

moon



express

# Pioneering the Lunar Frontier

PTMSS'13 / CIM Toronto

May 6 2013

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*Carlton Ray*

PHOTOGRAPHY CR



# Eons of Asteroid Bombardment Created Earth's Resources

The Earth was molten for much of its early history, as a result, most of the heavy metals sunk to its core.



# Asteroid Bombardment also Created Our Lunar Resources

**Lunar resources exist for the same reason that Earth resources exist**

**The Moon is a child of Earth.**

**The Moon cooled faster than Earth, and most asteroid resources are on or near the surface.**

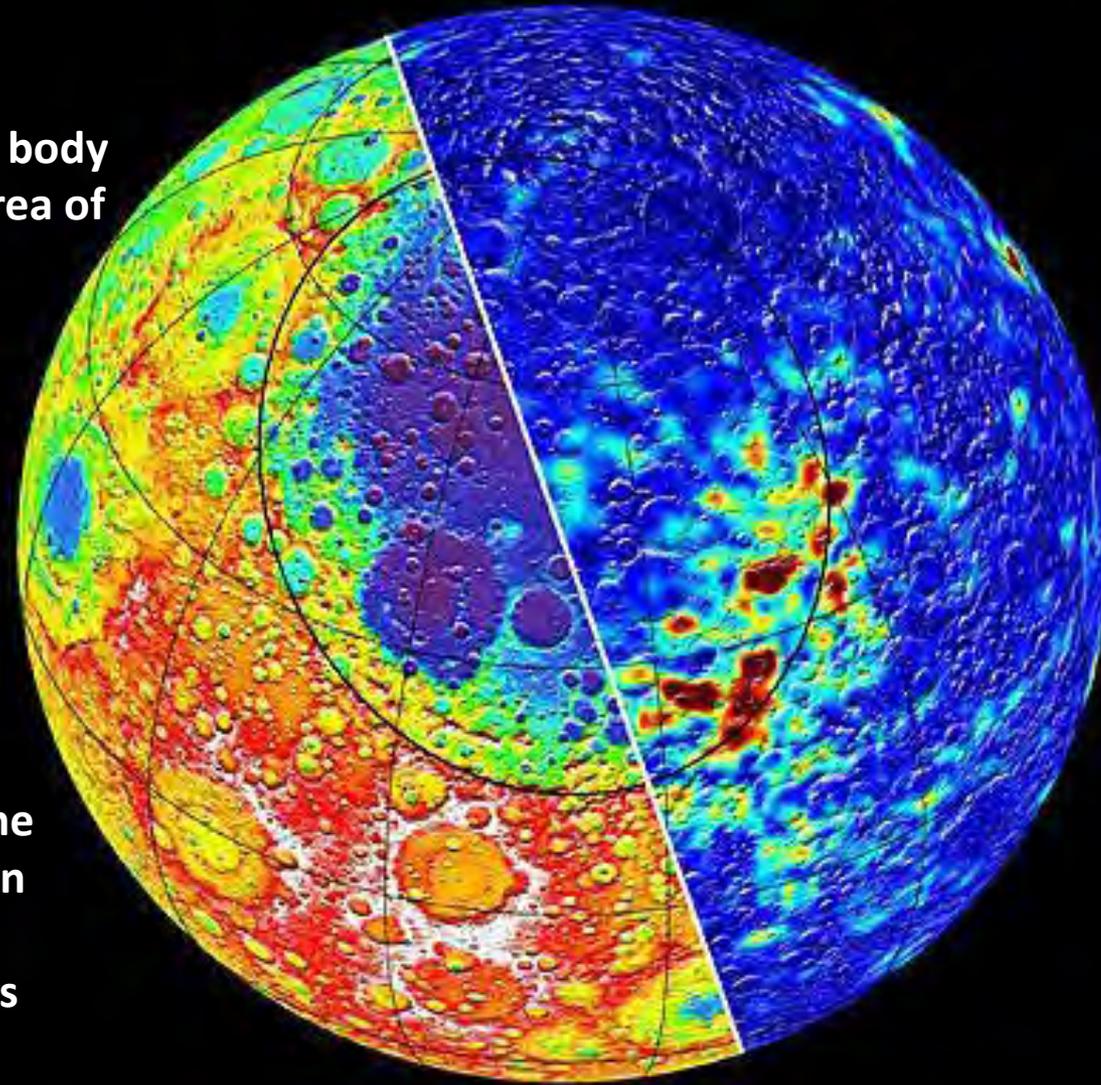
**There could be more platinum group metals on the surface of the Moon than all the reserves of Earth.**



# The Moon is an Aggregator of Accessible Asteroid Resources

The Moon is basically an ore body with the land area of the Americas.

Magnetic anomalies on the Moon have been correlated to asteroid impacts



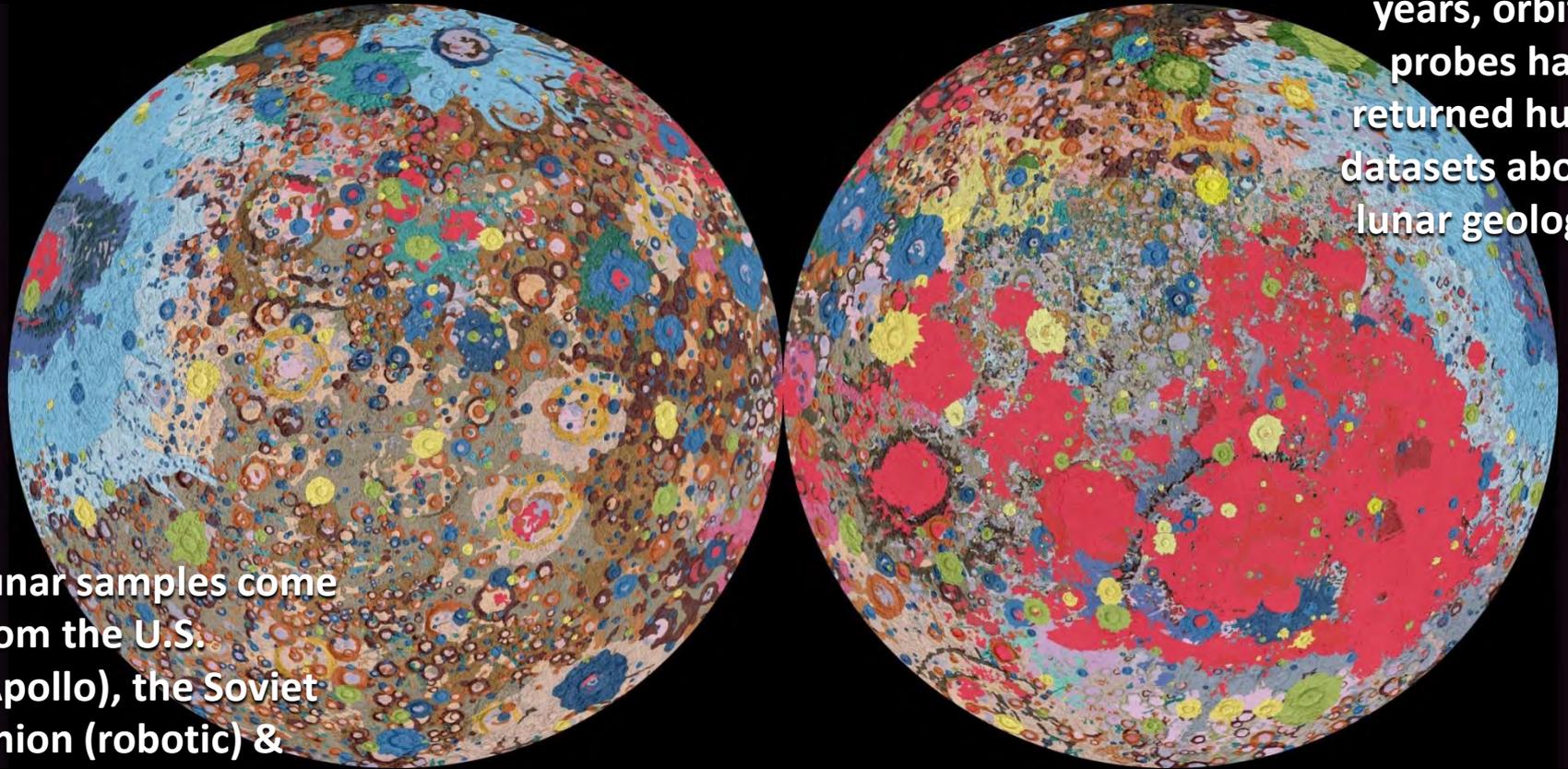
The Moon is an asteroid processing machine.

'Mining asteroids' is most effectively done on the Moon because of:

- GRAVITY.
- PROXIMITY.
- KNOWN TECHNOLOGY.



# The Moon's Geology is Well Mapped and Partially Sampled



Over the last 15 years, orbital probes have returned huge datasets about lunar geology.

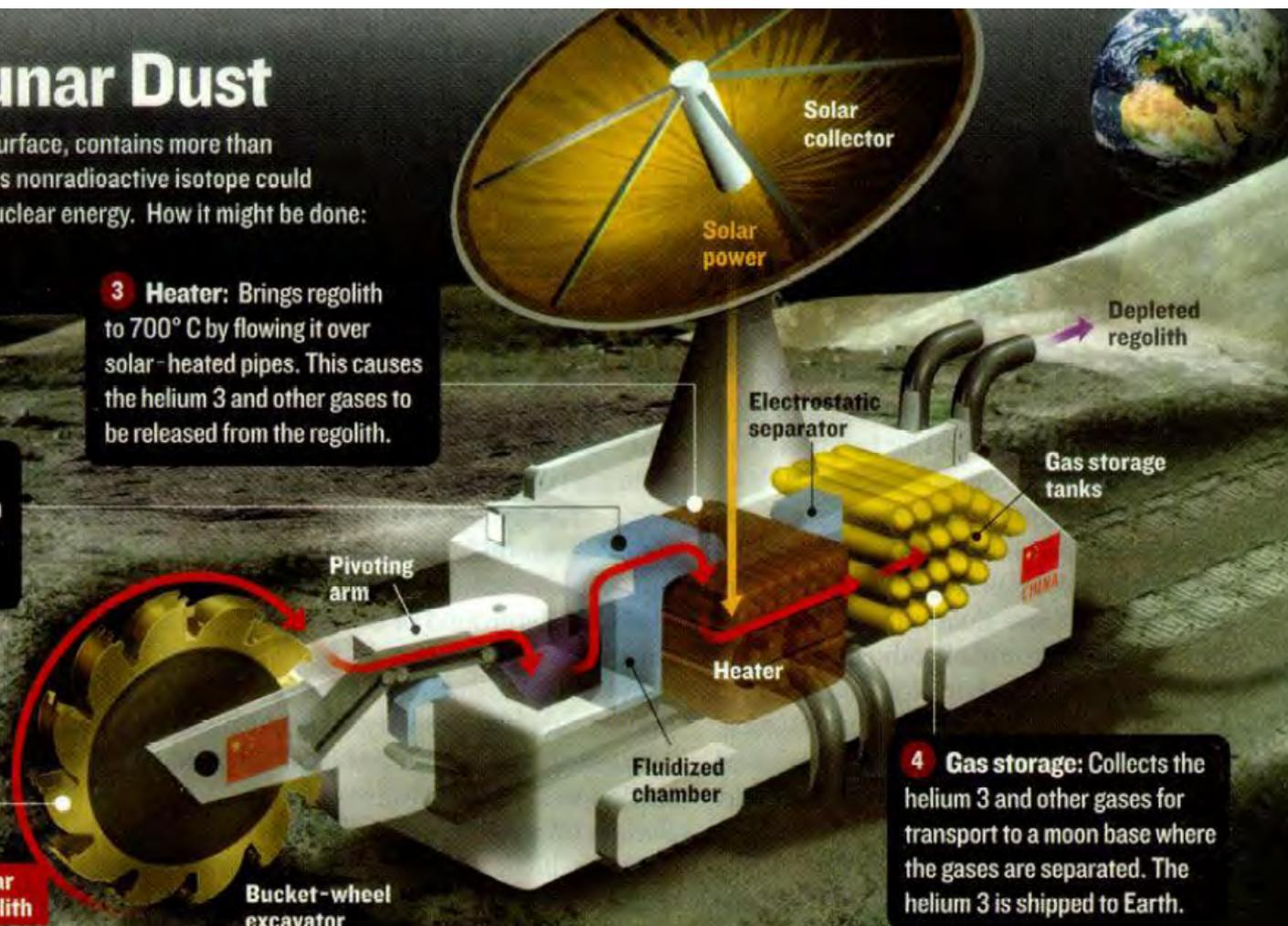
Lunar samples come from the U.S. (Apollo), the Soviet Union (robotic) & meteorites



# The Moon's Surface Contains >1 Million Tons of Helium 3

## Mining the Lunar Dust

Regolith, the loose soil on the moon's surface, contains more than 1 million tons of helium 3. In theory, this nonradioactive isotope could provide an abundant source of clean nuclear energy. How it might be done:



**2 Fluidized chamber:** Removes all grains larger than 100 microns. Excess regolith is returned to the surface.

**3 Heater:** Brings regolith to 700° C by flowing it over solar-heated pipes. This causes the helium 3 and other gases to be released from the regolith.

**1 Bucket wheel:** Moves the regolith onto a lifting belt to sift out large stones and keep only grains smaller than one millimeter in diameter.

**4 Gas storage:** Collects the helium 3 and other gases for transport to a moon base where the gases are separated. The helium 3 is shipped to Earth.

Lunar regolith

Bucket-wheel excavator

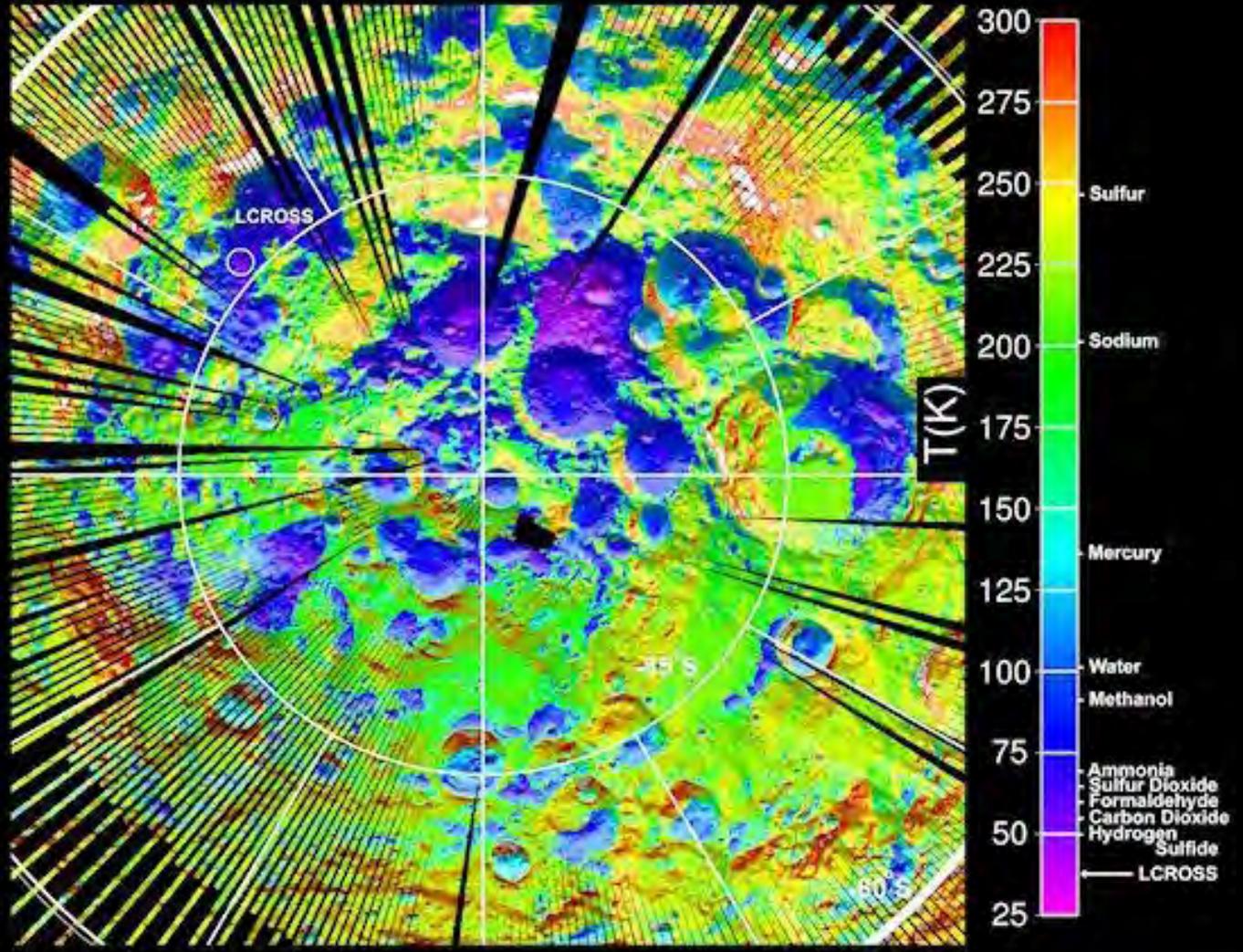
SOURCE: UNIVERSITY OF WISCONSIN \* MADISON FUSION TECHNOLOGY INSTITUTE GRAPHIC BY STANFORD KAY-NEWSWEEK



# Water on the Moon Creates the Economics of Lunar Resources

Permanently shadowed craters on the Moon are “Cold traps” for frozen water.

“Mining” water will be the 1<sup>st</sup> precious lunar resource that will change the economics of the Moon and the entire Solar System





# Welcome to the Moonrush

We are looking at the Moon as entrepreneurs, finding scalable opportunity in today's markets that bridge to a new frontier of massive economic resources for planet Earth.





# Welcome to Moon Express!

We're a **lunar resources** company with massive economic opportunity and early **profitable on-ramps** to commercial lunar **transportation and operations**.

We are **partnered with NASA** and a leading contender to win the \$30M Google Lunar X PRIZE challenge.





# The Big Picture

We're on a trajectory to intercept and dominate rapid market change in the U.S. and world demand for **lunar access** over next 1-5 years.

We have a long term goal of opening up and profiting from **lunar resources** for the benefit and security of Earth and our future in space.

**EXPLORE**

**PROSPER**

**SECURE**

2015

2020

2030





# Massive Economic Opportunity

The Moon has massive opportunities for economic value to Earth, including precious planetary resources for use on Earth and in space.

But the political will, technology, science, and economics were not ready during the last 40 years since Apollo.

New conditions create an opportunity for commercial on-ramps...

***The Technology, Science, Economics, and Politics are now right.***



# A New Global Moon Race

**China** is sending a lander to the Moon in late 2013 – and has plans to build a Moon base.

**Russia** has announced plans to return to the Moon and also build a Moon base.

**Europe, Japan and India** have all successfully sent lunar orbiters to the Moon in the last decade.

**Iran, South Korea and the U.K.** have announced plans for missions to the Moon.

The **U.S.** cancelled it's lunar landing plans in 2010 in favor of flexible destinations and public/private partnerships for lunar access.





# U.S. Commercial Lunar Emerges

The White House has embraced **commercial space** transportation and NASA has partnered with Moon Express to help put the U.S. back on the Moon.

NASA and the DoD have issued **>\$3B** in contracts to the commercial space sector in the last 3yrs. This commercial paradigm is being extended to the Moon, and **>\$1B** in potential lunar 'orphan payloads' have been identified.

NASA has already awarded Moon Express a **\$10M contract** under its first commercial lunar program.

2000 \_\_\_\_\_ 2015 \_\_\_\_\_ 2020



14



Confidential & Proprietary Information



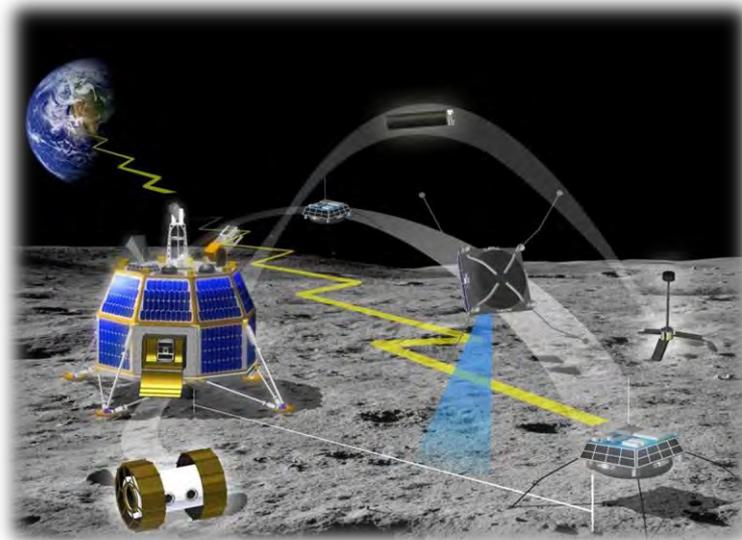
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# Today's Moon Markets (\$B)

2013-2020

- **Supporting** NASA & international exploration (*NOW*)
- **Delivering** science & commercial payloads (*NOW*)
- **Returning** samples for science and consumer markets (*NEXT*)
- **Strategic** lunar access & rapid response (*NASCENT*)





# Future Moon Markets (\$T)

*2020-2030*

- **Resources:** prospecting & mining operations
- **Energy:** Facilitating space-based fuels & solar power
- **Industry:** Space-based manufacturing and R&D
- **People:** Serving space tourism & entertainment markets





# How Much is a Moonrock?

~\$2M per gram  
in 1993 dollars

(~\$3.2M per gram  
in 2012 dollars)

**Allowing for a 2/3  
market dilution, a  
1 kilogram lunar  
sample returned  
to Earth could be  
worth >\$1B today**



**Moon rocks in numbers**

- 3** sources of moon rock (US Apollo missions; Soviet Luna missions; meteorites)
- 270** Rocks given as gifts to nations of the world
- 160** Total missing rocks from Apollo 11 and 17 missions
- 24** missing in the US

**\$5m (£3.1m)** offered on black market for Honduras goodwill moon rock

**\$442,500 (£280,800)** Price of 0.2 grams of lunar dust from Luna 16 mission in 1993

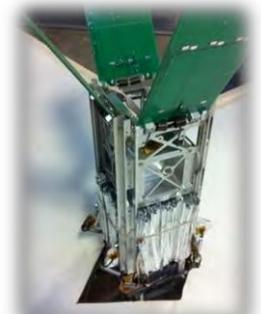


# Moon Express Leverages Disruptive Technologies

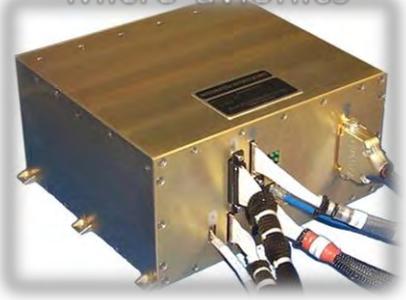
There are four **disruptive technology** areas that lead to our opportunity:

1. **Commercial rockets**
2. **Avionics micro-miniaturization**
3. **Advanced propulsion systems**
4. **Micro-lander technology**

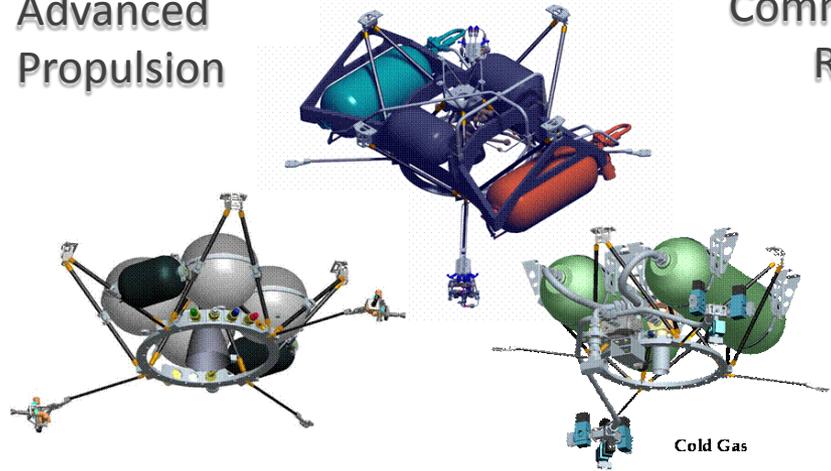
Micro-Lander Technology



Micro-avionics



Advanced Propulsion



Commercial Rockets





# NASA is our Partner and our Customer



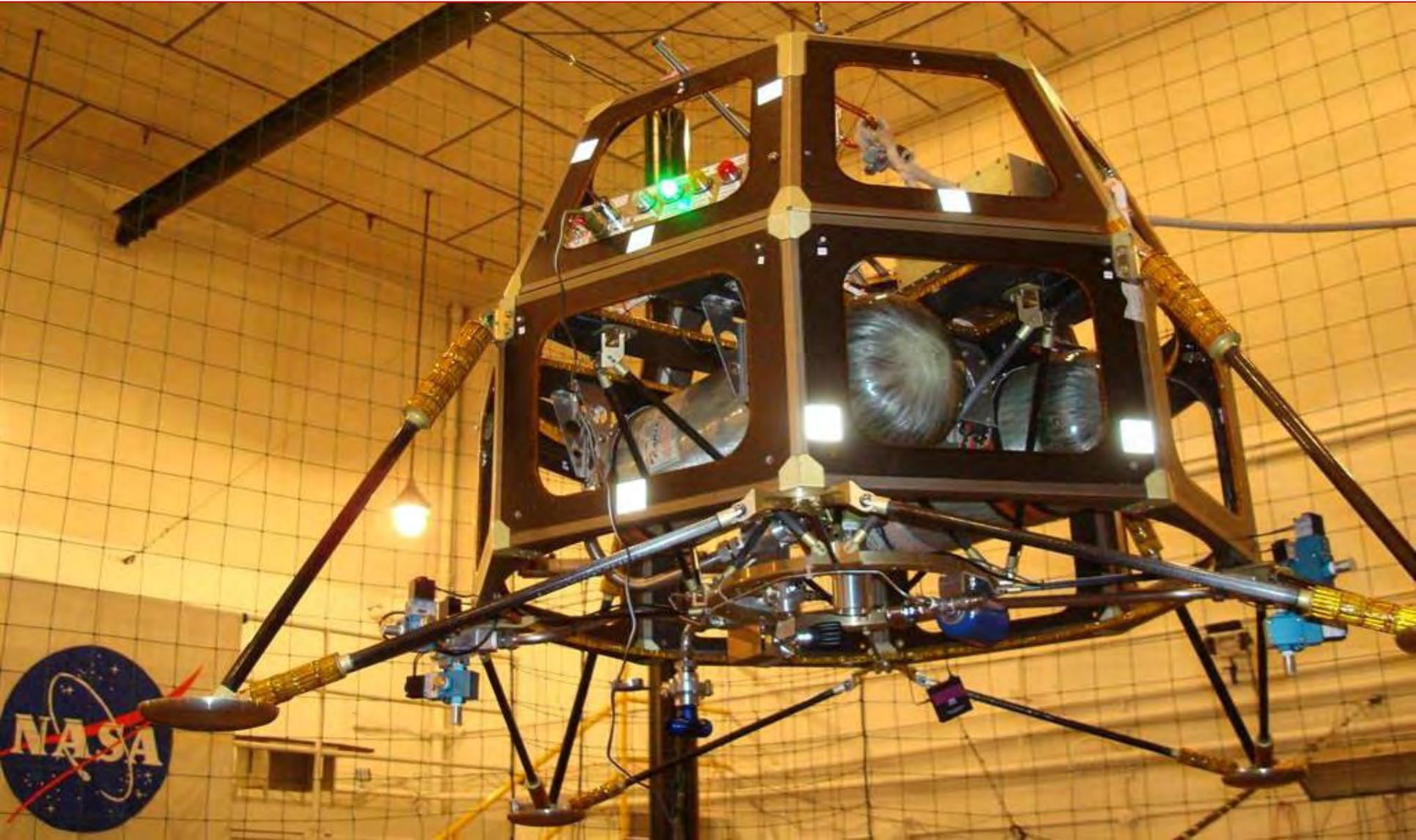
Moon Express entered into a **partnership** with NASA in October 2010 for the development of our robotic lunar lander system.

We were also **selected** by NASA in 2010 for its \$30M Innovative Lunar Demonstrations Data (ILDD) program, and have successfully achieved 3 of its milestone awards.





# We Have A Proven Lander Test Vehicle (derived from NASA Ames HTV/CSB)





# We Have A Unique Lander Test Facility

(commissioned in partnership with NASA)





# We Have Access to NASA's Facilities (Through our Space Act Agreement at NASA Ames)



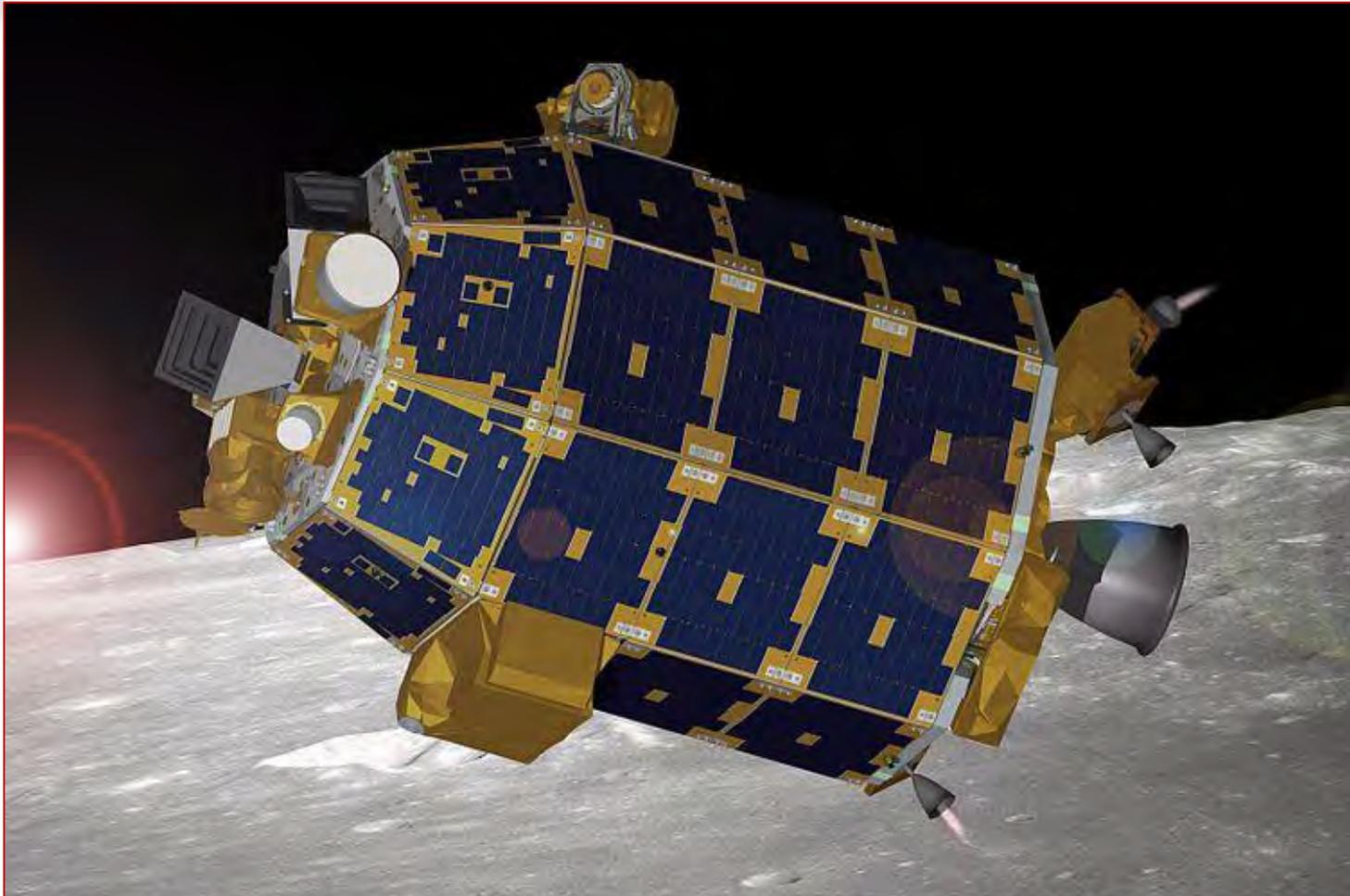


# We Are Harvesting NASA's Know-How (LADEE is our sister-spacecraft at NASA Ames)





# We'll Learn from NASA's LADEE Mission (Our sister-spacecraft is launching in August 2013)



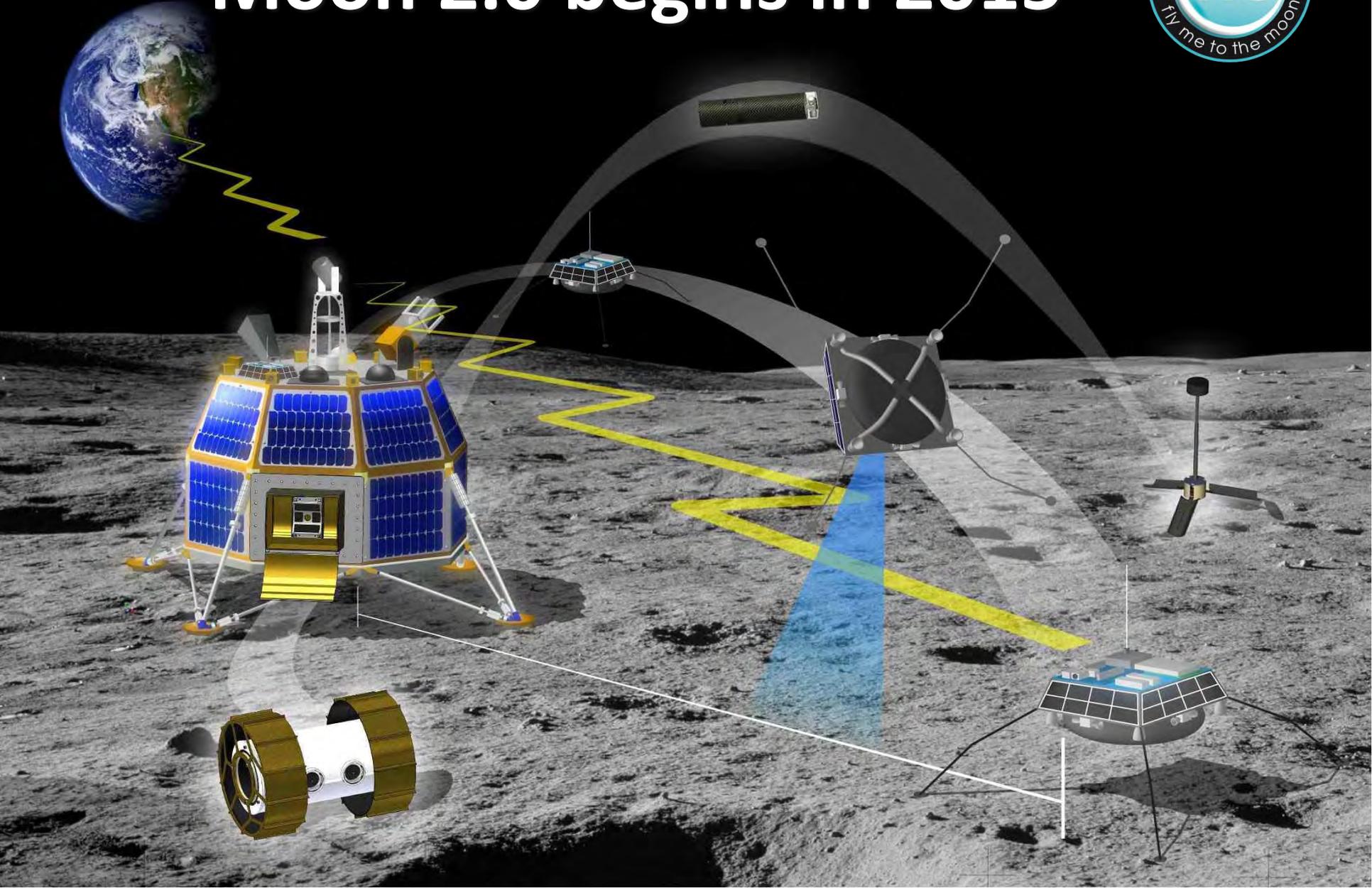
## Lunar Atmosphere and Dust Environment Explorer

NASA Ames Research Center / NASA Goddard Space Flight Center



ress, Inc.

# Moon 2.0 begins in 2015





# Driven by Great People





# Padawan:Obiwan Ratio = 3:1

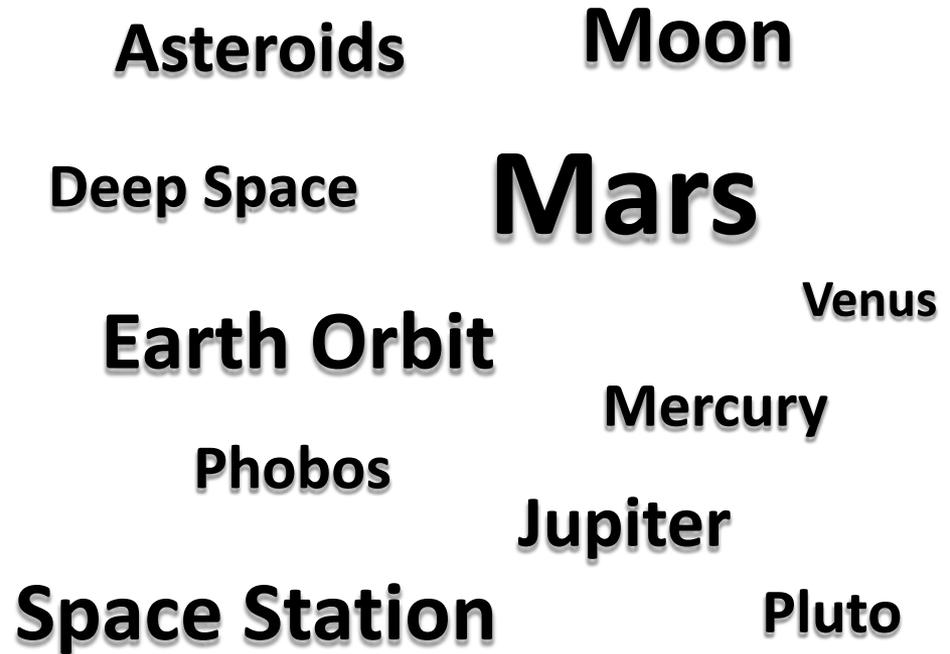
**~30 STAFF ON PAYROLL AS OF Q1 2013**

**Moon Express Team experience totals over 100 missions to most destinations in the Solar System:**

## DEGREES

Bachelors	39%
Masters	43%
PhDs	17%

Under 30	61%
Space Exp	~168 yrs
Missions	~111





# The Executive Team

Proven track records of business & technical experience

## Board



**Naveen Jain**  
*Cofounder, Chairman*  
inome, Infospace, Microsoft  
X PRIZE, Singularity U



**Dr. Robert (Bob) Richards**  
*Cofounder, Pres & CEO*  
Mars Phoenix, XSS-11  
ISU, Singularity U, Optech



**Dr. Barney Pell**  
*Cofounder, Vice Chairman*  
NASA Ames/DS-1, MER, Microsoft  
PowerSet, QuickPay, Singularity U

## Management Team



**Jim Cantrell**  
*VP Flight Programs*  
JPL, CNES, SpaceX, Cosmos 1  
Space Dynamics Laboratory



**Daven Maharaj**  
*VP Operations*  
Mars Phoenix, XSS-11  
Space Shuttle, Optech



**Michael Tanne**  
*VP Strategic*  
AdForce, Xdegrees, Verity  
LinkedIn, ICON Aircraft



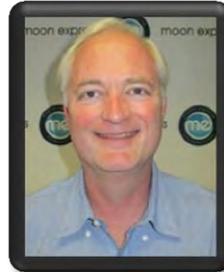
# Veteran Technical Leads

With over 100 missions of combined space experience



**Tim Pickens**

*Chief Propulsion Engineer*  
SpaceShipOne (propulsion lead), Dynetics,  
Orion Propulsion, Bigelow Aerospace



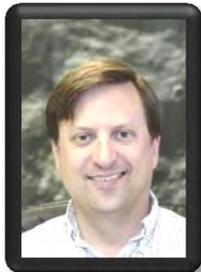
**Dr. James (Jimi) Crawford**

*CTO & SW Architect*  
Google, Mars Exploration  
Rovers (Spirit, Opportunity)



**Steve Bailey**

*Principal Systems Engineer*  
Orion, Mars Reconnaissance Orbiter,  
Pathfinder, Artemis Lander, Space Shuttle



**Adrian Adamson**

*Principal Avionics Engineer*  
Orion, Hubble Servicing, MoonRise,  
MRO, Phoenix, Odyssey Orbiter



**Jim Kaidy**

*Principal GNC Engineer*  
New Horizons, Messenger,  
LunarQuest



**Tom Gardner**

*Principal Mission Engineer*  
Lunar Explorer, Ares 1, EKV,  
Mars Explorer, Lunar Prospector



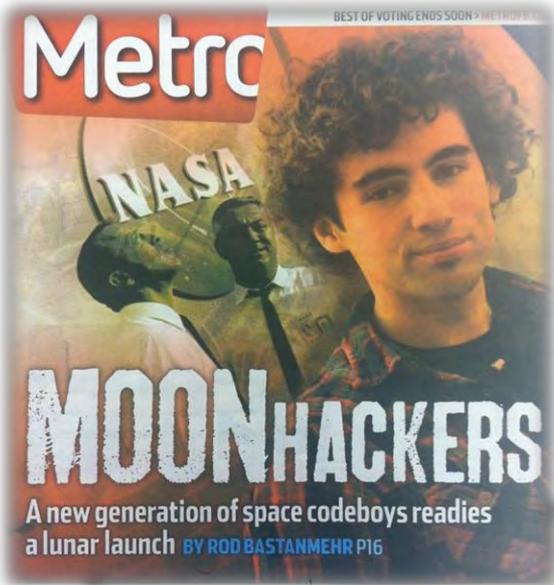
**John Evanyo**

*Principal Comm & Ops Engineer*  
NASA JUNO, GRAIL, STARDUST,  
Mars Surveyor Programs, NASA Orion



# Vibrant MOONHACKERS

Our “under 30’s” compliment our “seniors” ~3:1





# We're Going to the Moon!



# QUESTIONS?



**Bob Richards**  
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[@Bob\\_Richards](https://twitter.com/Bob_Richards)

