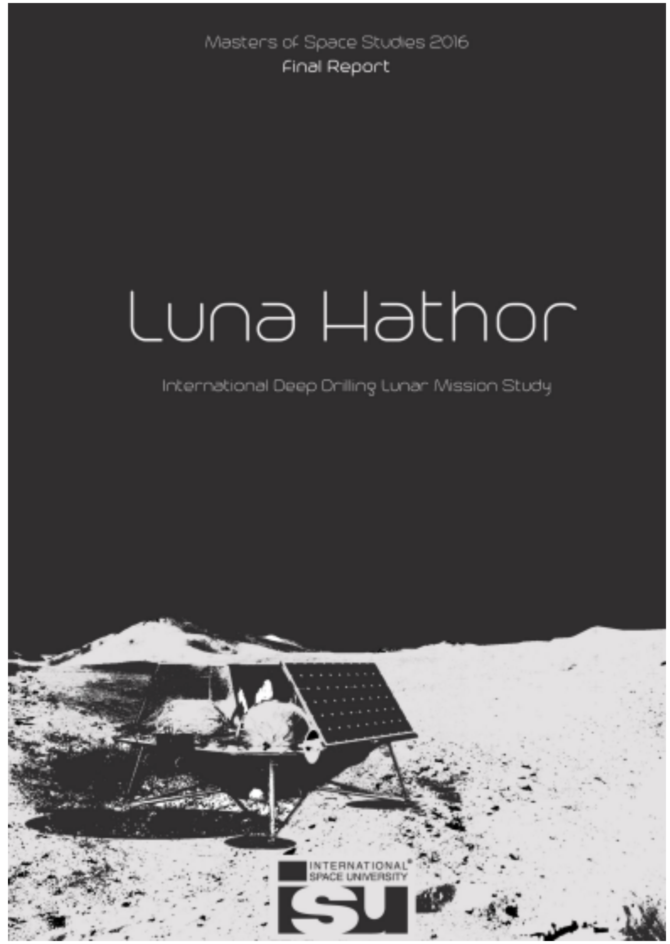


# Lunar Hathor:
# International Deep Drilling Lunar Mission Study

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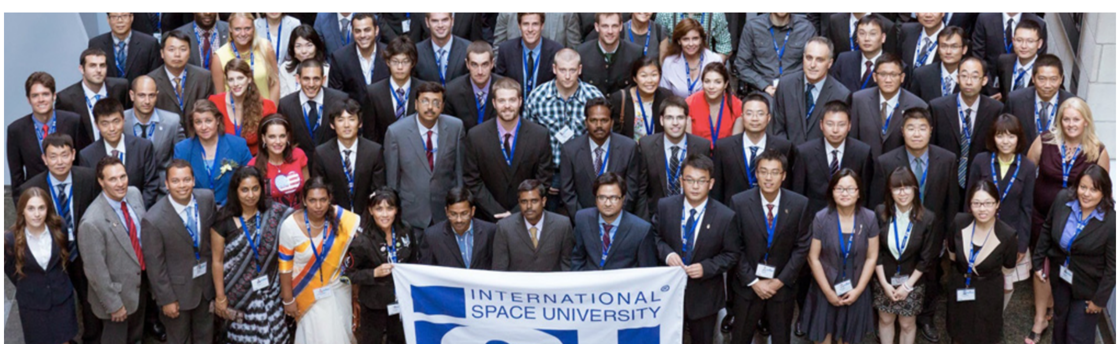
31 January 2017

# 1. International Space University

- ISU was founded in 1987 as an international institution of higher learning, dedicated to the development of outer space for peaceful purposes.
- ISU's Chancellor is Apollo astronaut Buzz Aldrin.
- The ISU Central Campus is in Strasbourg, France.
- ISU faculty members include astronauts, space agency leaders, space engineers, scientists, lawyers, managers, and experts in technical and non-technical space-related fields.
- There are 4200+ ISU alumni from 100+ countries


# ISU Educational Philosophy

- **ISU '3Is':**
  - Three aspects of ISU are key to success in meeting the present and future challenges of international space cooperation:
    - **Interdisciplinary**
    - **International**
    - **Intercultural**

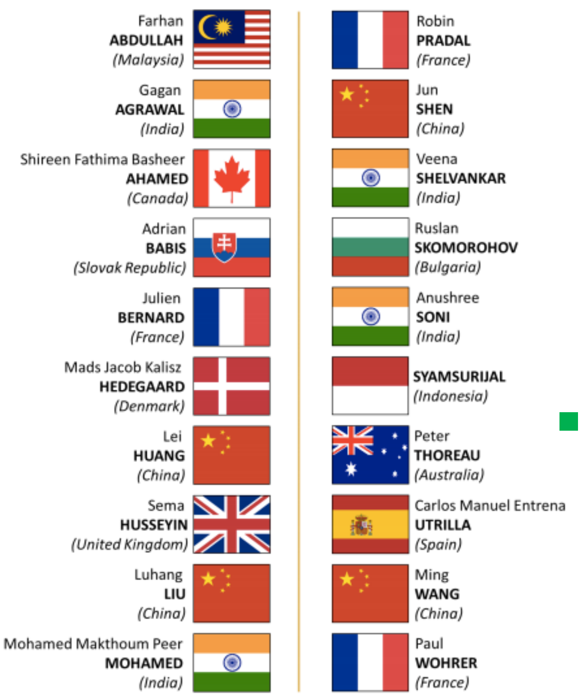
- **ISU disciplines:**
  - 3Is Space
  - Space Engineering
  - Space Sciences
  - Human Performance in Space
  - Space Applications
  - Space Management and Business
  - Space Policy, Economics and Law
  - Space Humanities

# ISU Programs

- **ISU Programs**
  - MSc in Space Studies (MSS)
  - Space Studies Program (SSP)
  - Southern Hemisphere Space Studies Program (SH-SSP)
  - Executive Space Course (ESC)


- A 3Is Team Project (or White Paper) is a core component of every ISU program.
- The team project develops their ability to organize themselves to work on a significant space-related problem in a 3I team environment, integrating their other learning.

# 2. Lunar Hathor Mission

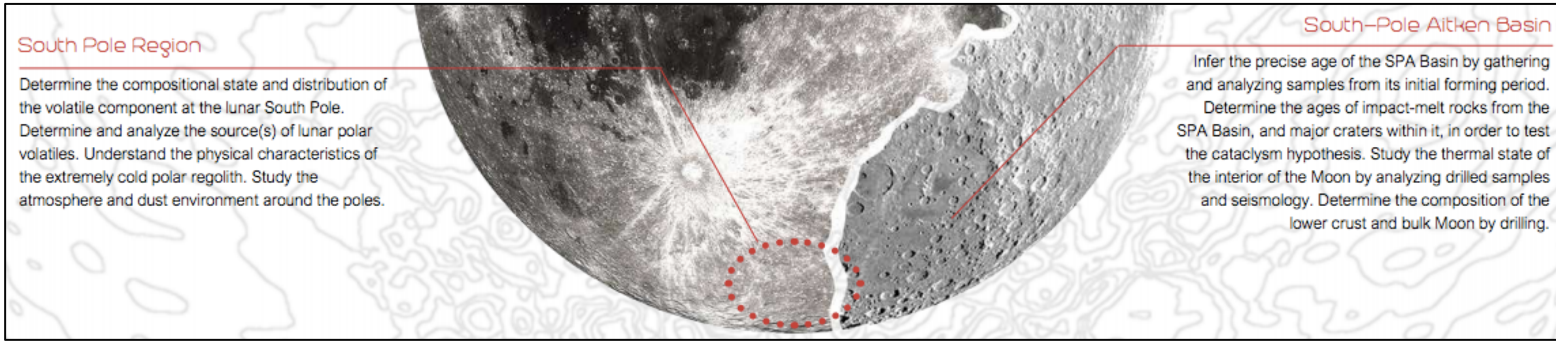



- Mission Statement
  - Luna Hathor will develop a framework for future international space mission collaborations and assess the scientific and technological aspects of a deep drilling mission to the Moon.
- Motivation
  - The motivation for the project stems from the necessity of promotion of international collaboration between different nations and private entities while obtaining valuable scientific and technical knowledge to further push the future frontiers of humankind.

# Lunar Hathor – Methodology

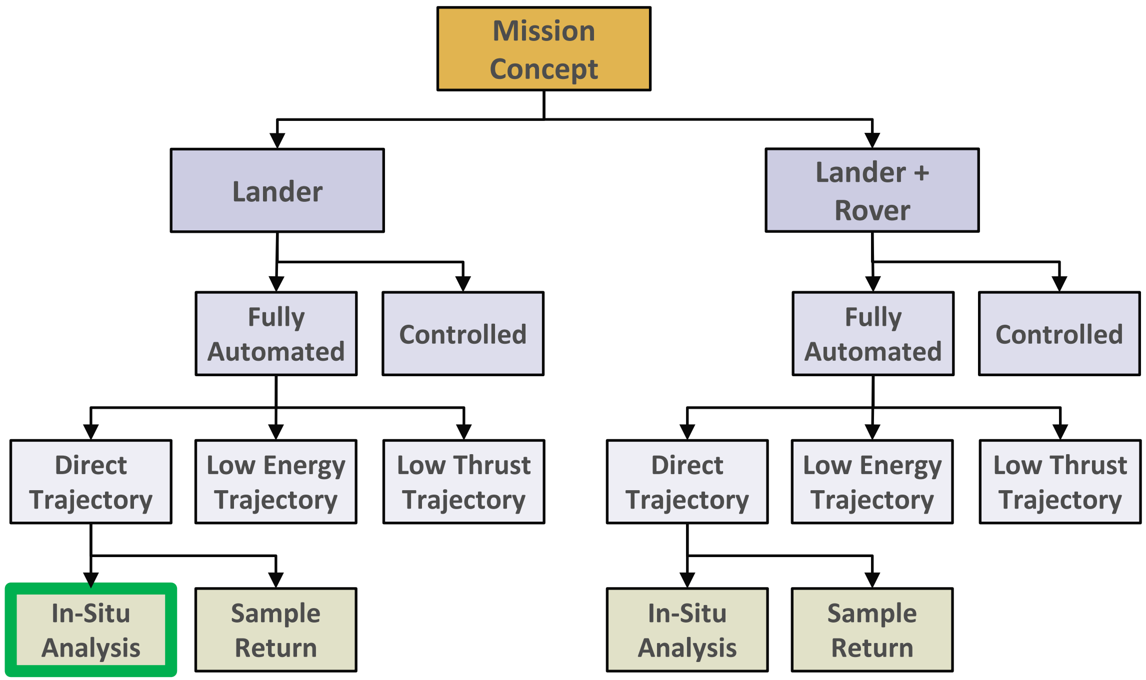
- A new framework for analyzing international collaborations is introduced to assess various space missions in an international environment from the policy, economics and industry perspective.
- New collaboration/ partnership structures are proposed and applied to the deep drilling lunar mission.
- Legal feasibility is examined and medium and high cost scenarios outlined.

# Lunar Hathor – Scientific rationale




- South Pole of Moon selected as target region of interest based on technical and economic rationales.
- Science Objectives
  - Study variety, age, distribution and origin of lunar rocks
  - Determine
    - Vertical extent and structure of the megaregolith
    - Compositional state and the volatile component
    - Distribution on the South Pole
    - Source(s) for lunar polar volatiles

# Lunar Hathor – Technology Assessment




## Mission Concept

To reach the Moon in a direct transfer, perform soft landing and drill 20m deep using a lander without a rover. Subsequently conduct in-situ analysis on the retrieved sample and relay the result data back to Earth in a directly-controlled mission.

# Lunar Hathor
# Complementary Rationales and Opportunities

Drivers influencing decision processes

Drivers affecting implementation

## Complementary Rationales

**A. Political and Security Rationales**
- A1. Historical Precedents for modern policy
- A2. National Space Policies perspective (US, Europe, Russia, China, Japan, India)
- A3. Friendly Collaboration
- A4. Foreign Policy and international collaboration precedents
- A5. Special case: Instability of US Space Policy
- A6. Military and Legal

**C. Economic Rationales**
- C1. Increasing GDP via opening new industries
- C2. Socio-economic benefits from investments – Jobs and value addition
- C3. Technology development via R&D – Spinoffs
- C4. ESA geo-policy advantages on industry through better economic geo-returns
- C5. Economic externalities in knowledge and cooperation

**B. Science and Technology Rationales**
- B1. Understanding solar system and cosmos
- B2. Permanent colonization
- B3. Space Manufacturing
- B4. Microgravity research
- B5. Improving space medicine
- B6. Improving technologies (Wireless, Remote Sensing, GNC, RTG etc.)
- B7. Deep space mining

**D. Public Participation and Outreach Rationales**
- D1. Scientific Community participation
- D2. Public (Taxpayer) participation
- D3. Government's role in communication and participation
- D4. Special case: ESA geo-policy
- D5. Special case: Prestige and People (China)
- D6. Public spending on Space vs. Defense

## Opportunities

**E. Stakeholders + Funding Access/Resource Allocation**
- E1. Government stakeholders (US, Europe, Russia, China, Japan, India and Canada)
- E2. Private sector (Direct or contractual)
- E3. NGO/CSR Funding
- E4. Mission specific stakeholders

**F. Technology Access and TRL Cost Levels**
- F1. High TRL technology capabilities - countries
- F2. Existing low cost - high TRL – countries
- F3. Technology readiness Level and cost associated
  - a. Low TRL, high cost to develop
  - b. Low TRL, low cost to develop
  - c. High TRL, high cost

**G. Mission Objectives (Scientific, Technological, Business)**
- G1. Science and Humanities objectives
- G2. Mining resources – long-term business
- G3. Make direct revenues

**H. Risks and Cost of Risk**
- H1. International Collaboration failure due to geo-politics
- H2. Low TRL + high budget + long time-line associated failures
- H3. Impact of poor management in international partnerships
- H4. Impact on future strategy due to mission failure
- H5. Internal political decisions and opportunity costs
- H6. Bankruptcy of private stakeholder

## Recommended Collaborations

# Luna Hathor - Resulting Collaboration Structures

## 1 Europe-Russia and/or Russia-China

- E1 G1 Science mission
- E2 E4 Privatization initiatives
- C3 C5 Economic impact through spin-offs/externalities
- A3 C3 Potential Russian technology transfer opportunity
- D6 Outreach for scientific community participation and geo-policy
- H5 H6 Lowering risks
- A6 Russia-China potential military agenda

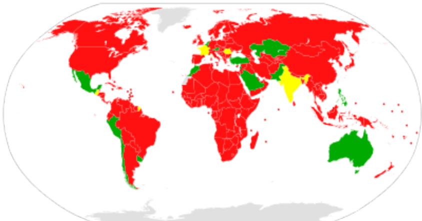
## 2 US Public-Private Partnership

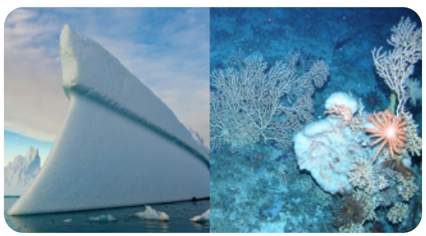
- A2 US government push into privatization policy
- B3 B6 and D2 D6 Space manufacturing systems with a government push in public communication
- B7 Deep space mining interests
- C1 C3 Opening of new industries
- E1 Secondary government stakeholders/actors in Europe and Japan

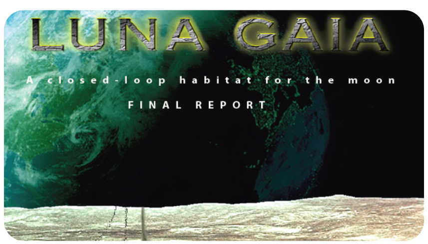
## 3 China Leading the Moon Race

- B1 B4 G1 Science and humanities objectives
- A1 D5 Chinese push for Prestige rationale
- F3 H1 H2 Potential for technology collaboration, and lower risks
- C2 Low private sector involvement although push for C2 in socio-economic benefits

# Lunar Hathor - Potential Legal Regimes








**Existing Frameworks**

1. OST/Status-quo
2. Moon Agreement
3. Modified Moon Agreement
4. US-Luxemburg Mining Laws
5. Collapse of International Law

**Legal Analogues**

6. Antarctic Analogue
7. Law of the Sea (Deep Seabed)
8. GEO Regulations Analogue
9. Credit System Analogue

**Proposed Frameworks**

10. Luna Gaia Settlement
11. SSPA/SSI
12. Preserve/UNESCO Site

*Sources: National Geographic, Joint Nature Conservation Committee, ISU SSP (2006)*

# Lunar Hathor – Missions and Legal Feasibility

## 1 Europe-Russia and/or Russia-China

### Mission Description

Drilling mission primarily focused on scientific goals with minor typical private participation mostly related to spin-offs and technology transfer

### Legal Issues

- No significant issues related to the mission expected

**Legal** | Illegal

## 2 US Public-Private Partnership

### Mission Description

Drilling mission with strong private partner participation and focused on prospecting for mining beyond scientific goals

### Legal Issues

- Issues could arise in case private entities pursue sample appropriation or activities with a risks of bio-contamination

**Legal** | Illegal

## 3 China Leading the Moon Race

### Mission Description

Primarily driven by prestige reasons and focus on later human flight, a drilling mission led by China would serve cooperation purposes

### Legal Issues

- No significant issues related to the mission expected

**Legal** | Illegal


# Lunar Hathor
# Executive Summary and Report available at:

[isulibrary.isunet.edu/opac/index.php?lvl=notice_display&id=9754]

If you would like to know more about ISU, please come and find us, or get in touch.

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