

RETURN TO THE LUNAR SURFACE

Lunar Exploration Campaign

COMMERCIAL CREW & CARGO

Next “COTS” Project?

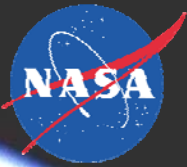


Commercial Development Summit - Lunar '08

Robert M. Kelso
Manager, Commercial Space Development
NASA-JSC, Commercial Crew/Cargo Program
May 13, 2008

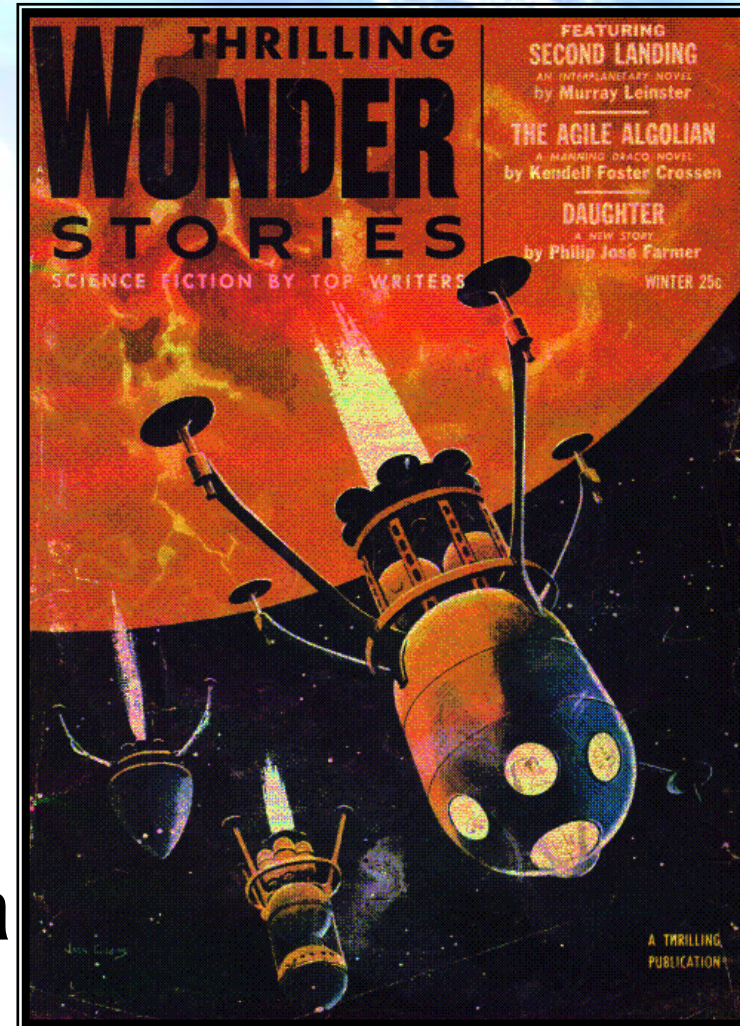
National Aeronautics and Space Administration

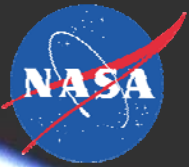




Executive Overview

- **Historical perspective**
- **State of renewed interest in the Moon**
- **Commercial lunar payload delivery - establishing an aggressive lunar science and technology campaign enabled by commercial leveraging with NASA...to a near-term technology demonstration on the lunar surface.**





Historical Perspective

- **Spring 2007 – trip to Hq Mission Directorates**
- **Aug 2007 – request for LESC white paper**
 - Ames, JSC, GSFC, industry, LPI, NASA headquarters
- **Sept 2007 - Google Lunar X- Prize**
- **March 2008 – NASA Lunar Science Institute**
- **April 2008 - NASA Acquisition of Lunar Payload Delivery and Lunar Data**



RENEWED INTEREST IN THE MOON

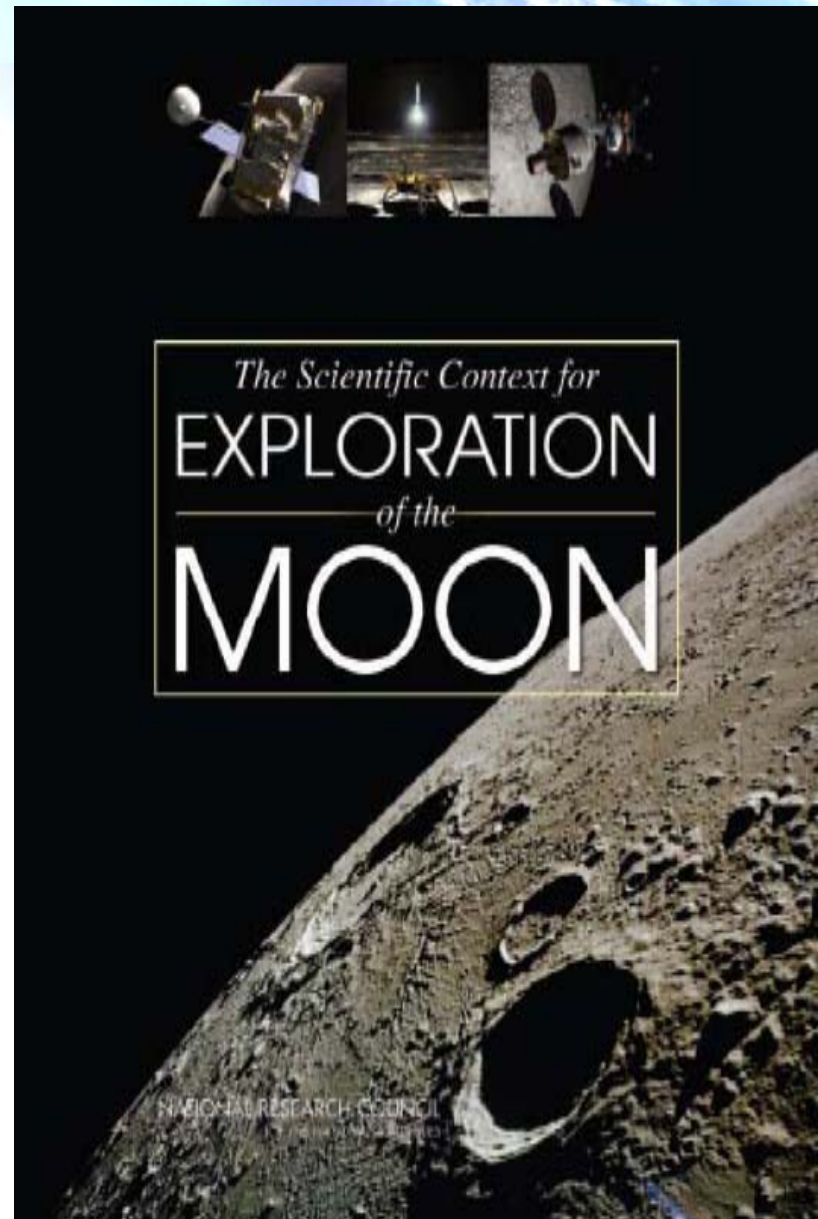
#1 Scientific Interests

• **National Research Council Report:**
“ Scientific Context for Exploration of the Moon”

• Asked by NASA SMD to provide guidance on the scientific challenges and opportunities enabled by a sustained program of robotic and human exploration of the Moon during the period 2008-2023 and beyond

Key Science Findings:

- Exploration of the **South Pole-Aitken Basin** remains a priority
- **Diversity of lunar samples** is required for major advances
- The Moon may provide a **unique location for observation and study of Earth, near-Earth space, and the universe**



COMMERCIAL CREW & CARGO

SMD LUNAR SCIENCE ROBOTIC MISSION INITIATIVE



Terrestrial Planet
Differentiation
& Evolution

Early
Earth/Moon
System

Lunar
Science

Solar System
Impact Record

Lunar
Environment

"It is the unanimous consensus of the (NRC) committee that the Moon offers profound scientific value....A vigorous near term robotic exploration program providing global access is central to the next phase of scientific exploration of the Moon and is necessary both to prepare for the efficient utilization of human presence and to maintain scientific momentum as this major national program moves forward."

-The Scientific Context for Exploration of the Moon, National Research Council, Space Studies Board, 2007.



RENEWED INTEREST IN THE MOON

#2 Foreign Interest

KAGUYA Captures The Earth Rising Over The Moon ...first Hi Def image from moon Nov 14, 2007



Congressman Nick Lampson comment

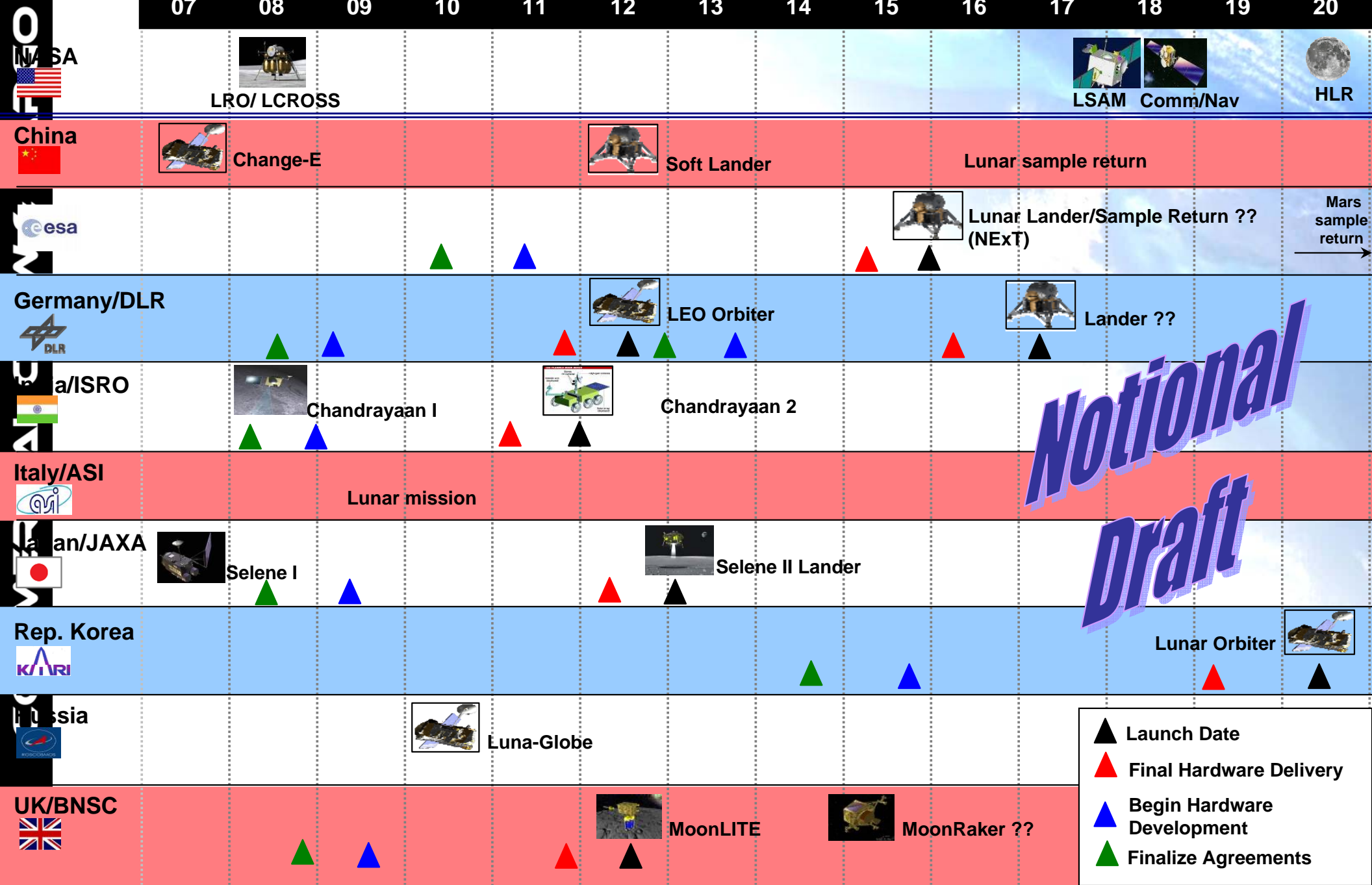
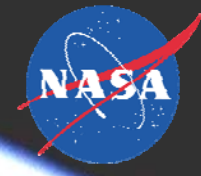
"We need to keep a focus on science in this country. Other countries are taking advantage of opportunities the U.S. isn't, for example – China's recent lunar launch and Japan's similar activities. We are losing technological ground".

Comments to BAHEP Aerospace
Adv. Cmte, 11/7/2007

**Japan's next mission in 2012 will
aim at landing
a robot on the moon's surface**

© JAXA/NHK

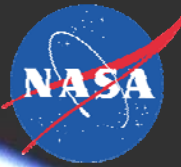
INTERNATIONAL LUNAR ROBOTIC MISSION PLANS



Notional Draft

- ▲ Launch Date
- ▲ Final Hardware Delivery
- ▲ Begin Hardware Development
- ▲ Finalize Agreements

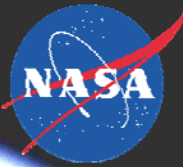
THE PROPOSED INTERNATIONAL LUNAR NETWORK (ILN)



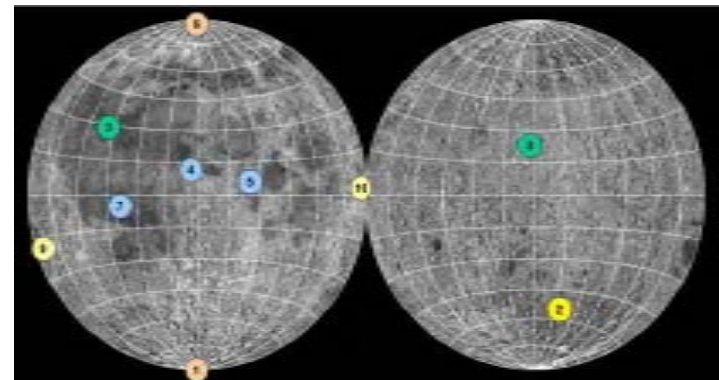
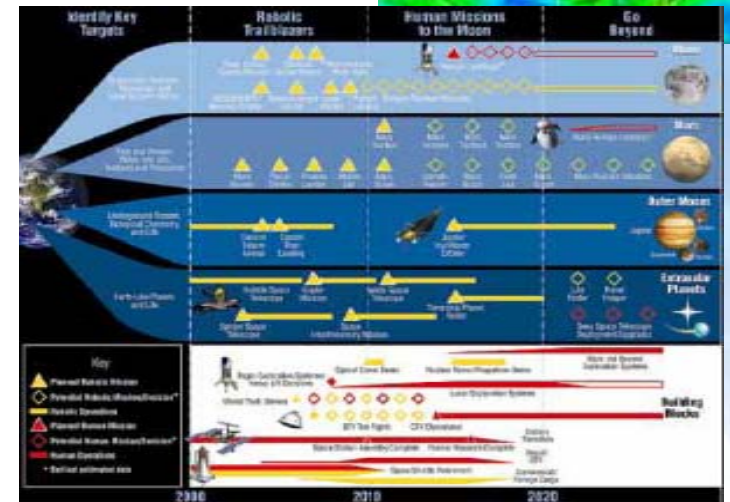
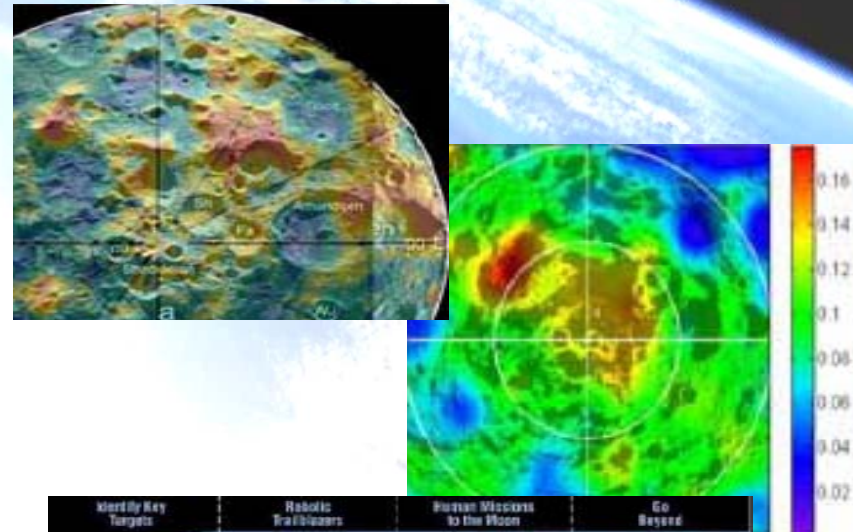
- ❑ NASA's Science Mission Directorate is initiating an effort to coordinate future lunar landed missions into an International Lunar Network (ILN).
- ❑ The ILN is designed to emplace 6-8 stations on the lunar surface, forming a second-generation geophysical network.
- ❑ Individual stations could be fixed or mobile.
- ❑ Each ILN station would fly a core set of instrument types (e.g., seismic, laser retro-reflector, heat flow) requiring broad geographical distribution on the Moon.
- ❑ Each ILN station could also include additional passive, active, ISRU, or engineering experiments, as desired by each sponsoring space agency.

RENEWED INTEREST IN THE MOON

#3 Sustainability / Technology



- Why Early Robotic Scientific Exploration?
- Sustain the Vision for Space Exploration
 - Sustain program with cadence of visible milestones
- Emplacement of assets
- Risk mitigation





RENEWED INTEREST IN THE MOON

#4 Commercial Interest

- **Market Supply side - transportation**
 - GLXP: Astrobotic Tech, Odyssey Moon, others
- **Market Demand side – transportation**
 1. NASA – Science
 2. NASA – Applied science, plus technology on-ramp
 3. Foreign countries
 4. Commercial users
 - Communication nodes and infrastructure
 - Power and mobility infrastructure
 - Cargo transport services
 - Entertainment and education
 - Observatories
 5. Other government agencies



Fundamental Change for NASA

COMMERCIAL CREW & CARGO

Apollo Model

From NASA as the customer funding prime contractors on a cost plus fixed fee basis



Open Architecture: Infrastructure
Open for Potential External Cooperation

- Lander and ascent vehicle
- EVA system
 - CEV and Initial Surface capability
 - Long duration surface suit
- Power
 - Basic power
 - Augmented
- Habitation
- Mobility
 - Basic rover
 - Pressurized rover
 - Other: mules, regolith moving, module unloading
- Navigation and Communication
 - Basic mission support
 - Augmented
 - High bandwidth
- ISRU
 - Characterization
 - Demos
 - Production

Robotic Missions

- LRO- Remote sensing and map development
- Basic environmental data
- Flight system validation (Descent and landing)
- Lander
 - Small sats
 - Rovers
 - Instrumentation
 - Materials identification and characterization for ISRU
 - ISRU demonstration
 - ISRU Production
 - Parallel missions
- Logistics Resupply
- Specific Capabilities
 - Drills, scoops, sample handling, arms
 - Logistics rover
 - Instrumentation
 - Components
 - Sample return

** US/NASA Developed hardware

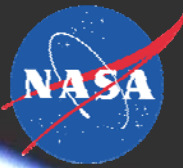
Implementing the Vision

Commercial – Leveraged (COTS) Model
To NASA as a customer and partner, working with other customers, financiers, and emerging space companies on fixed price basis to secure capabilities, services and products

Open Architecture: Infrastructure Open for Potential External Cooperation

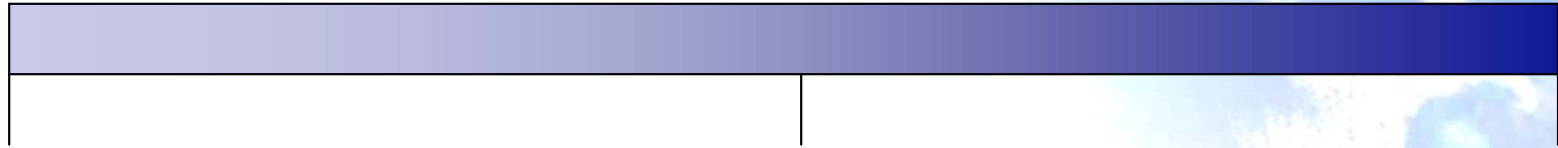
- **Lander and ascent vehicle**
- **EVA system**
 - CEV and Initial Surface capability
 - Long duration surface suit
- **Power**
 - Basic power
 - Augmented
- **Habitation**
- **Mobility**
 - Basic rover
 - Pressurized rover
 - Other; mules, regolith moving, module unloading
- **Navigation and Communication**
 - Basic mission support
 - Augmented
 - High bandwidth
- **ISRU**
 - Characterization
 - Demos
 - Production
- **Robotic Missions**
 - LRO- Remote sensing and map development
 - Basic environmental data
 - Flight system validation (Descent and landing)
 - Lander
 - Small sats
 - Rovers
 - Instrumentation
 - Materials identification and characterization for ISRU
 - ISRU demonstration
 - ISRU Production
 - Parallel missions
- **Logistics Resupply**
- **Specific Capabilities**
 - Drills, scoops, sample handling, arms
 - Logistics rover
 - Instrumentation
 - Components
 - Sample return

** US/NASA Developed hardware



Options for Commercial Participation in NASA Missions

Spectrum of Options for Commercial Participation



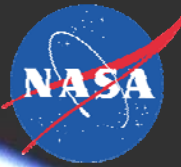
Lunar X-Prize
(Commercial funded and managed)

Odyssey Moon

Lunar Exploration
Science Campaign -
Regular Small Missions
to the Moon
(Hybrid model - NASA and commercial funding and management)

Lunar
Precursor
Robotic
Program
(NASA funded and managed)

- Lunar Comm/Nav
- Lunar Micro-Landers
- Lunar Observatories
- Lunar Sample Return (e.g. dust)
- ISS National Lab Science
- Earth Observations
- Sub-Orbital Observations
- Free Flyers



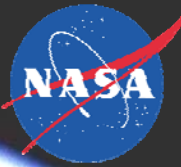
- **COTS Project executed in two phases:**

- Phase 1: Technical Development/Demonstration funded Space Act Agreements
- Phase 2: Competitive Procurement of Orbital Transportation Services

COTS Phase 1 is NOT a procurement or contract for products and services – It is NASA's catalyst for technology demonstrations where the potential high return on investment outweighs the associated financial risk

- **Lunar COTS**

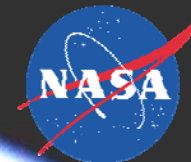
- Lunar COTS Phase 1 - GLXP essential provided LC Phase 1 funding for demonstration
- Lunar COTS Phase 2 - Be prepared for entering LC-Phase 2 once demo flight successful (procure services)
 - Similar to Commercial Resupply Services (CRS)



MISSION FEASIBILITY

- **Several low-cost private robotic missions to the Moon have been proposed in recent months**
- **Fully private companies have raised money and are procuring launch vehicles**
- **Industries outside of the traditional space markets have been approached and have shown strong interest**

MISSION FEASIBILITY: BlastOff!



COMMERCIAL CREW & CARGO

- **Entertainment and Media-driven business model**
- **Missions sending multiple rovers to Apollo sites**
- **Technology Demonstrations to create saleable legacy hardware**



Source: BlastOff!



MISSION FEASIBILITY: LunaCorp

- **Plan to land 440-pound (200-Kg) rover on the Moon**
 - Night-time operation
 - 4-foot drill
 - Science Instruments
- **Signed \$1M sponsorship deal with RadioShack**
- **Additional deal with RadioShack to create computer game**
- **Partnership with Carnegie Mellon University**



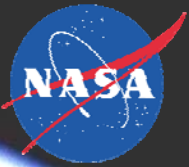
Source: LunaCorp



Possible Scenario for Lunar Science and Technology On-ramp

- (1) Establishing an aggressive lunar science/technology campaign to the lunar surface**
- (2) Lunar transportation enabled by commercial leveraging with NASA**
 - commercial delivery system**
- (3) Leading to a near-term technology demonstration on the surface.**



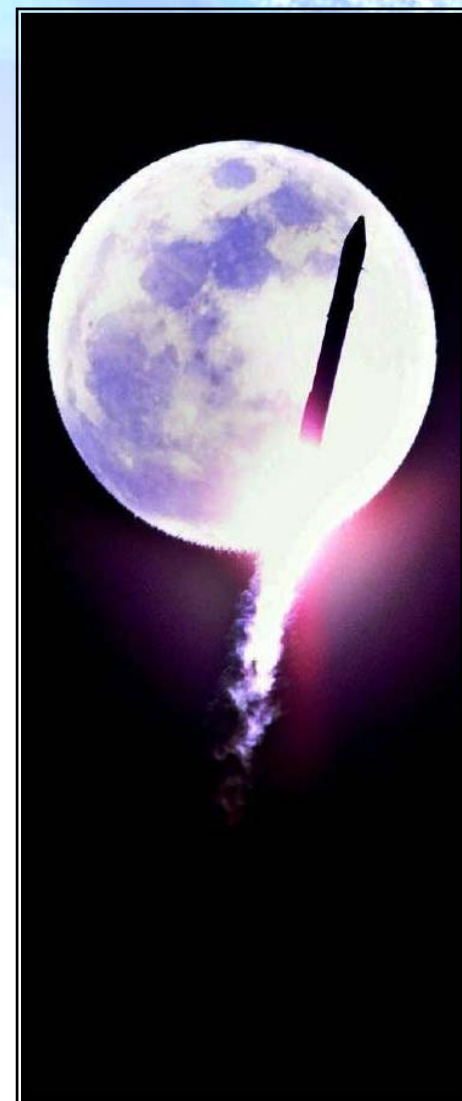


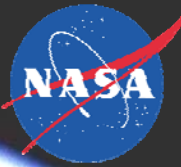
Lunar COTS

- **Small (\$100M)**
- **Frequent, multiple flights**
- **Commercially-leveraged: Open Competition for lunar transportation services**
- **Fixed price service**
- **Industry provide the “Fed-Ex” to the surface**

Launch Vehicles

- **Launch is clearly a large expense, and a significant portion of the total mission costs**
- **Falcon 9 / Minotaur V class**
 - \$25M
 - TLI: 465 kg (1025 lbm)
- **Discussion with ULA**
 - Secondary payload adapter (ESPA)
 - 180kg
 - GEO
 - ~\$2M
- **AdAstra lunar tug from LEO**



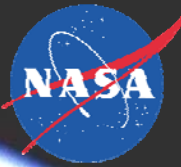


How could the Lunar-COTS help?

Relative to the lunar science campaign, it is felt that this business model could:

- Enabling the campaign (sooner than later...)
- Enabling global science on the moon (ILN)
- Enabling ESMD risk reduction
- Enabling more commercial opportunities relative to the moon. (ex: lunar commercial communications).
- Getting more public interest and participation

PLANNED NASA LUNAR FLIGHT PROGRAM



FY08 FY09 FY10 FY11 FY12 FY13 FY14 FY15

Lunar Research and Analysis + NLSI

Missions of Opportunity + International Coop.
(Science-Funding & Opportunity Driven)

Lunar Mapping Project

ILN Operation (Goal)

Possible International Partner Early Operations

C/D E

↑ MMM + Mini-RF
(Chandrayaan/ISRO)

C/D E

↑ LRO

B C & D Cruise E

GRAIL

SDT Science Definition

A B C & D ... Cruise E

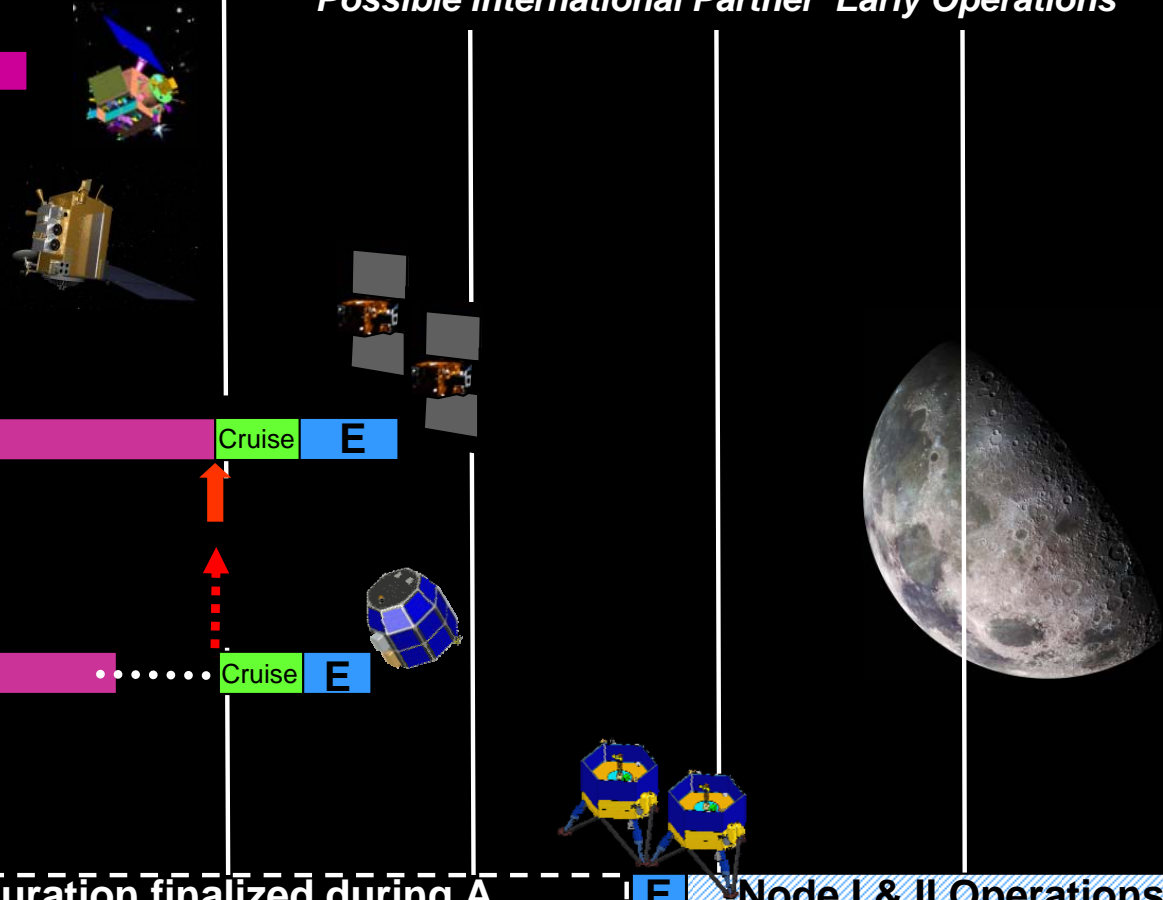
LADEE

SDT Science Definition

A B B/C/D duration finalized during A E Node I & II Operations

Mini Landers

↑ Launch date to be set during Phase A



Commercial Lunar Payload Delivery.... GOING FORWARD



- Enabling earlier lunar access to the surface.



COPYRIGHT 2005-2007 SPACEREF.COM