Commercial Issues and Opportunities in the Global Exploration Strategy

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As a part of the National Aeronautics and Space Administration (NASA) Global Exploration Strategy (GES) activity, input was solicited from a variety of sources regarding issues and opportunities from the entrepreneurial communities interested in lunar commerce. This paper will briefly present an overview of the GES, including terminology and time line. The raw inputs collected from the GES exercises and related to lunar commerce issues and opportunities will be shown and their categorization will also be described. By performing a fundamental "gap" analysis using an industry sector classification set, potential commercial opportunities that have not yet been received as part of the GES solicitation activities can be highlighted. Examples of how new inputs from yet-unheard-from participants will be solicited and incorporated into the GES process will be discussed as a way to invite new ideas from additional sources.

1.0 The Global Exploration Strategy

1.1 Overview

In 2005 NASA initiated the Exploration Systems Architecture Study (ESAS) to define some early elements of the transportation architecture required to support post-Shuttle crew and cargo transfer between Earth-orbit and the moon. ESAS also took an initial look at lunar surface architecture elements that might drive the requirements for this transportation system.

In 2006, NASA initiated a significant effort to solicit input and feedback from a multitude of scientific, governmental, and private-sector communities from around the world. Referred to as the Global Exploration Strategy (GES), this activity sought to identify the compelling reasons why NASA and other stakeholders would benefit from a concentrated focus on lunar exploration.

A goal of the GES was to answer the following questions:

- Why we are going back to the moon?
- What do we hope to accomplish when we get there?

GES was not an attempt to determine the operations or architecture (i.e., 'how') lunar exploration (or beyond) would be conducted.

The term "Global" in GES refers to the inclusion of all stakeholders in the strategy development process. This was done to ensure that the interests of all the involved communities would be considered as NASA moves forward in planning for future exploration missions. Stakeholders fell into three distinct communities: international space agencies, academia, and the private sector.

Although the GES initially focused on human and robotic exploration of the Moon, plans that could evolve and expand to possible destinations beyond the Moon (e.g., Mars or near Earth asteroids) were also considered in the exercise.

Results of the GES exercise will serve as a starting point for coordination among participants to maximize what can be accomplished, discussions between participants regarding areas of potential collaboration, and a detailed technical analyses that addresses time phasing of activities and identification of interdependencies, prioritization of tasks based on individual stakeholder goals, and operational and architecture impacts of strategy implementation.

1.2 Terminology

There are three hierarchical levels of information categories that encompass the information collected in the GES exercise to date. These are:

- Themes, addressing the question "Why should we return to the moon?".
- Subject Categories, which are high-level groupings of Objectives. It is possible that a single category can map into more than one theme. It is also possible that a single objective could be a member of more than one category, but this was not allowed in the GES activity solely for accounting purposes, although any connection to multiple categories was retained for possible future reference.
- Objectives, which address the question "What are we going to do when we get there?" for most of the categories. Coming from multiple sources, approximately 800 individual inputs (each one an objective) were received in 2006.

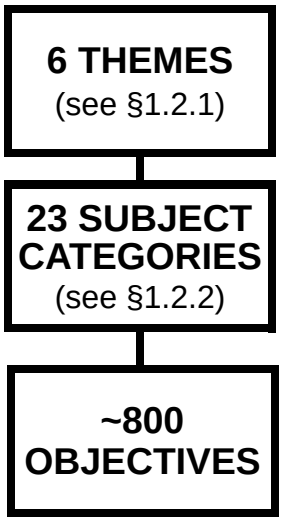

FIGURE 1. General GES information hierarchy.

A graphic depiction of the levels of information collected in the GES exercise is given in Figure 1.

1.2.1 Themes

In the GES, there are six over-arching themes broken into two types: Core and Cross-cutting.

Core themes address the primary activities to be conducted on the Moon, and include the following:

1. Exploration Preparation: Use the Moon to prepare for future human and robotic missions to Mars and other destinations.
2. Science: Pursue scientific activities to address fundamental questions about the solar system, the universe, and our place in them.
3. Sustained Presence: Extend sustained human presence to the Moon to enable eventual settlement.

Cross-cutting themes address ways to maximize the benefit of the Core themes, and include:

4. Economic Expansion: Expand Earth's economic sphere to encompass the Moon and pursue lunar activities with direct benefits to life on Earth.
5. Global Partnership: Strengthen existing and create new global partnerships.
6. Inspiration: Engage, inspire, and educate the public.

1.2.2 Subject Categories

Subject Categories describe the discrete set of activities that the global community has identified in supporting the exploration themes. For example, the Exploration Preparation theme can be described by a set of associated functions or subjects, such as scientific measurements, mission simulations, and technology and operations validation.

The division into Subject Categories serves as a means for breaking down the theme areas into achievable parcels of work that can be time-phased and prioritized, while still being at a strategic level.

The 23 GES Subject Categories are shown below in Table 1.

TABLE 1. Twenty-three Subject Categories of GES Objectives

• Astronomy & Astrophysics	• Environmental Hazard Mitigation	• General Infrastructure
• Earth Observation	• Power	• Operations Test & Verification
• Geology	• Communication	• Lunar Resource Utilization
• Materials Science	• Guidance, Navigation & Control	• Historic Preservation
• Human Health	• Surface Mobility	• Development of Lunar Commerce
• Environmental Characterization	• Transportation	• Global Partnership
• Operational Support	• Operational Environmental Monitoring	• Public Engagement
• Life Support & Habitat		• Program Execution

1.3 Time Line and Products

The GES activity was initiated in 2006 and followed an aggressive schedule for development of the interim strategy that was presented at the 2nd Space Exploration Conference (SEC) in Houston, Texas on 6 December 2006. The GES schedule that was executed in 2006 is shown in Figure 2

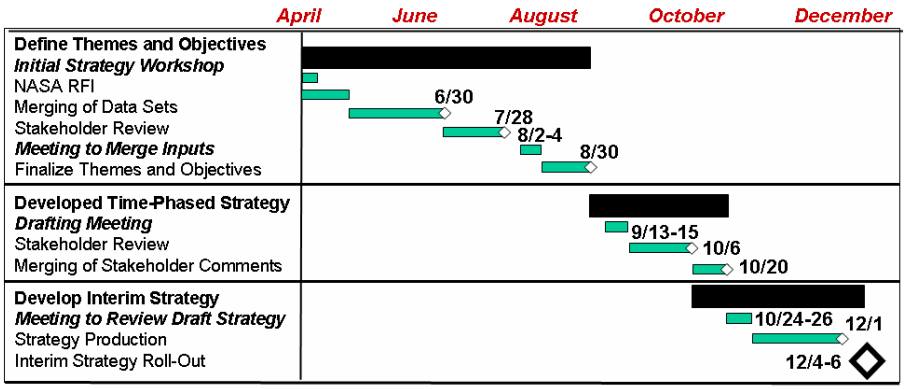

FIGURE 2. Schedule of 2006 GES tasks.

2.0 Identification of Issues and Opportunities

In 2006, the GES process began soliciting input about specific lunar and exploration issues and opportunities. Chances to solicit input from the industry and commercial sectors in 2007 will present themselves at upcoming meetings and conferences.

As the first round of solicitations has already been presented to members of the traditional aerospace sector and some of the smaller space start-ups and advocacy groups, efforts to continue to collect this information will continue to be extended to members of the smaller organizations of the aerospace sector. A special effort will also be made to solicit inputs from members of the non-aerospace industry sectors.

Extending the scope of input solicitations (beyond identification of issues and opportunities for space commerce), GES's new requests for input will ask how commercial opportunities (categories and/or specific ideas) might be incorporated into the baseline lunar architecture as presented at the SEC.

2.1 Activities Conducted, Audiences Surveyed

The principle method of input solicitation of lunar commerce issues and opportunities has been through direct request at a variety of meetings. A Request for Information (RFI) was also conducted and a large fraction of all objectives were received in response to that solicitation instrument. Table 2 gives information for each of the information collection methods conducted in 2006.

TABLE 2. GES Input Solicitation in 2006

Date	Location	Method/ Meeting Name	Led By	Participation
24-26 April	Washington, DC	International GES Workshop	NASA ESMD	Attendance was by invitation only and included members of U.S. and international aerospace industry, space agencies, and academia.
11 April - 12 May	Not Applicable	Request For Information	NASA ESMD	Open to the public (U.S. and international)
17-19 July	Las Vegas, NV	Lunar Commerce Roundtable	Lunar Commerce Roundtable	Attendance was by invitation only and included members of U.S. and international industry.
21 July	Las Vegas, NV	Space Frontier Foundation NewSpace Conference	NASA ESMD	Attendance was open to the public with paid registration.
29-30 August	Washington, DC	NASA Lunar Exploration Architecture Plan Workshop	The Space Enterprise Council, U.S. Chamber of Commerce	Attendance was by invitation only and included members of U.S. aerospace industry.

Through these meetings and the RFI, the GES has successfully begun the solicitation of ideas from a variety of communities and groups, including personnel from NASA, non-US governmental space agencies, the U.S. aerospace industry (i.e., large NASA and DoD contractors and subcontractors), the U.S. commercial space companies (i.e., smaller companies not typically funded through NASA or DoD contracts), and space interest groups.

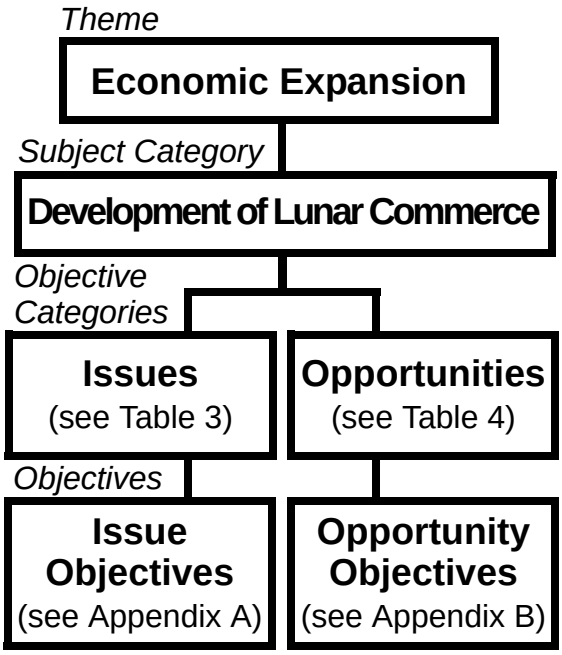

FIGURE 3. The GES information hierarchy specifically for the case of the Commercial Development subject category.

2.2 Lunar Commerce Information Collected

In the case of the "Development of Lunar Commerce" category, some objectives addressed the question "What are the barriers to achieving the the development of space or lunar commerce?", and other objectives answered "What are the commercial opportunities on the Moon or in space?". To keep these two types of comments separate, an additional information layer, or "Objective Categories", was inserted between the Subject Category and Objectives levels. This is graphically depicted in Figure 3.

2.2.1 Lunar Commerce Issues

Based on the 61 responses (individual objectives) received, there are nine instances of Lunar Commerce Development Issues. These are all shown in Table 3 and a full table showing the 61 responses mapped to these 9 types of Issues is given in Appendix A.

TABLE 3. Nine Types of Lunar Commerce Issues

• Planning Exploration Process Participation	• Establishment of New Relationships	• Legal Issues
• Planning Exploration to Promote Commerce	• Enable Commercial Markets	• ITAR and Other Regulatory Issues
• Challenging the Status Quo	• Provide Government Assistance	• Procurement and Financial Issues

2.2.2 Lunar Commerce Opportunities

Based on the 72 responses (individual objectives) received in the category of Lunar Commerce Development Opportunities, 18 industry subsectors (in 9 industry sectors) were identified that encompassed all of them. These industry subsectors, based on the U.S.

Department of Commerce Export Industries, are given in Table 4 and a full table showing the 72 responses mapped to these 18 industry subsectors is given in Appendix B.

TABLE 4. Eighteen Industry Subsectors of Lunar Commerce Opportunities

Automotive/Aviation/Marine • Aviation Services	**Environmental** • Pollution Control Equipment	**Information Technology/ Telecommunications** • Computer Services • Computer Software • Telecommunications Equipment
Business Services • Advertising • Services (other) • Trade Promotion • Transportation Services & Logistics • Travel & Tourism	**Hotel & Restaurant Equipment, Food/Food Processing** • Hotel & Restaurant Equipment	**Materials** • Production Machinery
Electrical/Electronics • Electrical Power Generation/ Distribution Equipment • Broadcasting	**Industrial Equipment, Services & Supplies** • Chemical Production Machinery • Mining & Extraction Equipment	**Medical/Scientific Products & Equipment** • Laboratory & Scientific • Medical Instruments, Equipment & Supplies

2.2.3 Opportunity Gap Analysis

The selection of industry sectors as the groupings of Lunar Commerce Opportunities was intentional to allow the identification of terrestrial sectors that were not populated by ideas for commercial activity on the moon. There are many existing industry-sector groupings and alternate industry-sector sets that could be applied to the categorization of the Lunar Commerce opportunities in addition to the U.S. Department of Commerce Export Industries classification set that was applied. Some of the alternative classification sets are shown in Table 5 below.

TABLE 5. Alternative Industry-Sector Sets

• International Standard Industrial Classification of All Economic Activities (UN)	• North American Industry Classification System (NAICS) • United Kingdom Standard Industrial Classification (UKSIC)	• Global Industry Classification Standard (GICS) by Morgan Stanley Capital Int'l • U.S. Department of Commerce Export Industries

Continuing with the same classification set used, it is interesting to look at what "gaps" in the industry sectors exist as indicated by the lack of lunar commerce opportunity objectives received. Table 6 lists the results of this rudimentary industry sector "gap analysis."

Some of the industry sectors and subsectors are not suited for lunar or space commerce, but a surprisingly large fraction of the terrestrial list is pertinent to space ventures.

It is clear from the large number of industry sectors that have *not* received associated opportunity ideas that there still remains an untapped plethora of lunar and space commerce ideas.

For example, there are obvious lunar and space commerce opportunities in each of the three subsectors of the Agricultural industry sector, including methods, products, chemicals, and produce that will be required to feed humans in space or on the lunar surface.

As new inputs are received over the course of future months, the structure of issues and opportunities will continue to evolve and develop in accordance with the information collected.

TABLE 6. Results of the Industry Sector Gap Analysis

Agriculture
- Agricultural Chemicals
- Agricultural Machinery & Equipment
- Agricultural Services

Automotive/Aviation/Marine
- Automobiles & Light Trucks/ Vans
- Auto Parts/Accessories & Service Equipment
- Trucks, Trailers & Buses
- Commercial Boats
- Port & Shipping
- Aircraft & Parts
- Airport Equipment

Building/Construction/ Hardware
- Architectural/Construction/ Engineering
- Building Products
- Construction Equipment
- Hand & Power Tools/ Hardware

Business Services
- Artwork
- Business Equipment (non-computer)
- Education & Training
- Financial Services
- Management Consulting
- Printing/Graphic Arts Equipment

Consumer Goods
- Consumer Goods
- Furniture
- Giftware
- Housewares
- Lawn & Garden
- Pet Supplies

Consumer Goods (con't)
- Arts & Crafts
- Toys, Games & Hobbies
- Books & Periodicals
- Photographic Equipment

Electrical/Electronics
- Audio Visual Equipment
- Consumer Electronics & Appliances
- Electronic Components
- Electrical Lighting Equipment & Supplies

Environmental
- Biotechnology
- Renewable Energy
- Water Purification

Franchising

Health & Beauty/Fashion
- Apparel
- Textile Fabrics
- Cosmetics & Toiletries
- Jewelry
- Vitamins

Hotel & Restaurant Equipment, Food/Food Processing
- Food Processing/Packaging Machinery
- Marine Fish Products
- Processed Food

Industrial Equipment, Services & Supplies
- Air Conditioning, Heating & Refrigeration Equipment
- Cylinders - Pneumatic & Hydraulic
- Forestry & Woodworking Equipment
- General Industrial Equipment

Industrial Equipment, Services & Supplies (con't)
- Materials Handling Machinery
- Metalworking & Machine Tools
- Operations & Maintenance
- Packaging Equipment
- Industrial Process Controls
- Pumps, Valves & Compressors
- Railroad Equipment
- Used/Reconditioned Equipment
- Industrial Chemicals
- Industrial Cleaning Supplies
- Oil & Gas Field Equipment
- Oil, Gas (other mineral) Production/Exploration
- Textile Machinery

Information Technology/ Telecommunications
- Computers & Peripherals

Materials
- High-Tech Ceramics
- Paper & Paperboard

Medical/Scientific Products & Equipment
- Dental Equipment
- Health Care Services
- Veterinary Equipment & Supplies

Safety & Security
- Security & Safety

Sports & Recreation
- Exercise Equipment
- Pleasure Boats
- Sporting & Recreation Products

3.0 Potential New Approaches

The goal of realistically filling in as many of the currently-existing industry-sector gaps is a driving factor for future idea solicitation efforts. New efforts that may be implemented will be based on past experiences gained during the past year, and may also try some different strategies to draw out different ideas from a different audience, as well.

3.1 Alternate Industries

Due to time limitations, not all sources of lunar commerce ideas have been solicited for their input to the GES. Communities or groups that have already been solicited (listed above) need to be solicited again to try to get input from other individuals or subgroups who may not have already participated.

Other communities or groups that have not yet contributed to the process include:

- Non-aerospace commercial entities

- University students in technical and business colleges.

3.2 Alternate Methods

There are a number of ways that the GES Lunar Commerce activities could continue to solicit input from a variety of commercial sectors, including:

- Print and electronic announcements to different communities.
- Personal and meeting interactions.
- Competitions to solicit lunar commerce ideas.

Below are brief descriptions for each of these ideas.

3.2.1 Print and Electronic Announcement to Different Communities

A persistent and deliberate effort is required to maintaining an awareness in the private sector of ESMD's commercialization intentions and policies, and to reach members of industry sectors who do not normally receive messages from NASA. Specific methods for achieving these goals may include:

- Placing articles in trade magazines and publications aimed at specific industry sectors that will solicit feedback and active participation from members of those communities.
- Posting similar articles in industry-specific news groups, chat rooms, and blogs.
- Providing an opportunity for dialogue and interaction with members of private sector communities through discussion boards, chat rooms, and blog comments.
- Providing a generic NASA email address to solicit voluntary, free-format input from private sector community members.

3.2.2 Personal and Meeting Interactions

The same goals can be achieved via a similarly persistent and deliberate effort on a personal level through one-to-one, or one-to-many personal interactions in the following ways:

- Presenting at conferences or in small-group meetings, answering questions and clarifying points of confusion.
- Soliciting free-format inputs from all attendees, including the creation of a generic email address to collect ideas electronically.
- Organizing meetings and other activities in cooperation with other U.S. government organizations (e.g., the U.S. Department of Commerce Office of Space Commercialization, or the U.S. Federal Aviation Administration, Office of Commercial Space Transportation) the to attract attendance and input from non-aerospace industry sector members.

3.2.3 Competitions to Solicit Lunar Commerce Ideas

In order to tap a fresh perspective for immediate and future space (and lunar) commerce opportunities, university-level competitions can be conducted.

Traditional aerospace-industry professionals and enthusiasts have been the source of many innovative ideas that tend to reflect an “insider’s” perspective of the question at hand.

Traditional non-aerospace-industry professionals and enthusiasts have realistically focused on near-term opportunities and that has led to a natural disinterest in to space-related business ideas.

One possible method to solicit space-related business ideas from specific, non-aerospace-industry sectors that have not been overly affected by “real-world” thinking is to engage university-level students (both business and technical) instead of working professionals in a given sector.

Specific universities to be solicited can be targeted based on research or geographical ties to an industry sector of interest (e.g., universities in the U.S. state of Michigan could be targeted based on their proximity to Detroit-based, U.S. automotive industry).

A variety of competition structures, formats, and outputs are possible and would be dependant on the administrating and executing organization.

3.3 Future Phases

Members of industry that have already participated in the initial round of input solicitation will be re-engaged to get their ideas about how specific commercial issues and opportunities can be inserted into the baseline lunar architecture that was revealed at the SEC. Inversely, ideas about how the baseline lunar architecture might be modified to accommodate commercial issues and opportunities will also be solicited.

Those members of industry that will be participating in the initial round of solicitation (identification of specific commercial issues and opportunities) will also be asked to consider the baseline lunar architecture to maximize their input opportunities.

4.0 Summary

The Global Exploration Strategy (GES), being conducted by NASA’s Exploration Systems Mission Directorate (ESMD), is a multi-year, multinational, and multi-sector planning exercise started in 2006 and continuing in 2007. Approximately 800 specific issues and opportunities were solicited and received via the many GES-related meetings held by and conducted primarily with members of the traditional aerospace industry. This paper provides an overview of the GES and provides details regarding the processing of the issues and opportunities received that focus on Commercial Development of lunar and space resources. Lunar and space commerce issues were parsed into nine unique categories. Lunar and space commerce opportunities were sorted into eighteen unique categories (or industry sectors). Issues and opportunities will continue to be collected via conference presentations, personal meetings, and electronic solicitations. Categorization of the inputs will continually evolve as the data is received and processed.

Appendix A. Table of Lunar Commerce Issues

TABLE 7. Lunar Commerce Issues

Issue Category	Specific Objectives	
Planning Exploration Process Participation	• Evolutionary Stages for Lunar Exploration • Establish activities/ capabilities to allow humans to prosper beyond Earth • Enhance Affordability and Sustainability • Engage the Enthusiast's Viewpoint Early	• NASA is Listening • Asset Predeployment • Maintaining Communication With NASA • Engage Non-Aerospace Industry and Investors • This Vision is Bigger than “Apollo The Sequel”
Planning Exploration to Promote Commerce	• Create an economically rewarding frontier • A Method for Increasing Commercial Participation	• Select Systems Concepts that Facilitate Commerce • Promote Commercial Space Access • Commercial Role in Exploration
Challenging the Status Quo	• Ask “Why NASA?” First • Why Did We Leave? • Reevaluate Gov’t Cost Models • Objective-Oriented Solutions • NASA's Hypocritical Oath • Avoid Competition between Government & Industry	• Setting a Global Example • Set metrics that we are making progress • Establish International Standards • NASA Follows Industry Standards • Unintended Consequences
Establishment of New Relationships	• Create Public-Private Partnerships • OrbImage Model • Look to Comsats as a model, Not Apollo, Shuttle, or Station	• Institute a public-private lunar development corporation • Revive the NACA Model • Interagency (Gov’t) Councils
Enable Commercial Markets	• Enable and encourage significant commercial and private sector participation • Encourage & enable commerce	• Facilitate establishment of commercial markets • Create opportunities for lunar commerce
Provide Government Assistance	• Provide opportunities for commercialization pilot programs (payloads/ISRU) • Ensure the option to privatize all aspects of government lunar activities • Test-bed for private industry to conduct experiments • Transition of government-sponsored development to privately-sponsored as soon as practical	• Ensure viable activity after Government transition • Planning for Gov't to Industry Transitioning • Purchaser, Not Provider • Pursue Technology R&D and System Development • Access to Data • Plan for the Privatization of Government-Developed Systems
Legal Issues	• Use NASA OGC Early and Often • Resolve Operational Liability Issues • Roadblock Removal	• Protect Private Ownership of Technology and Intellectual Property • Clarify Property Rights Issues
ITAR and Other Regulatory Issues	• Adjust Export Control Measures • Make Regulatory Policy More Commerce-Friendly	• Permit Moon as a commercial destination • Int'l Exploration Under ITAR • Non-obstructionist Regulations
Procurement and Financial Issues	• Commit To Infrastructure Investment • Long-Term Commitments • Pursue Anchor Tenancy • Balance Government and Industry Financial Risk	• Catalytic contingency contracting • Optimize Acquisition Practices • OTA For Exploration • Promote Creative Business Approaches

Appendix B. Table of Lunar Commerce Opportunities

TABLE 8. Lunar Commerce Opportunities

Opportunity Category	Specific Objectives	
Automotive/Aviation/ Marine • Orbit-to-Orbit Services	• On-orbit repair, assembly, and maintenance	
Business Services • Advertising	• Commercial Missions – Without Scientific or Engineering Motives	• New Pay-for-Placement Venues • New Methods of Delivery
Business Services • Other Services	• NASA/Industry Settler/Explorer Program	• Commercialize the Astronaut Corps, Mission Specialists
Business Services • Trade Promotion	• Market- and commerce-based approach to robotic lunar exploration • Lunar infrastructure and commerce	• Deliver profitable lunar products to Earth and in-space use • Enhancing Other Lunar Activities • Building Lunar Infrastructure
Business Services • Transportation Services and Logistics	• Commercial Lunar Rovers • Delivering Items to the Lunar Surface • Create a commercial cis-lunar transportation industry • Activities To Enable Lunar Commerce and Sustainable Transportation	• Transportation • Activities to Enable Lunar Commerce and Sustainable Transportation • Planetary Voyages • Trade Route • Paris-Dakar Lunar Rover Race
Business Services • Travel and Tourism	• Tourism and entertainment.	• Your Own Lunar Spacecraft
Electrical/Electronics • Electrical Power Generation, Distribution Equipment	• Lunar activities that can help solve problems here on Earth • 1GW “Oil Well on the Moon” • Develop a Space Energy Economy	• Commercial Solar Power • Power Beaming • Energy for Earth from Space — Lunar Solar Power
Electrical/Electronics • Broadcasting	• Multi-player interactive gaming • Exploit multi $Billion media opportunity for Lunar Activities	• A/V from LEO • Micro-g sports events broadcasts • Multi-player exploration game
Environmental • Pollution Control Equipment	• Pay for Reuse of Orbital Debris	
Hotel and Restaurant Equipment	• Facilitation of Hotelier Services Integral to Federally Funded Base Infrastructure • Tourism as Secondary Payloads	• Create opportunities for service industries (e.g., tourism) • Pioneer the moon
Industrial Equipment • Chemical Production Machinery	• Commercial Propellant Production	• Propellant Depot • Water Observatory - ISRU Demo
Industrial Equipment • Mining and Extraction Equipment	• Getting the Right Lunar Geological Data • Dual-Use Lunar Topo Data • Topo Mapping Data • Detailed Scientific Lunar Examination • What's On the Moon? • Answer the Ice Question • Sample Return Mission	• Lunar Regolith Simulant for Public Use • Lunar Sample Return • Mining Toward Solar Power Satellites • NEO/Planetary data • Development of Technologies to Support Resource Delineation and Recovery • platinum group metals

TABLE 8. Lunar Commerce Opportunities

Opportunity Category	Specific Objectives	
Information Technology • Computer Services	• Distributed Computing • Space-Based Internet Company	• Augmented Reality • Bandwidth
Information Technology • Computer Software	• Engaging Data Visualization	
Information Technology • Telecom Equipment	• Communication, Navigation, Telecom • Ground Based Lunar Navigation Beacons	• GPS • GEO Communications Satellites • Lunar GPS
Materials • Production Machinery	• Large-Scale Production of Reduced-G Materials	
Medical/Scientific • Laboratory and Scientific Products and Equipment	• Small Visual Popular Telescope • Earth Observing IMAX Telescope • Optical Observatory • Radio	• Scientific Space Telescopes • Earth Observation Satellites • Make Far-Side and Polar Activity Possible
Medical/Scientific • Medical Instruments	• Genetic Repositories in Cold Lunar Craters	