Location, Location, Location

A Lunar Investment Strategy

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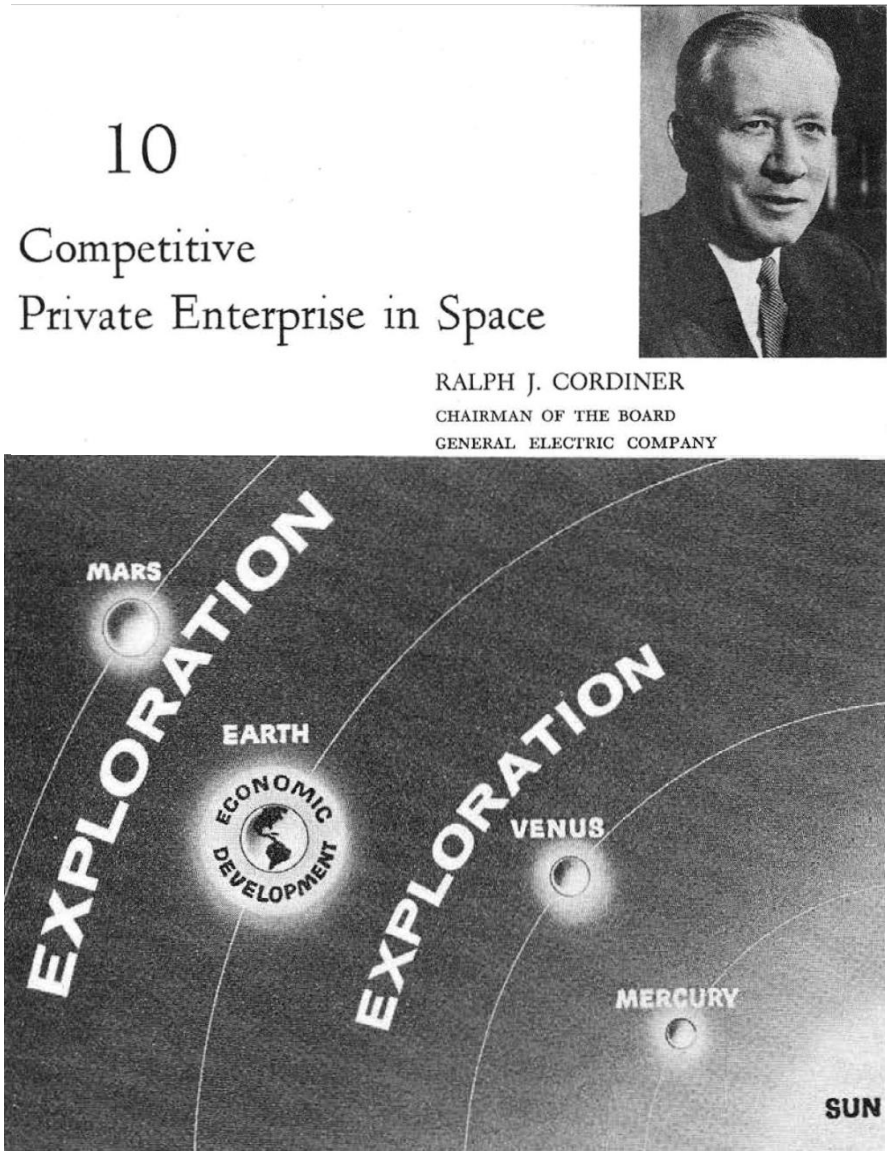
ISU's International Institute of Space Commerce

Lunar Economic Action Plan (LEAP)

Questions from 1960 Still Relevant Today



Space and Economic Development

- How can we utilize our dynamic system of competitive private enterprise in space, as on earth, to make newly discovered resources useful to man?
- How can private enterprise and private capital make their maximum contribution?

Philosophy and Policy

The ultimate goal is not to impress others, or merely to explore our planetary system, but to use accessible space for the benefit of humankind. It is a goal that is not confined to a decade or a century. Nor is it confined to a single nearby destination, or to a fleeting dash to plant a flag. The idea is to begin preparing now for a future in which the material trapped in the Sun's vicinity is available for incorporation into our way of life.

Dr. John Marburger, Head of the Office of Science and Technology Policy 2006

The Investment Premise

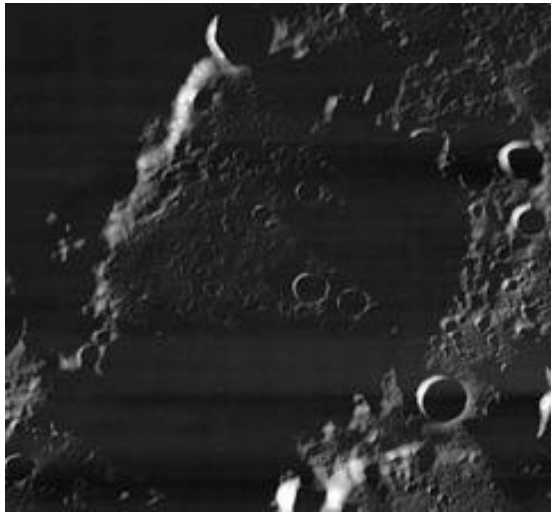
- Just as on Earth, lunar real estate "value" is driven by **location, location, location**

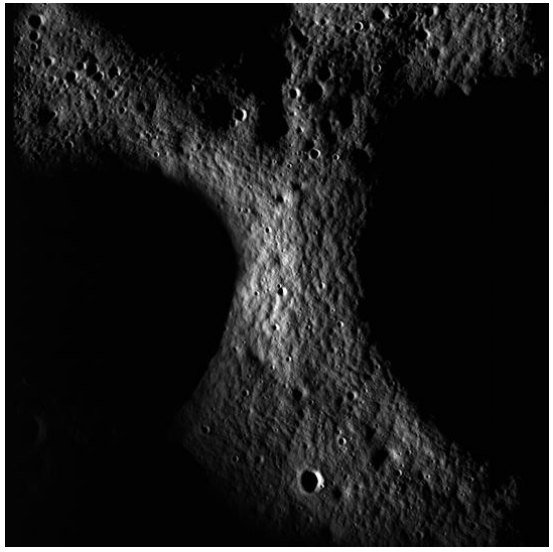
Rank	Location	Why Valuable
1	Peary Crater	Best 1st industrial base and settlement
2	Sinus Medii	Good cargo port & space elevator site
3	Largest skylights / lava tubes	Best large scale settlements
4	Tsiolkovskiy crater, dark side	Prime radio astronomy site
5	High helium-3 concentrations	Potential high value mining
6	Lipsky Crater	Space elevator site for Earth-Moon L2
7	Aristillus	High Thorium concentrations

- Lunar real estate cannot be "owned" under international treaty, but regions of non-interference are likely to prevail
- **The international group & PPPs that lead the settlement of this prime real estate will enjoy the greatest value creation**

Location #1: Peary/Whipple Crater

- Images taken by Clementine in 1994 determined four mountainous regions on rim of Peary near the Moon's north pole remain illuminated for entire lunar day; the "**peaks of eternal light**"
- Crater interior receives little sunlight, and portions remain permanently cloaked in shadow allowing **persistent water ice**
- A lunar base here would receive constant solar energy, have a very small temperature variation versus the 280 °C variation at the equator and be close to insitu resources
- According to Ben Bussey of Johns Hopkins University who analyzed the Clementine images, the best spot to settle on the Moon may be on the northern rim of Peary crater



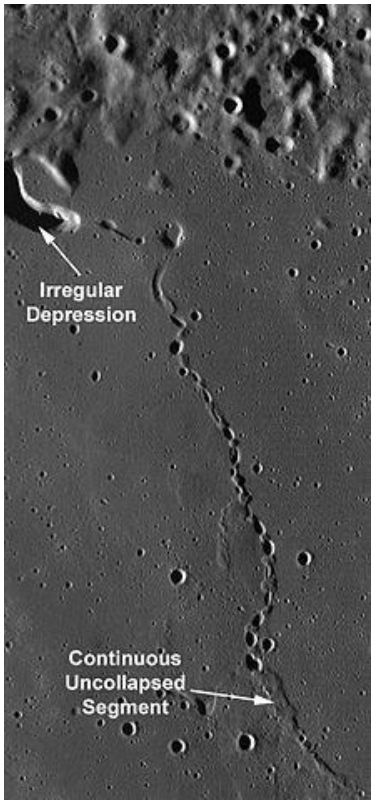


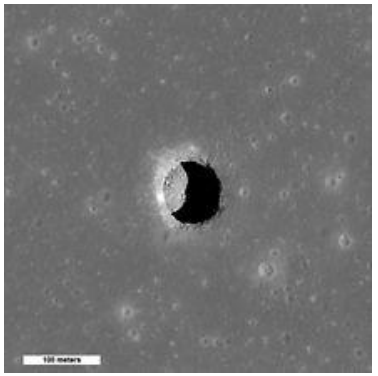
Location #2: Sinus Medii

- A small lunar mare at intersection of Moon's equator and prime meridian
- The point closest to the Earth, which would always appear directly overhead from this spot
- Would be directly underneath any space stations at Earth-Moon Lagrange Point 1 (EM L-1) (e.g. NASA's planned Gateway)
- An ideal terminus for a space elevator to raise lunar regolith to EM L-1
- Equatorial location requires less delta-V from Earth to landing
- **Surveyor 6 landed inside Sinus Medii November 1967**. In July 1967, Surveyor 4 crashed nearby

Location #3: Lava Tubes

- Lunar lava tubes may be ideal enclosures for human habitats and be as large as 300 meters in diameter
- Lying under 40 meters or more of basalt with a stable temperature of −20 °C, these tunnels provide protection from cosmic radiation and meteorites and are shielded from the large variations in temperature at the surface
- Typically found along boundaries between lunar mares and highland regions, they have access to elevated regions for communications, basaltic plains for landing sites and regolith harvesting, and underground mineral resources
- One such area is **Marius Hills region**. A skylight photographed in 2011 by the Lunar Reconnaissance Orbiter showed a 65-meter diameter pit and the floor of a cave 36 meters below

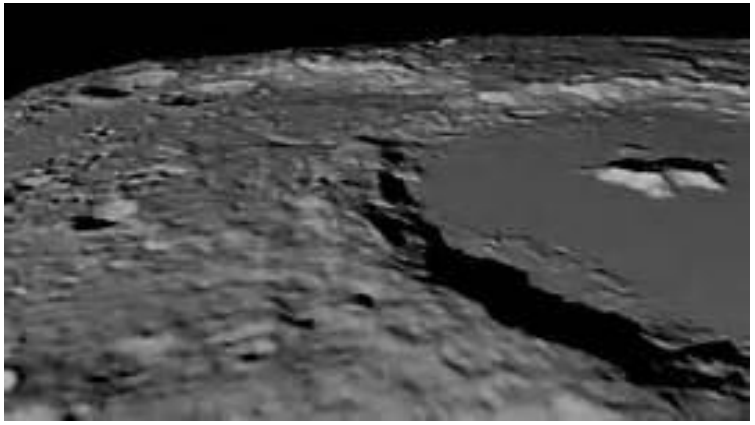




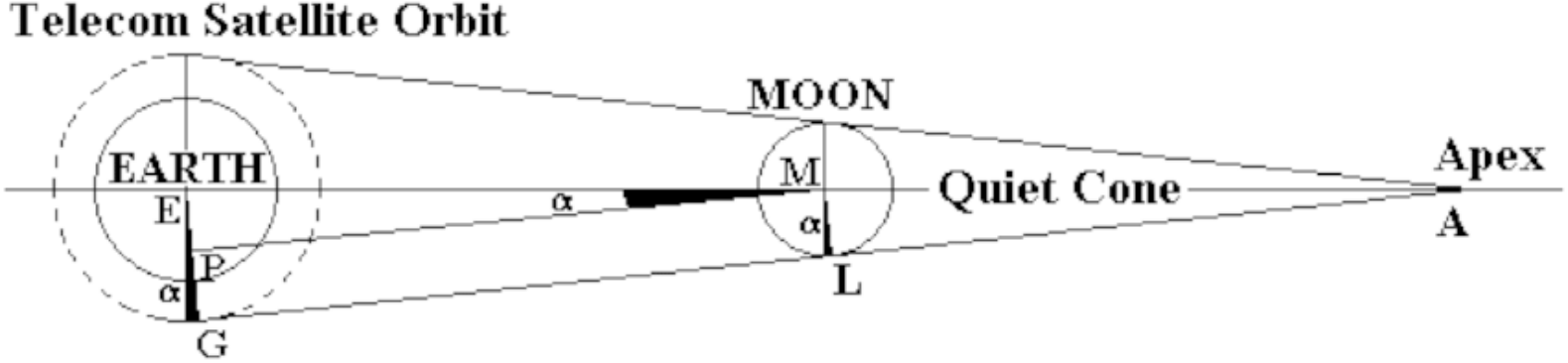
Location #4: Tsiolkovskiy Crater

Far Side Radio Free Zone

- Ideal site for radio astronomy: radio signals from Earth constantly blocked
- Astronomers favor flat bed of 180-km wide Tsiolkovskiy crater, where Apollo 17 astronauts first wanted to land
- 2008 U.S. Naval Research Laboratory proposed a giant telescope, Dark Ages Lunar Interferometer at Tsiolkovskiy
- European Space Agency proposing to build a Moon village and giant

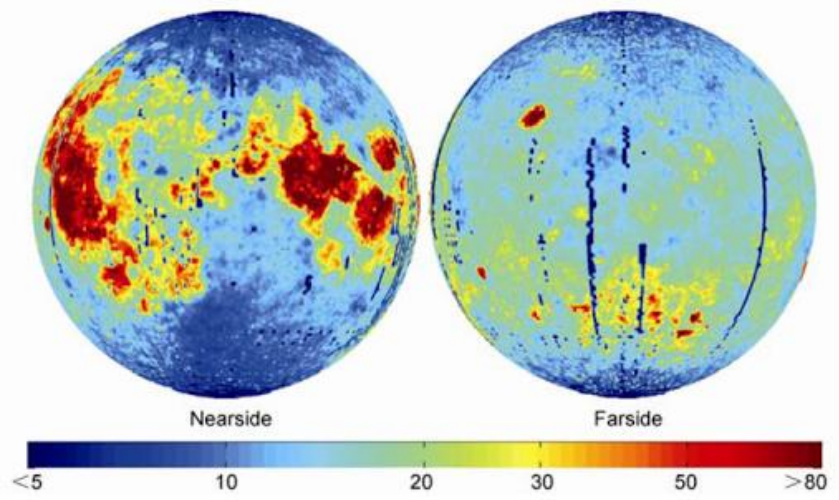


Note: Some astronomers prefer Daedalus Crater which is closer to the center of the Radio Free Zone



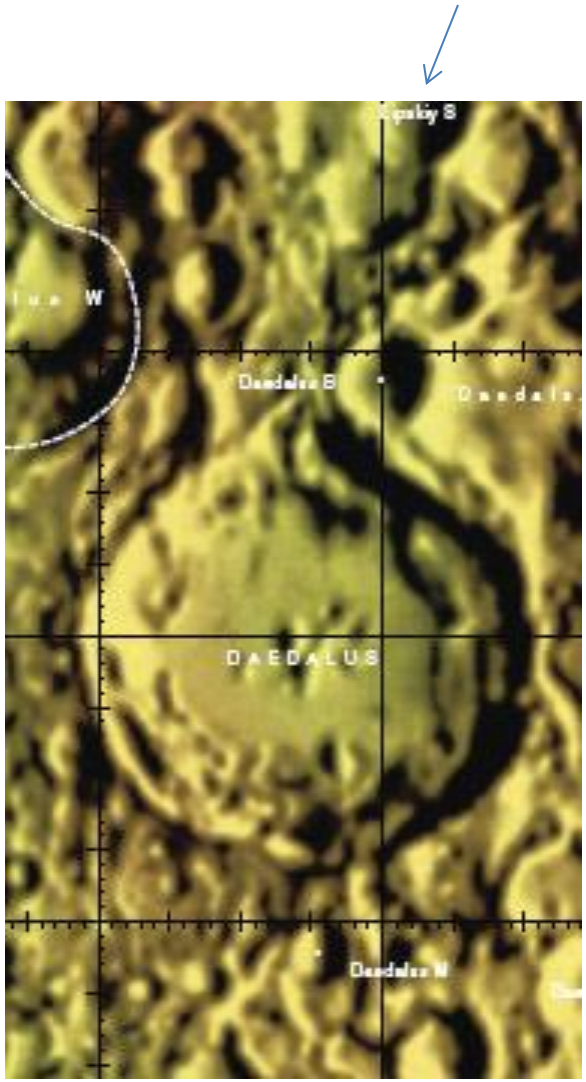
Location #5: Helium-3 Sites

- Helium-3 believed to be important future fuel for fusion reactors, but this is highly speculative
- Lunar surface may contain Helium-3 at concentrations of 80 ppb or higher (dark red in image below)
- Would need to process over 150 million tonnes of regolith for 1 ton of HE-3
- Chinese Lunar Exploration Program has stated one of its main goals would be the mining of Helium-3
- Russian space company RKK Energiya considers lunar Helium-3 a potential economic resource to be mined by 2020



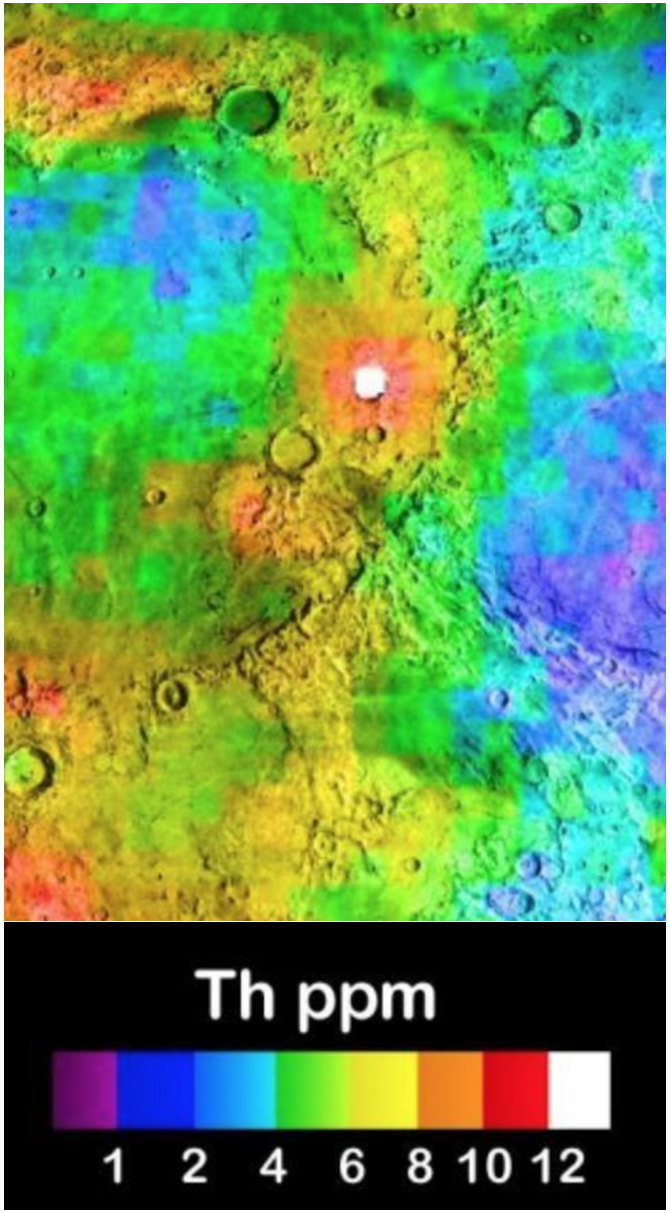
Location #6: Lipsky Crater

- At the antipode of Sinus Medii on the far side of the Moon
- Crater is old and not ideal for settlement, but it would be the necessary terminus of a space elevator to Earth-Moon L2 point
- L2 may become an important location for large scale manufacturing and construction of space infrastructure
- L2 can be reached with a Ballistic Lunar Transfer which may have long-term significance as low-cost “slow boat” to the Moon (up to 33% more mass delivered per unit of propellant)



Location #7: Aristillus

- Eastern Mare Imbrium
- Location for mining of Thorium for local reactors on the Moon for power and for space reactors.
- The Thorium concentrations at Aristillus is among the highest on the Moon.



Public Private Partnerships

- Key parameters of public private partnership structuring
  - Shared investment in infrastructure, at least 1/3rd to 1/2th commercial
  - More than one commercial participant to ensure ongoing competition
  - Funding based on fulfillment of milestones
  - Long term facility operations and maintenance contracts with participating governments
    - to support partial debt financing of commercial portion of investment

Lunar Bases	Government	Commercial
Design	Technology & facility contributions; design advice	Lead responsibility
Construction	Funding (50%-67%), limited oversight	Funding (33%-50%), Lead responsibility
Launch to IOC	Funding of commercial delivery to lunar orbit or EM L-1 Gateway	Funding of landing, set up, installation and checkout
Oper. & Maint.	Anchor tenancy, some oversight	Lead responsibility
Commercial Ops	Coordination	Sole responsibility