



# Shackleton Energy Lunar-Sourced Propellant Depot Architecture

PTMSS / SRR 2012

6 June 2012

Cleared for Public Release

**Shackleton Energy Company**

*“Fueling the Space Frontier”*



# Vision

By 2020

Open the World's First Low Earth Orbit and Moon-based Propellant Depots To Enable Untold New Business Opportunities in Space



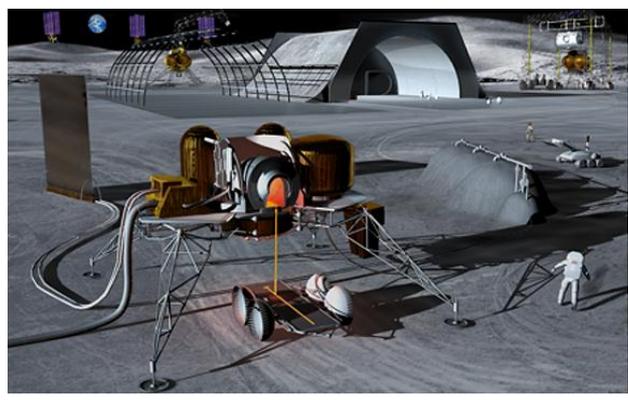
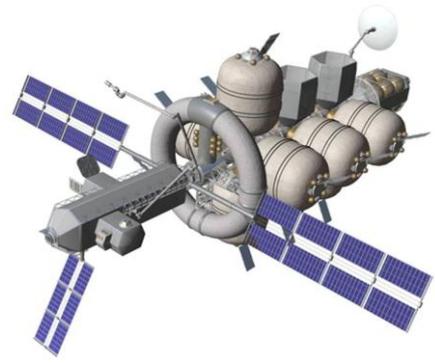
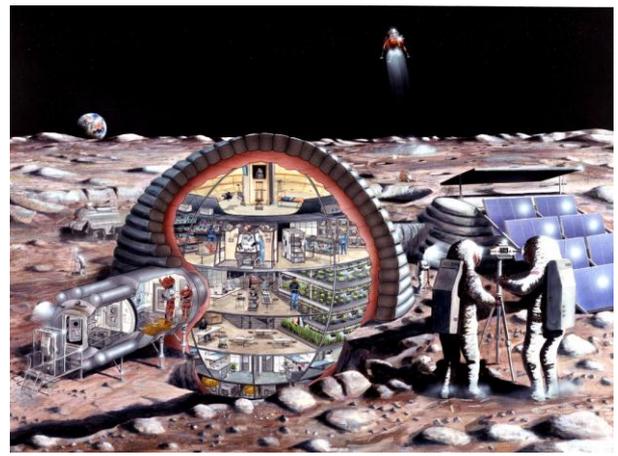
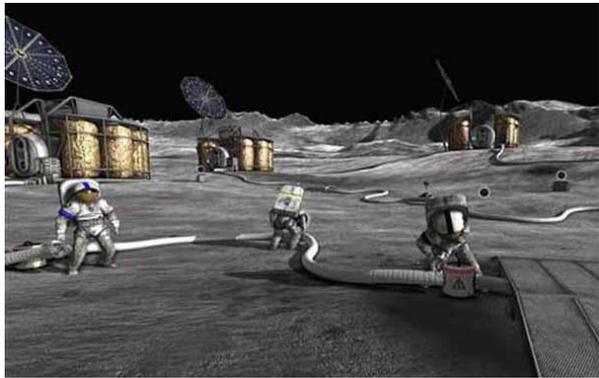
***Using Lunar Ice-derived Rocket Propellants to Power Commerce***



- SEC will enable
  - Opening the New Space Frontier
  - Creating the Cis-Lunar Transportation System
  - Installing industrial-scale infrastructure for customer build outs and improved operations
  - Facilitating massive expansion of opportunities off Earth
    - Science
    - Security
    - Commerce
    - Multi human space programs
    - Settlements (species preservation)



# Infrastructure Required



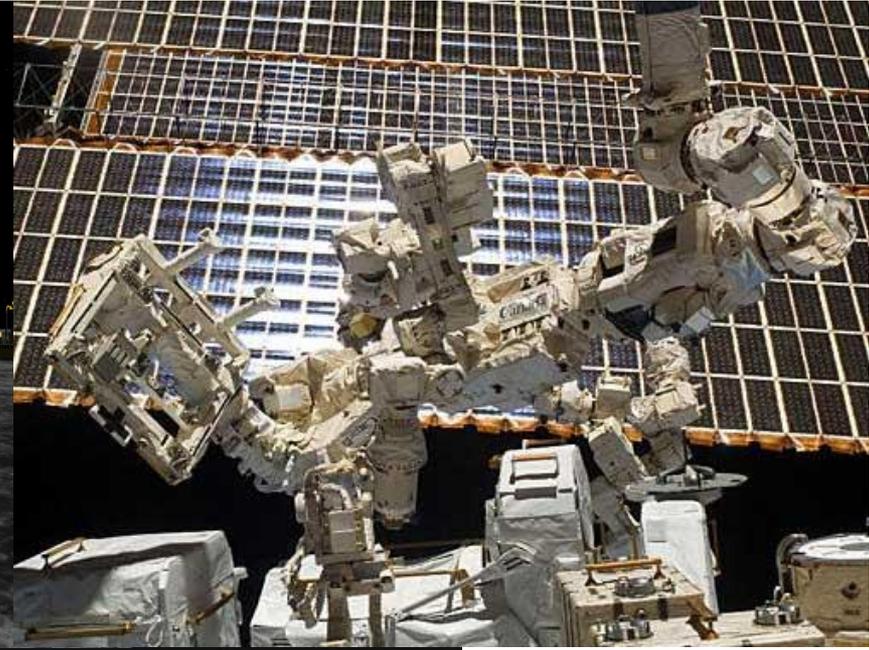
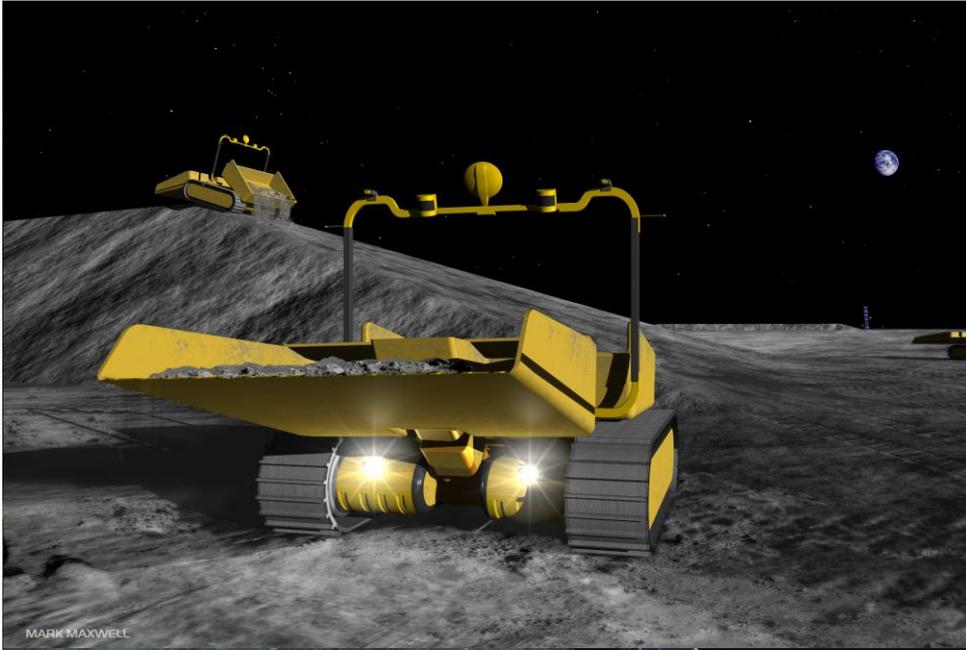


# Total Capability





# Total Capability





# Enabling Platform

- Profitable in-space business
- Realistic milestone-based CAPEX
- Delivery timescales in years not decades
- Rapid revenue generation and positive ROI
- Interconnected expanding market place
- Multiple customer service opportunities
- Highly reliable, scalable, reconfigurable, modular infrastructure
- Human operations in space—absolutely essential
  - Real-time mission optimization and problem solving
  - Quickest route to market



# Shackleton Energy Company

- Comprehensive business model with multiple profit centers
- Early revenue generation (within 12 months of program start)
- First propellant delivery 2018 (launched from Earth)
- Subsequent in-space business streams
- Customer service to nations and companies
- World-class team
- Privately financed
- 20 years of planning anchored by Clementine, Prospector, Chandryaan and LRO discoveries



# Team Experience





# Team Experience

- Aerospace missions
  - Launch vehicles; satellites; high altitude, long endurance aircraft; mission operations
- Extreme endurance manned/unmanned missions
  - Underwater, underground, land, air and space
- Autonomous, intelligent robotic vehicles and systems
- Ultra-long endurance life support systems
- Extreme remote mining and operations (Chile)
- World-class expeditionary leadership and teams
- Essential NASA-funded exploration technologies developed for Europa missions
- *International participation*

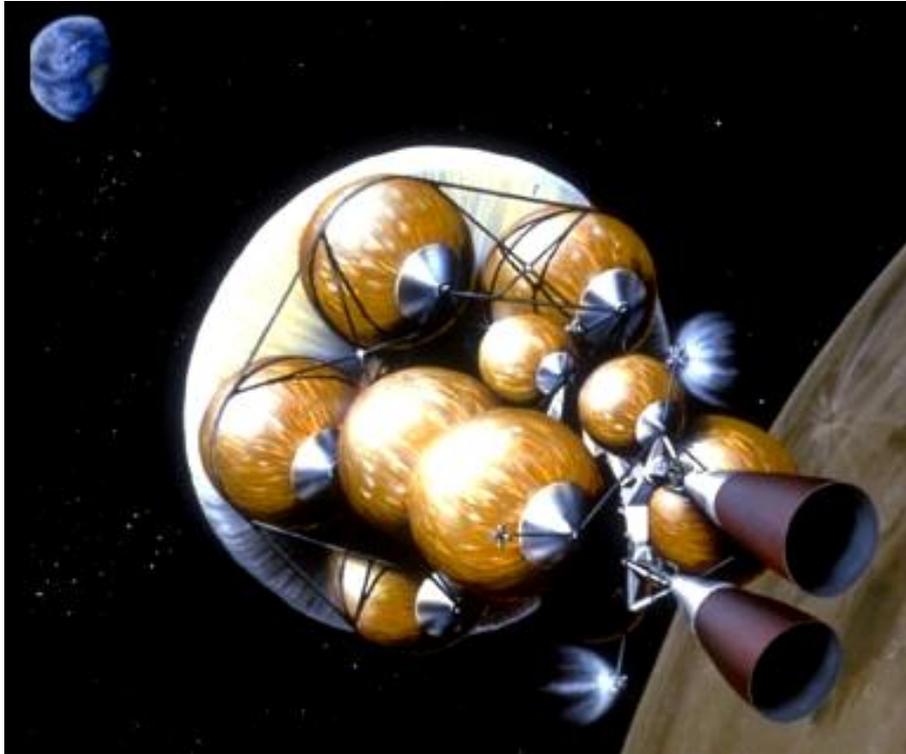


# Multi-phase Program

- Robotic prospecting and mapping missions
- Human-tended operations
  - In orbit infrastructure
  - Lunar mining and processing operations
  - Full lunar geo-physical prospecting after 2020
- Customer propellant transfer and sale
  - Just in time delivery
  - Favorable terms for advance bulk-buy purchases
- Spin-off services and facilities



# Cis-Lunar Transportation



An inflatable tug based on the Moon will deliver water to Earth orbit.

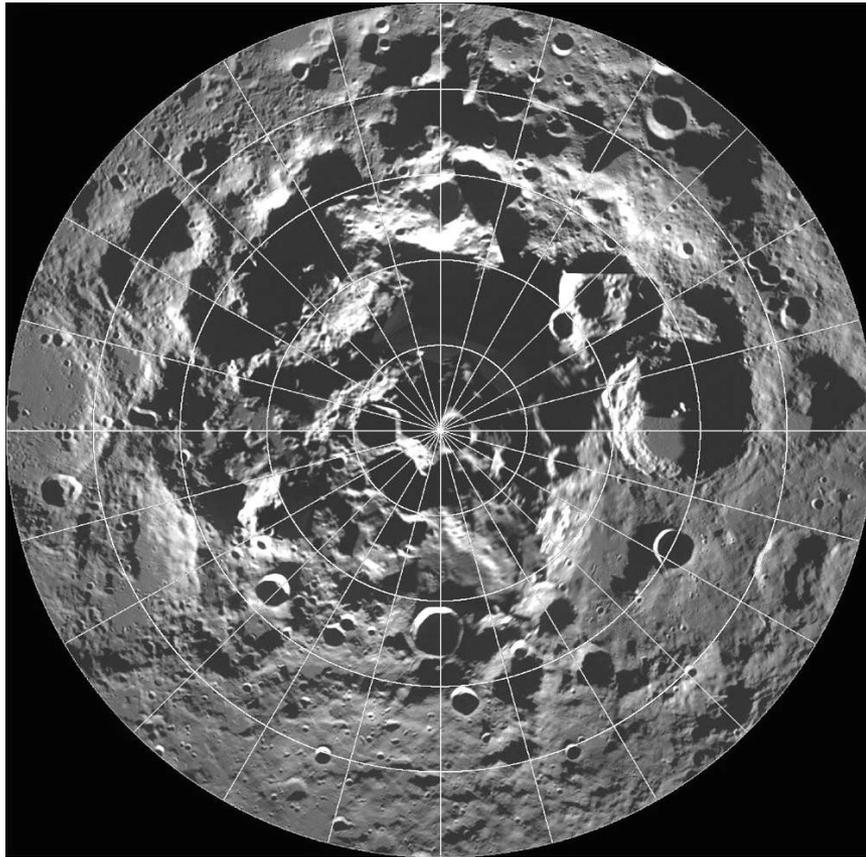


Inflatable “Ore” barges will store water and propellants in orbit.

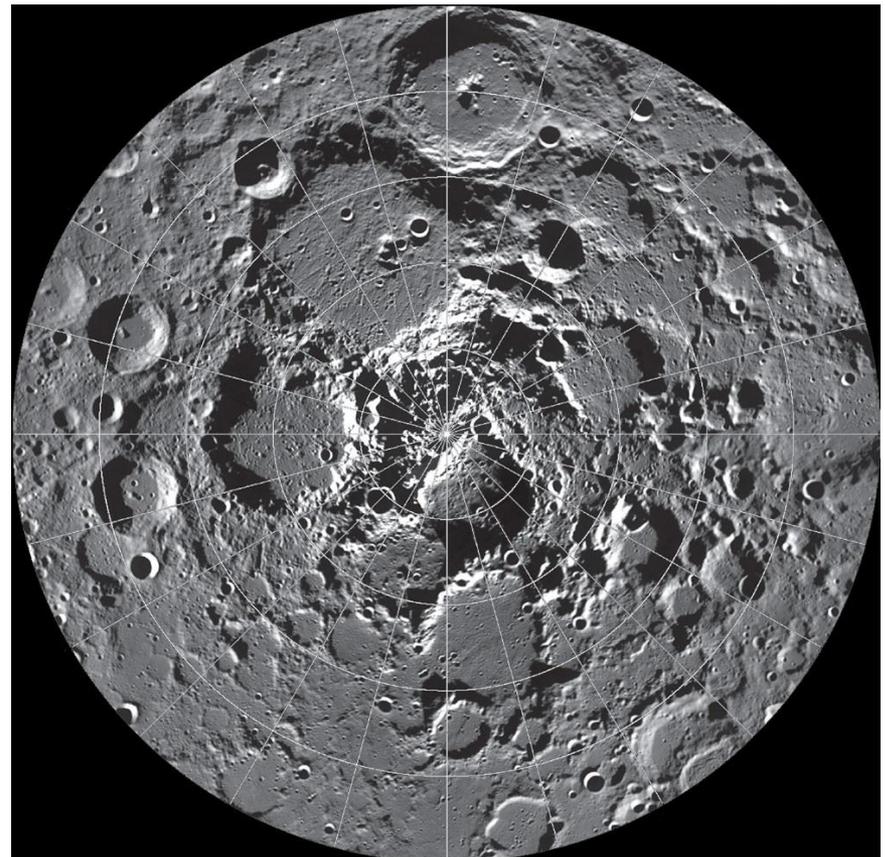


# Lunar Poles with Ice

**South Pole**

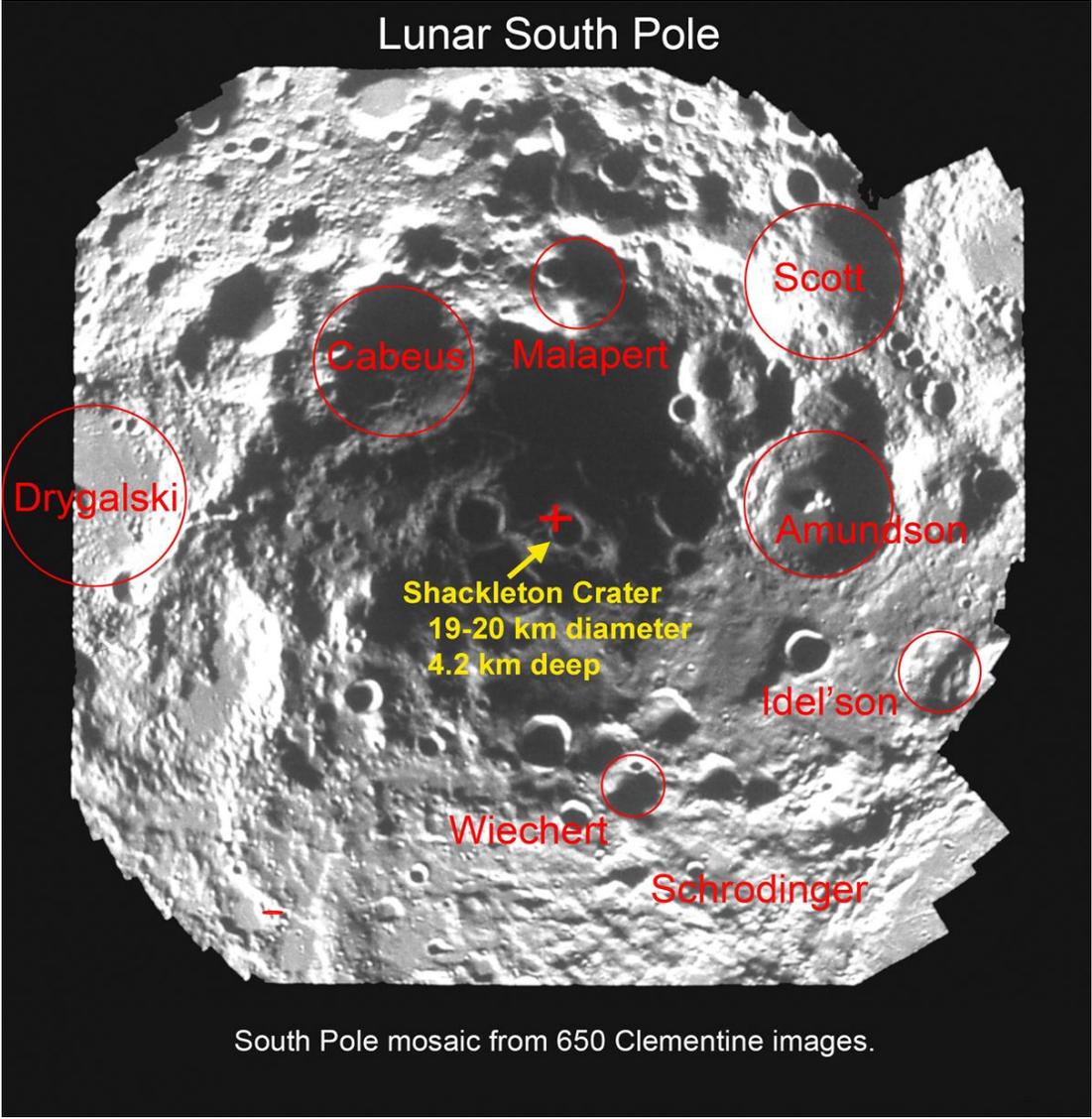


**North Pole**





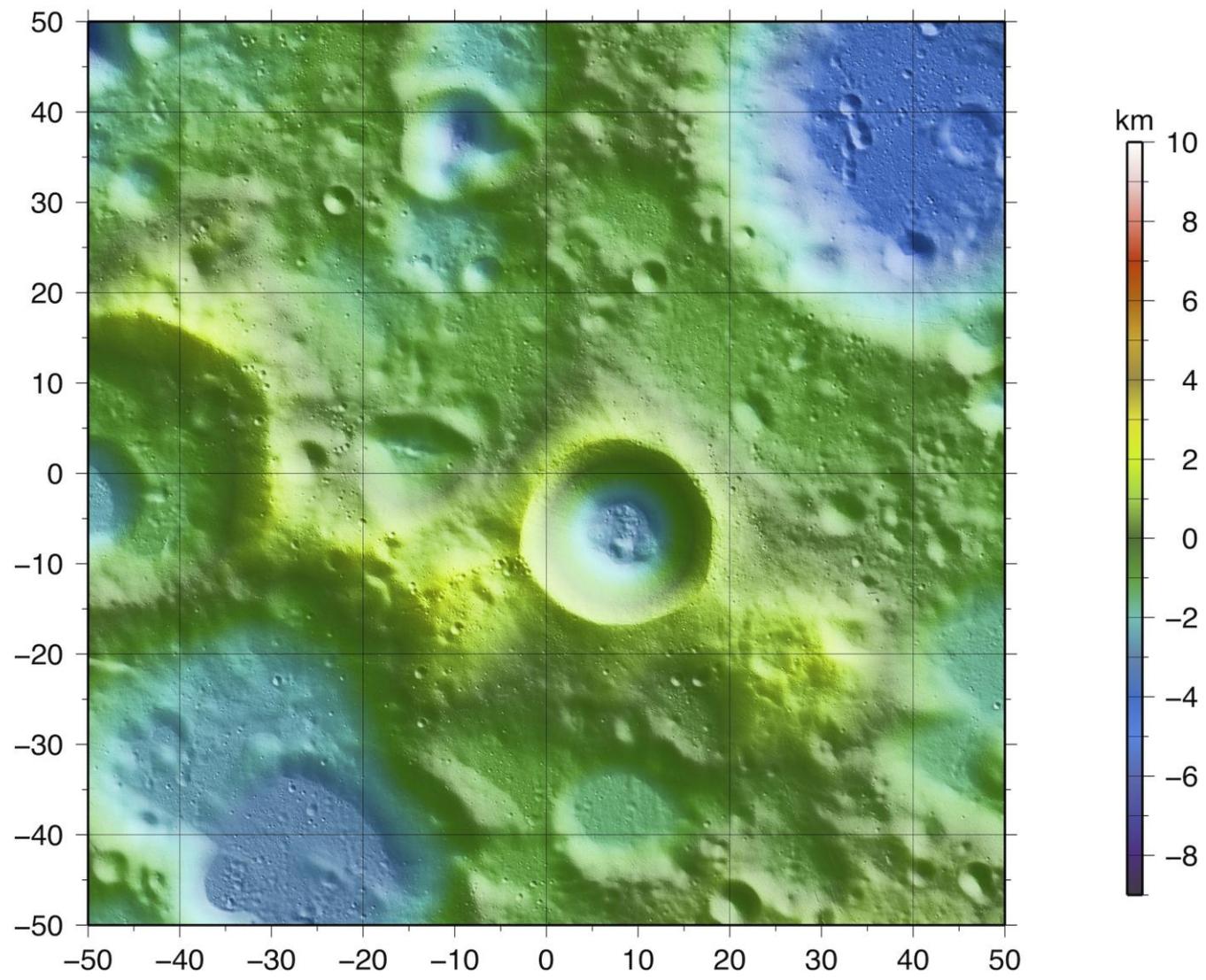
# Shackleton Crater



South Pole mosaic from 650 Clementine images.



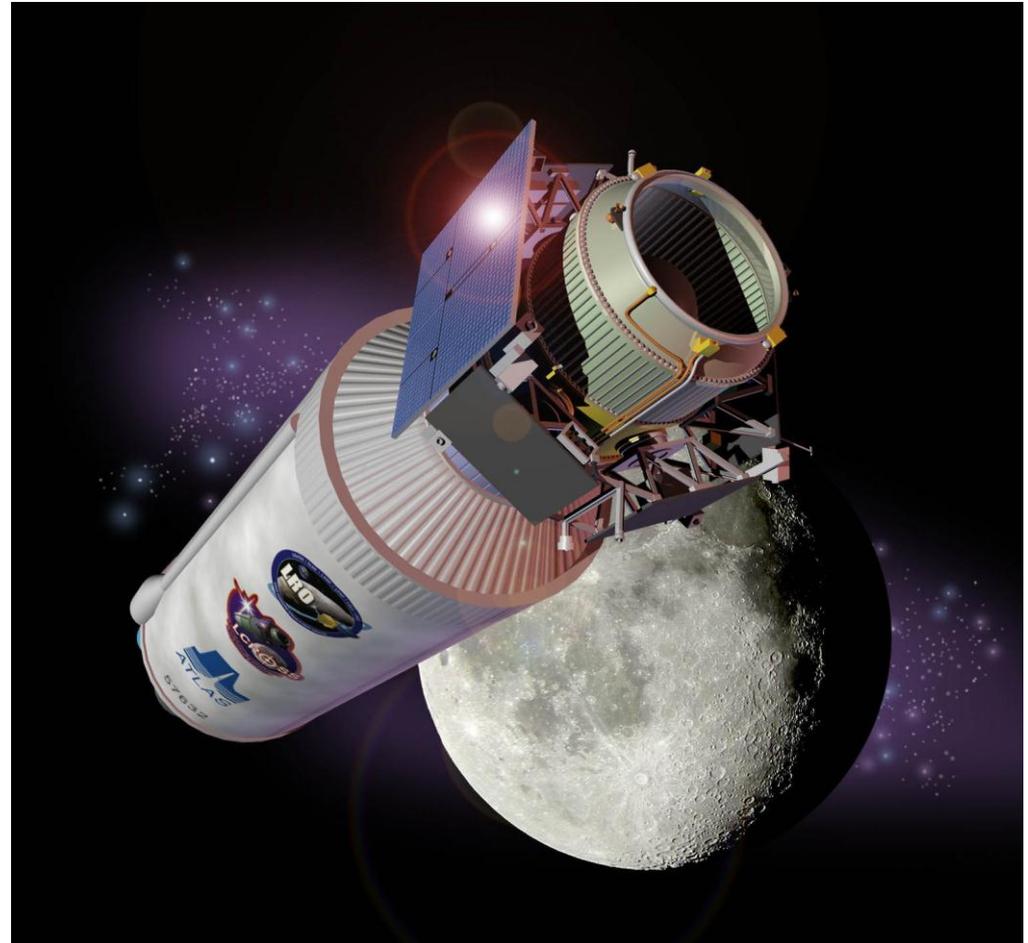
# Shackleton Crater





# Water Discovery

- Billions of tons of ice estimated to exist at the Lunar Poles
- Trapped in dark, cold craters
- Most hostile places in this Solar System other than the Sun
- Ready for in situ prospecting by SEC



***US (NASA), Japan (JAXA), India (ISRO)***



# Primary Ice-Derived Products

- Water
  - Products for human consumption, hygiene, aqua/agriculture, life, radiation shielding, habitat insulation, cargo
- Electrolysis
  - Gaseous oxygen and hydrogen
  - Products for life support, fuel cells (power), heating and welding
- Liquefaction
  - Liquid oxygen and hydrogen
  - Products for rocket propellants and fuel cells
- Chemical Processing
  - Highly pure hydrogen peroxide
  - Product for catalytic on-demand propulsion



# Value Proposition

- Access to space is incredibly expensive
  - >\$5,000/kg LEO
  - >\$80,000/kg Lunar
  - Major barrier to business expansion off Earth
  - SpaceX and others attempting to reduce launch costs
  - However, 85-95% of all mass going beyond LEO is propellant
  - Why pay the severe gravity/atmospheric drag penalty when you don't have to?
- SEC will provide propellant services *in space* to all customers on demand in unlimited quantities
  - Significantly cheaper (\$/kg) than anything launched from Earth
- Potential \$ trillion business within 10 years of operations
- Huge business multiplier effect for those who use our propellants and services



# Challenges

- Technology
  - Ultra cold (30K), space vacuum machine/human ops
    - Rovers, drillers, transporters, habitats, processors, miners, movers
    - Water separation
    - Volatiles separation, gasification, liquefaction, storage
    - Cryogenic (LOX/LH2) storage and refueling
  - Power generation and transfer (solar, laser, microwave, nuclear)
  - Reusable propulsion systems
  - Robust, reliable communications
  - Turnkey reliable, rapidly-reconfigurable transport systems
  - Smart, risk tolerant operations
- Policy/Regulations
- Capital
- Market development



# Take-Away

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# T-Minus and Counting





**Thank You**

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***“Accelerating Industrialization of Space”***