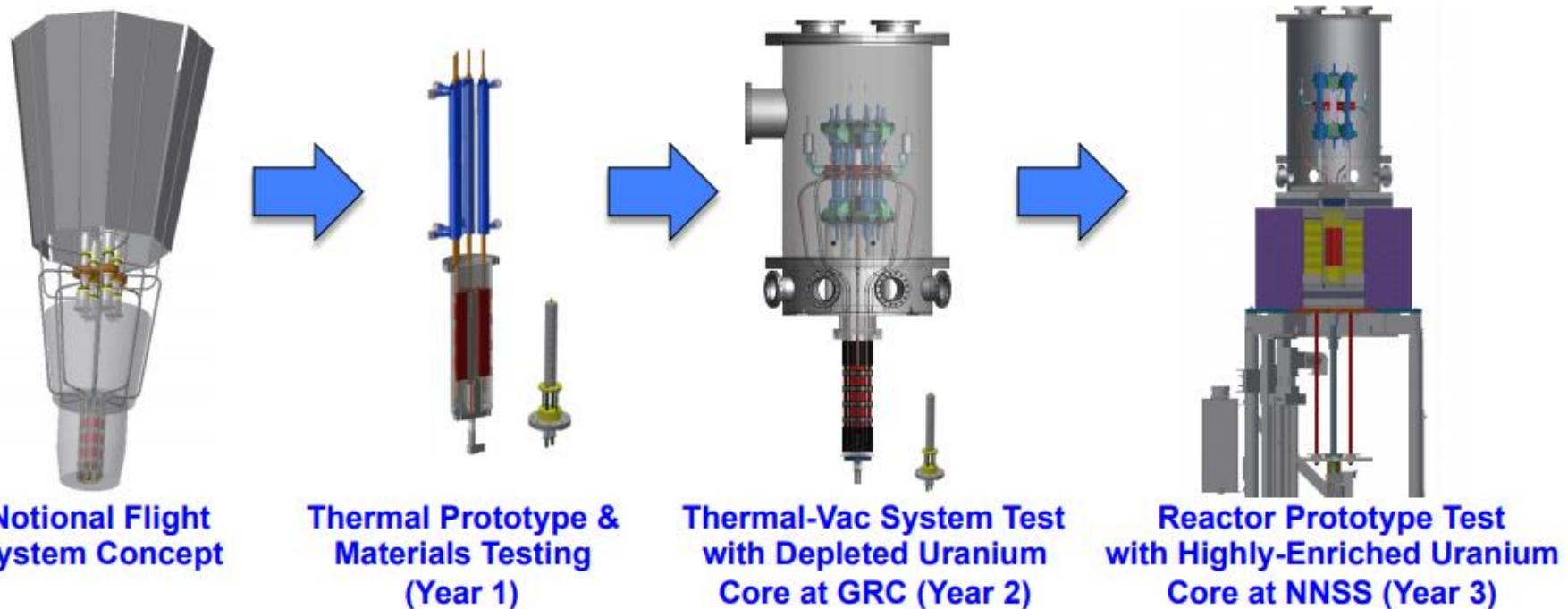


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*Assuming today's 30% solar cell efficiency



Kilowatt Reactor Using Stirling Technology (KRUSTy)



- Verify system-level performance of flight-like U-Mo reactor core, sodium heat pipes, and Stirling power conversion at prototypic operating conditions (temperature, heat flux, power) in vacuum
- Establish technical foundation for 1 to 10 kWe-class fission power systems



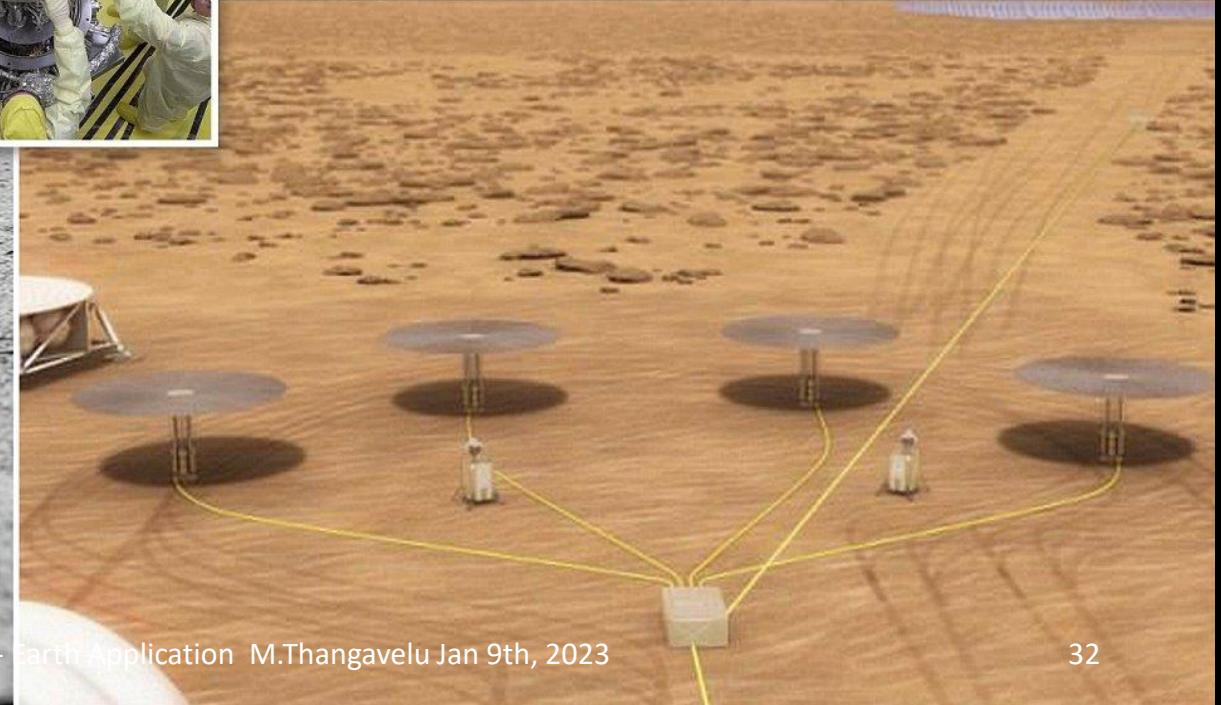
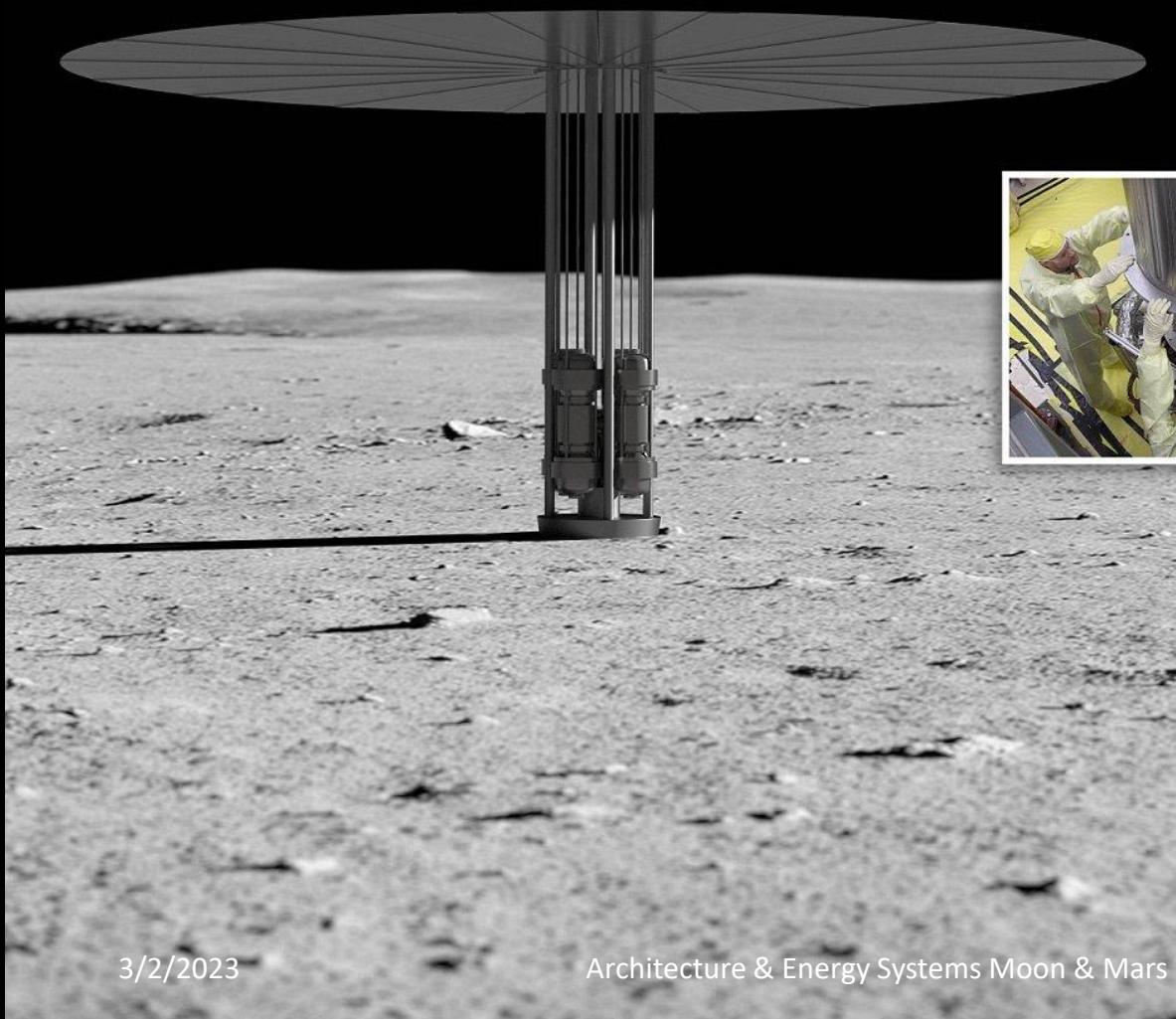
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2016 Kilopower Overview



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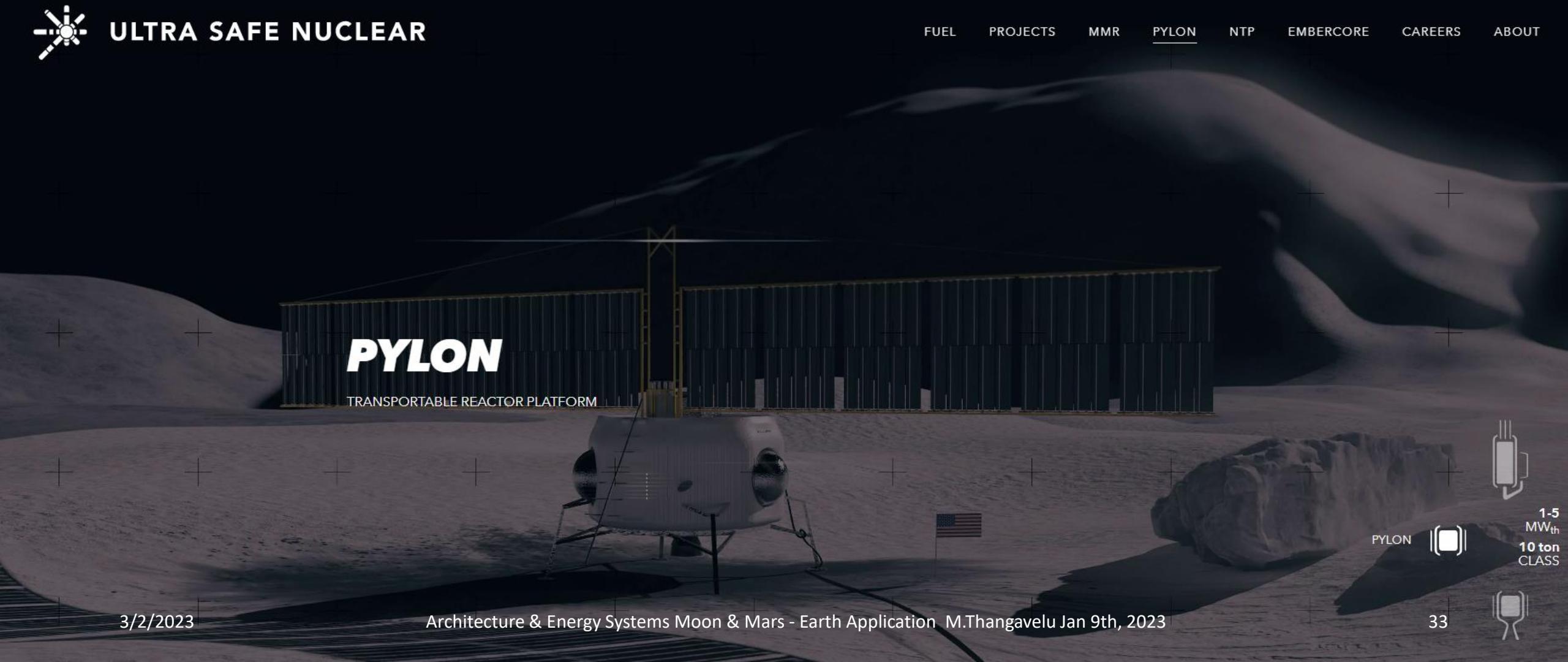
KILOPOWER – 1-10kW Stirling



Pylon – 1-10MW Brayton



FUEL PROJECTS MMR PYLON NTP EMBERCORE CAREERS ABOUT



PYLON

TRANSPORTABLE REACTOR PLATFORM



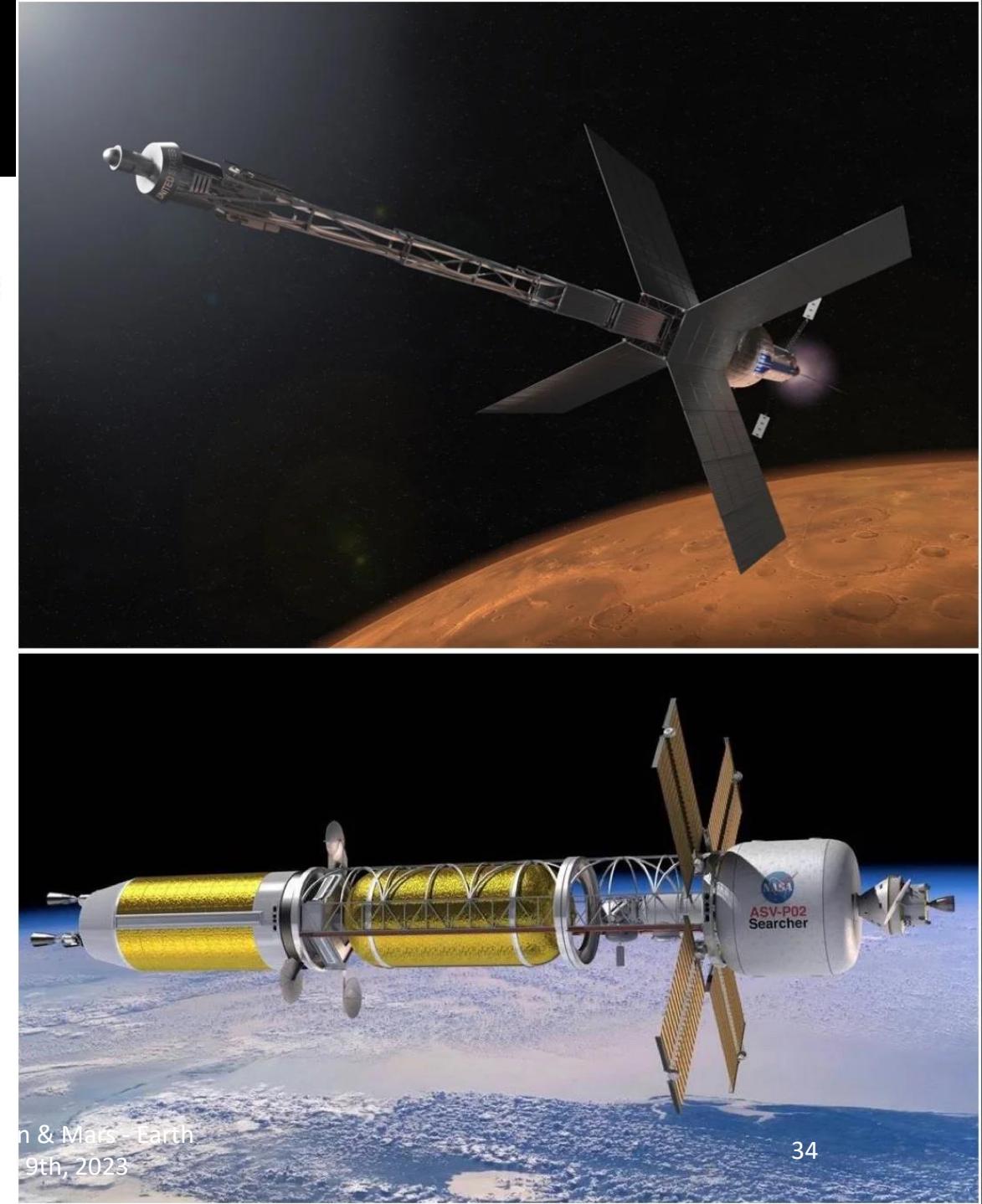
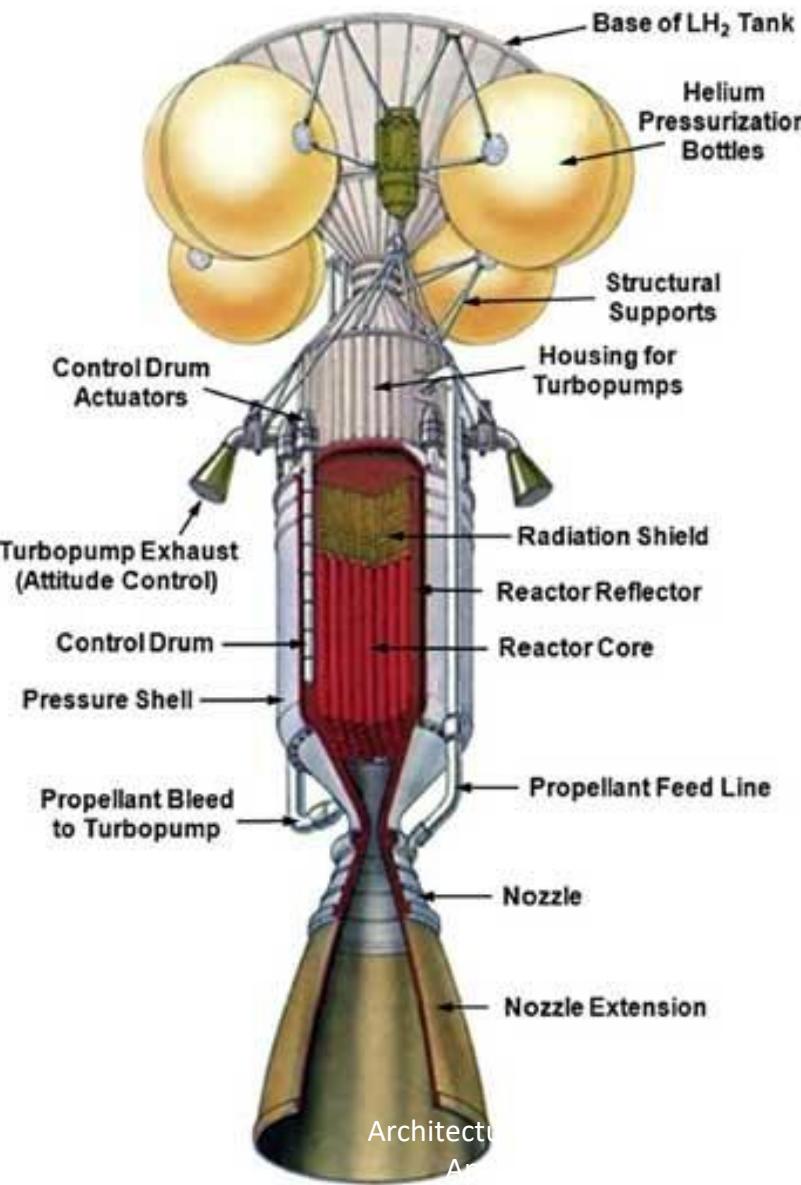
PYLON



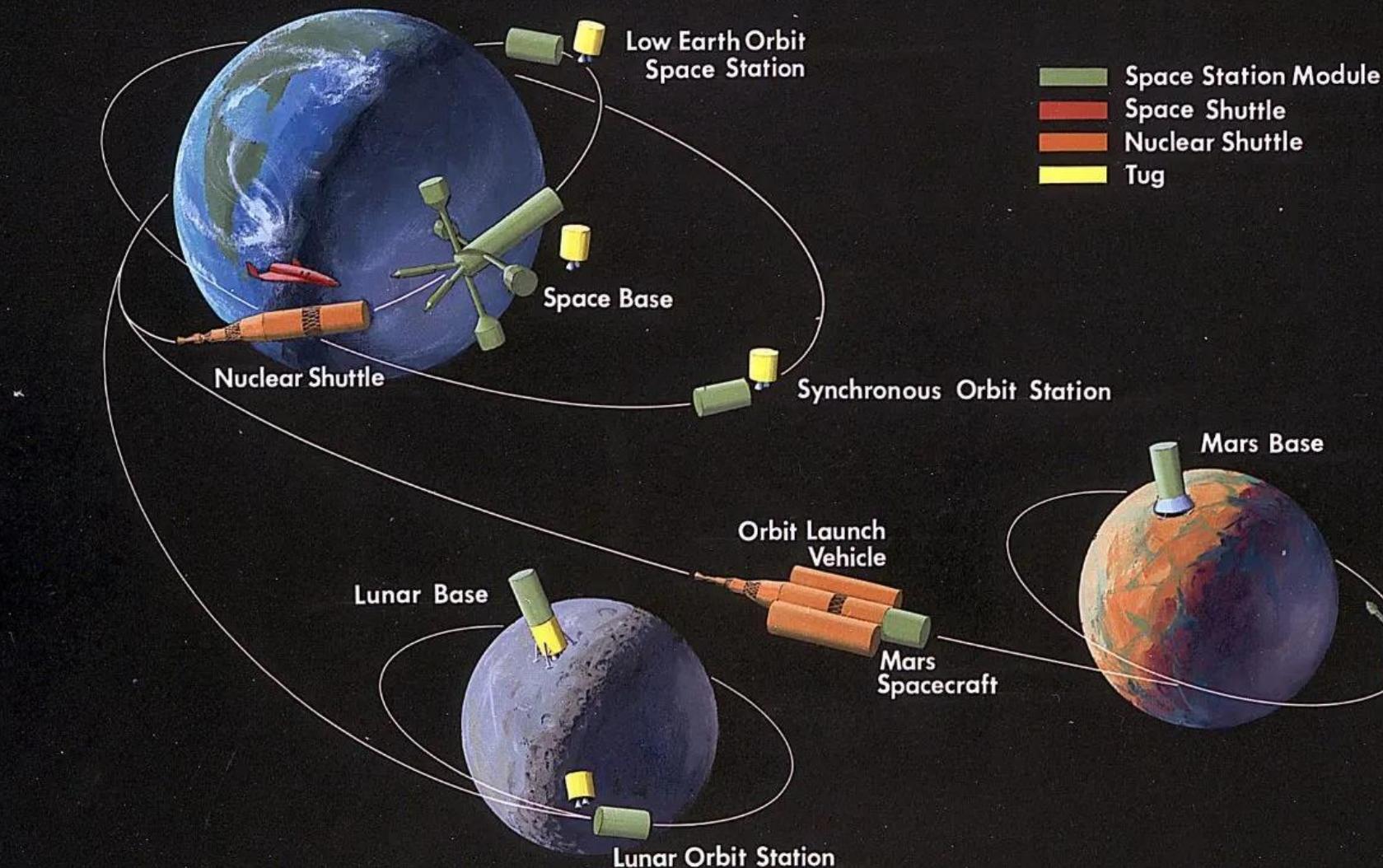
1-5
MW_{th}
10 ton
CLASS



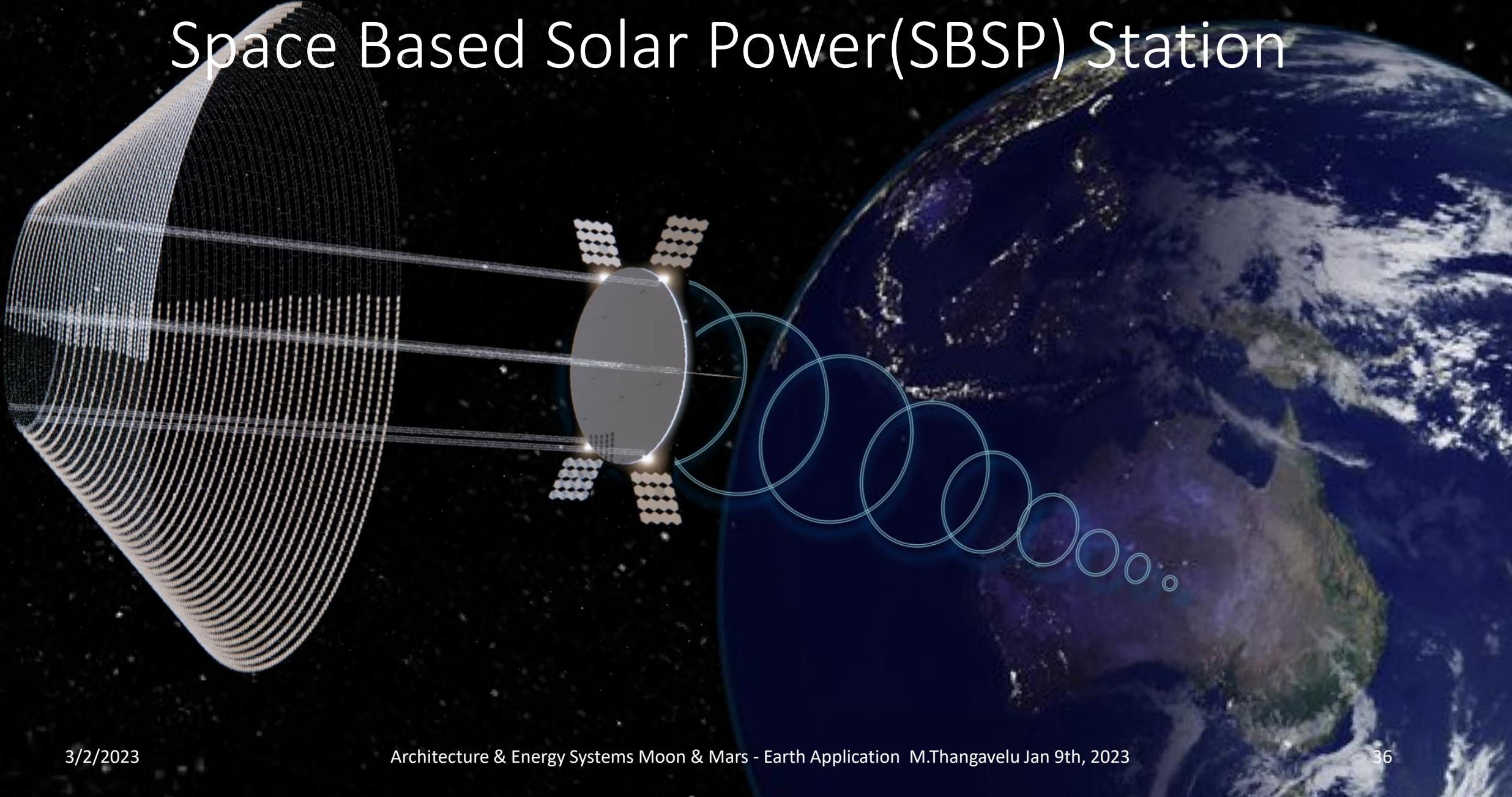
1960 NERVA – 2022 BNTR



MISSION EVOLUTION THROUGH HARDWARE COMMONALITY

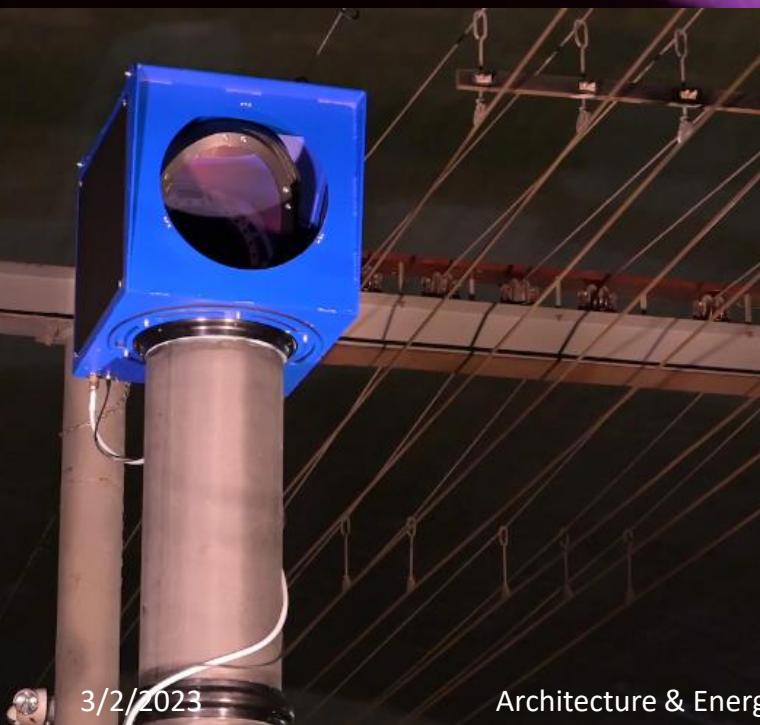


Space Based Solar Power(SBSP) Station



Jaffe, P.,(2019) Researchers transmit energy with laser in 'historic' power-beaming demonstration

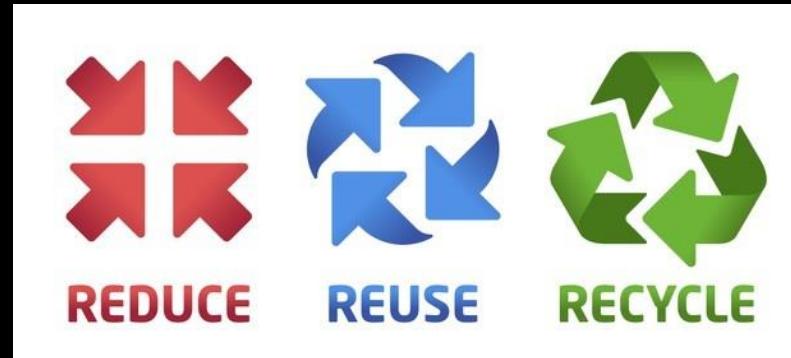
[Researchers transmit energy with laser in 'historic' power-beaming demonstration > U.S. Naval Research Laboratory > NRL News \(navy.mil\)](#)



Small Modular Fission Reactor - NuScale



Water & Air Reduce, ReUse, ReCycle





ISS ECLSS – Shower, Waste, Water Recovery X2, O2 Generation

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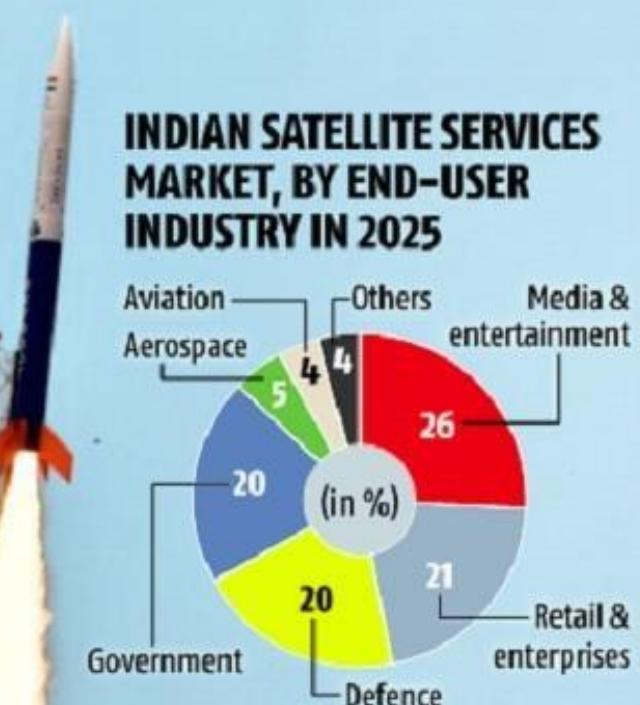
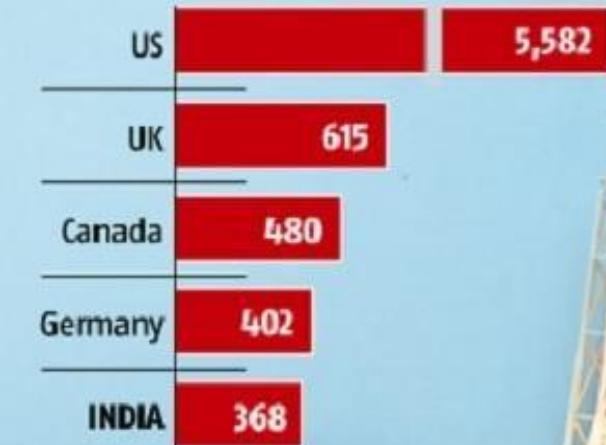
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HIGH STAKES

NUMBER OF SPACE-TECH FIRMS, BY COUNTRY



\$9.6 bn India's share in global space economy

\$13 bn India's share by 2025

India's first privately developed rocket

Skyroot's Vikram series of space launch vehicles is named after Dr. Vikram Sarabhai, founder of the Indian Space Program



Naga Bharath Daka



Pawan Chandana



Vikram - i

480 kg to 500 km Low Inclination Orbit



Vikram - ii

595 kg to 500 km Low Inclination Orbit



Vikram - iii

kg to 500 km Low Inclination Orbit



Space Technology for Future City

- Energy - Solar & Nuclear
- Fuel Cells - Hydrogen + Oxygen
- Potable Water - Reduce, Reuse, Recycle
- Agriculture - Indoor Farming – 5X Yield - No pests, No pesticides
- Transportation - Electric & Rapid Global
- Climate Change - Surface Phenomena
- Underground - Dwellings, Infrastructure
- Communication Advances - Optical - Robots - Education=Freedom
- AI - MIRI - Machine Intelligence Research Institute(UC Berkeley)



SUSTAINABLE DEVELOPMENT GOALS

1 NO POVERTY



2 ZERO HUNGER



3 GOOD HEALTH AND WELL-BEING



4 QUALITY EDUCATION



5 GENDER EQUALITY



6 CLEAN WATER AND SANITATION



7 AFFORDABLE AND CLEAN ENERGY



8 DECENT WORK AND ECONOMIC GROWTH



9 INDUSTRY, INNOVATION AND INFRASTRUCTURE



10 REDUCED INEQUALITIES



11 SUSTAINABLE CITIES AND COMMUNITIES



12 RESPONSIBLE CONSUMPTION AND PRODUCTION



13 CLIMATE ACTION



14 LIFE BELOW WATER



15 LIFE ON LAND



16 PEACE, JUSTICE AND STRONG INSTITUTIONS

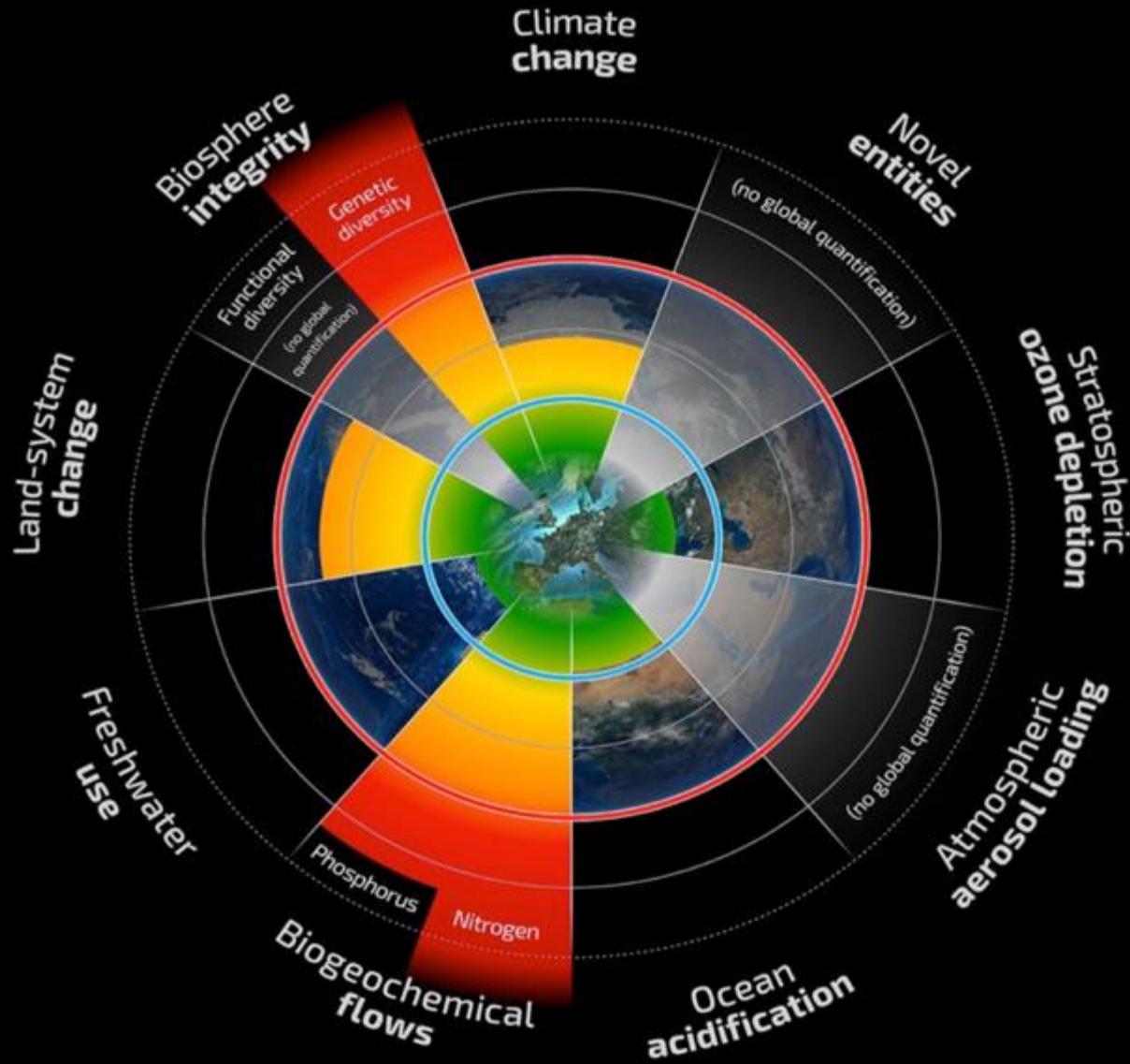


17 PARTNERSHIPS FOR THE GOALS



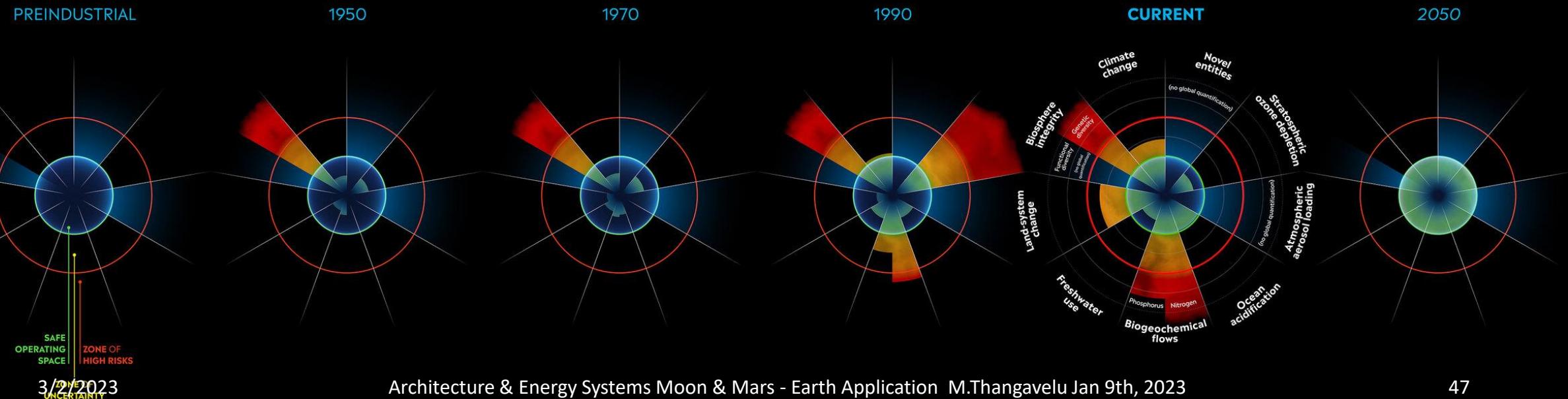
SUSTAINABLE
DEVELOPMENT
GOALS

Planetary Boundaries



Sustainability

- J.Rockstrom - Stockholm Resilience Centre
- Environmental Sustainability
- Urban Sustainability - City



Energy + Water + Air + Nutrients = FOOD

ISS Food Growth Chamber



EDEN ISS Project – 5kg food/week in 12.5m²

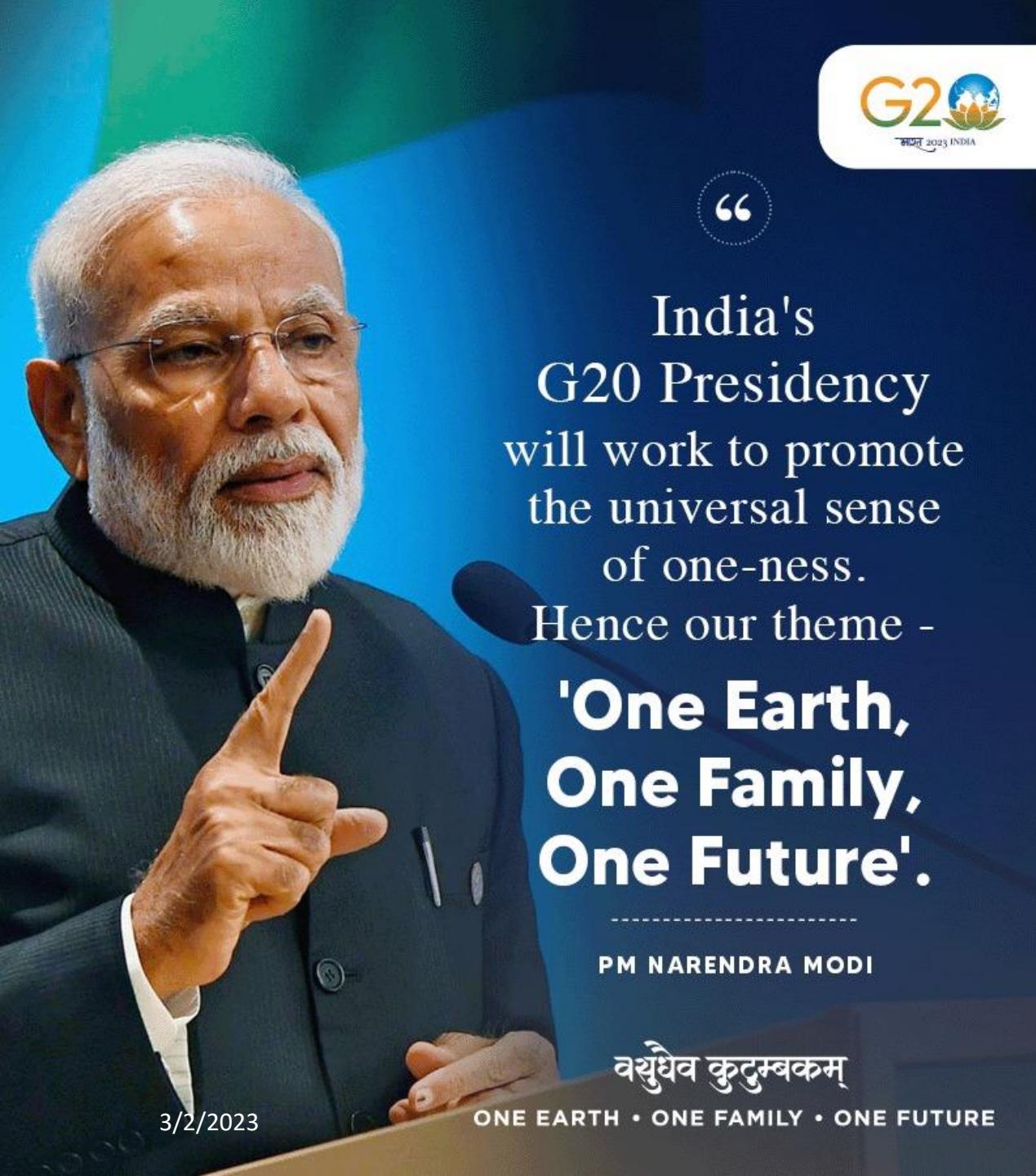




Connections

- UN COPUOS
- IAF/IAC
- IAA
- AIAA
- SRI
- MVA
- ACES
- ISU
- NSS
- TPS
- TMS
- COP 28





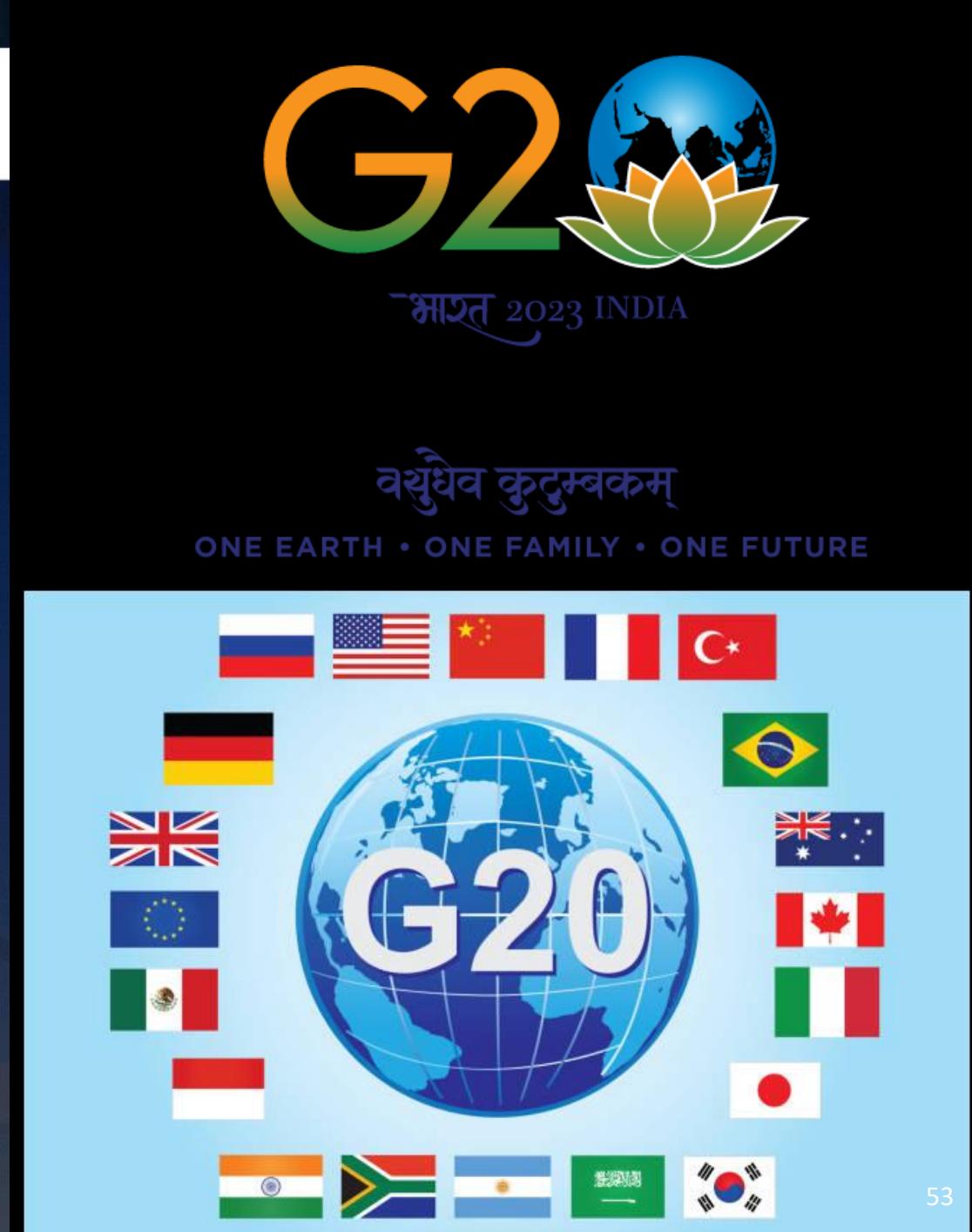
3/2/2023

“
India's
G20 Presidency
will work to promote
the universal sense
of one-ness.
Hence our theme -
**'One Earth,
One Family,
One Future'.**

PM NARENDRA MODI

वसुधैव कुटुम्बकम्

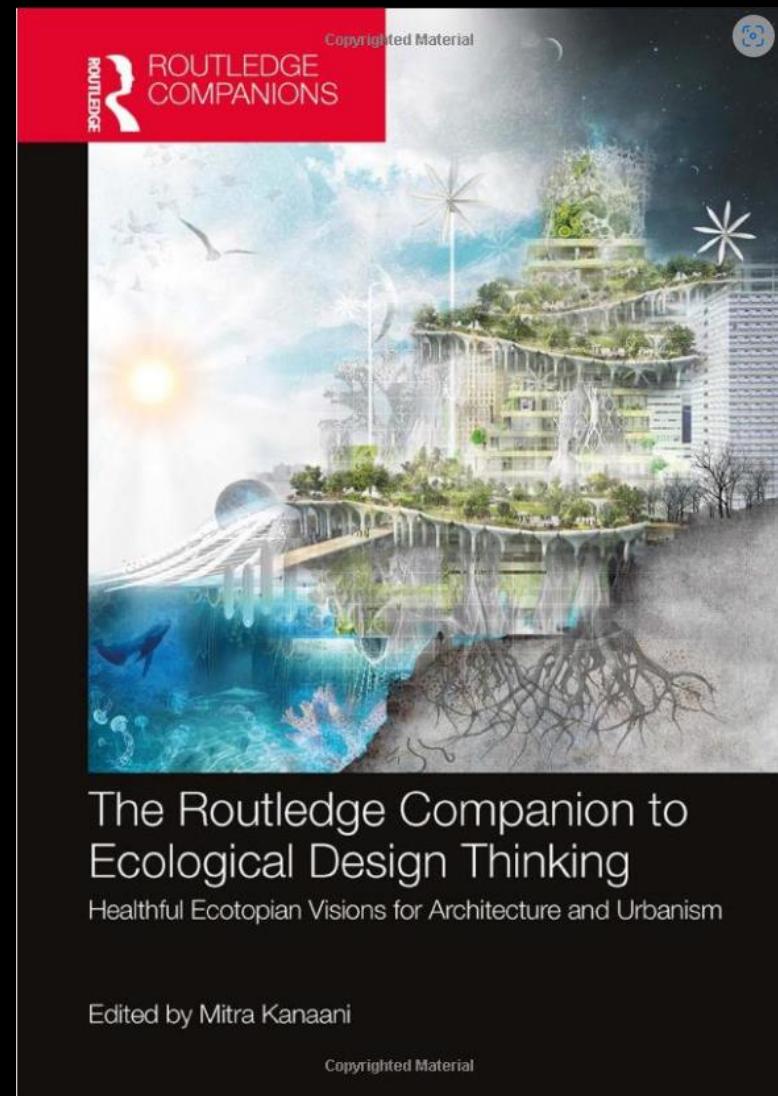
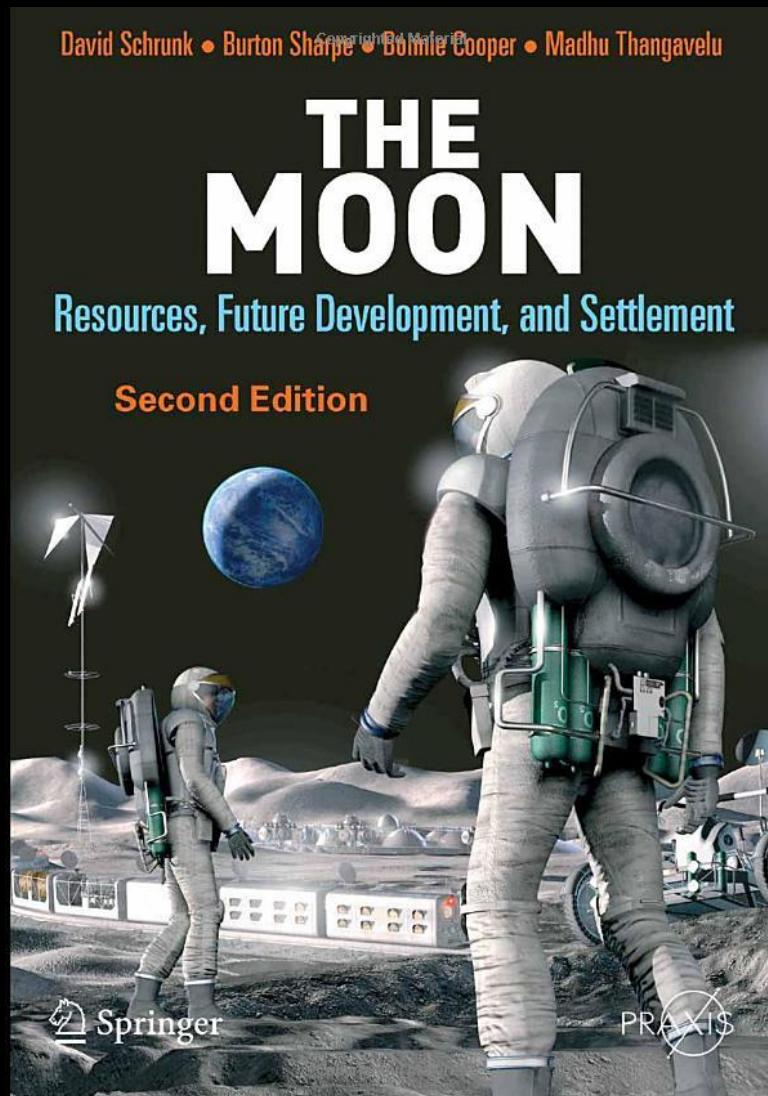
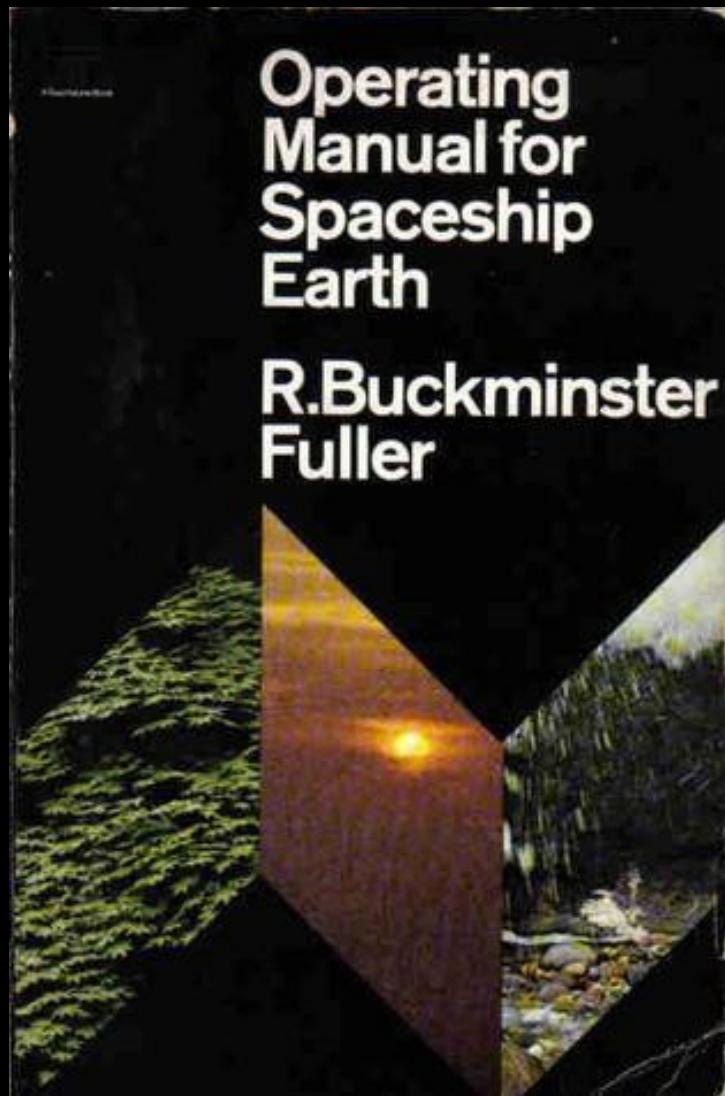
ONE EARTH • ONE FAMILY • ONE FUTURE



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The Books



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