
Solar Splinter Group

Preliminary Synthesis of Opportunities

17-19 July 2006

Solar Power Working Group

What Comprises the “Core Business”

- Family of core technologies and systems concepts, taken together and/or in various combinations
 - Representing the foundation for supplier businesses
 - Providing the basis for service / energy delivery businesses
- Key elements
 - Solar power generation
 - Power management and distribution
 - Wireless power transmission
 - Supporting elements / technologies
 - Controls, etc.
 - Modular systems interfaces
 - Others?

What are the Business Opportunities?

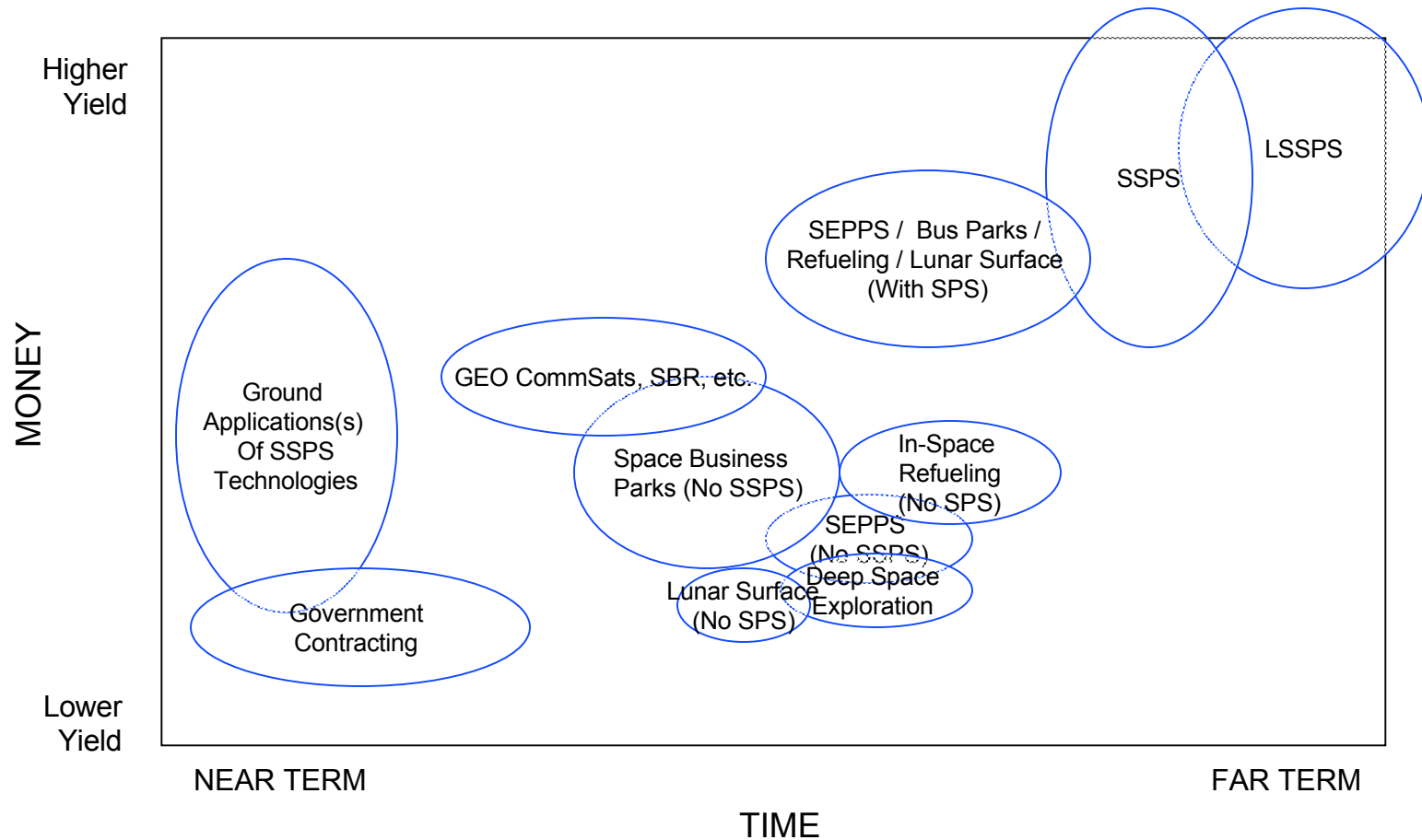
- Energy for Earth from Space — Solar Power Satellites (Large Market, Moderate Margin; Far Term)
- Solar Power for Lunar Surface Operations (Small Market at High Margin, or Modest Market at Modest Margin; Mid Term)
- Solar Electric Power/Propulsion for Transport (High Margin; Market size Depends on SPS; Mid to Far Term)
- Ground Energy Applications (Large Markets; High Margins, Near Term)

- Government Contracting (Small Market, High Value; Near Term)
- Power for Communications Satellites (Small Mkt, Moderate Margin; Mid Term)
- Power for Large Space Based Radar (Modest Mkt, High Margin; Mid Term)
- Power/Propulsion for Deep Space Exploration (Small Mkt, High Margin; Mid Term)
- Power for Space Business Parks (Small Mkt, Moderate Margin; Mid Term)
- Power for In-Space Refueling Stations (High Margin, Small Mkt; Mid Term)
- Power for Asteroid Exploration, Threat Mitigation and Utilization
- Energy for Earth from Space — Lunar Solar Power (Large Mkt, Moderate Margin; Far Term)
- Others ...

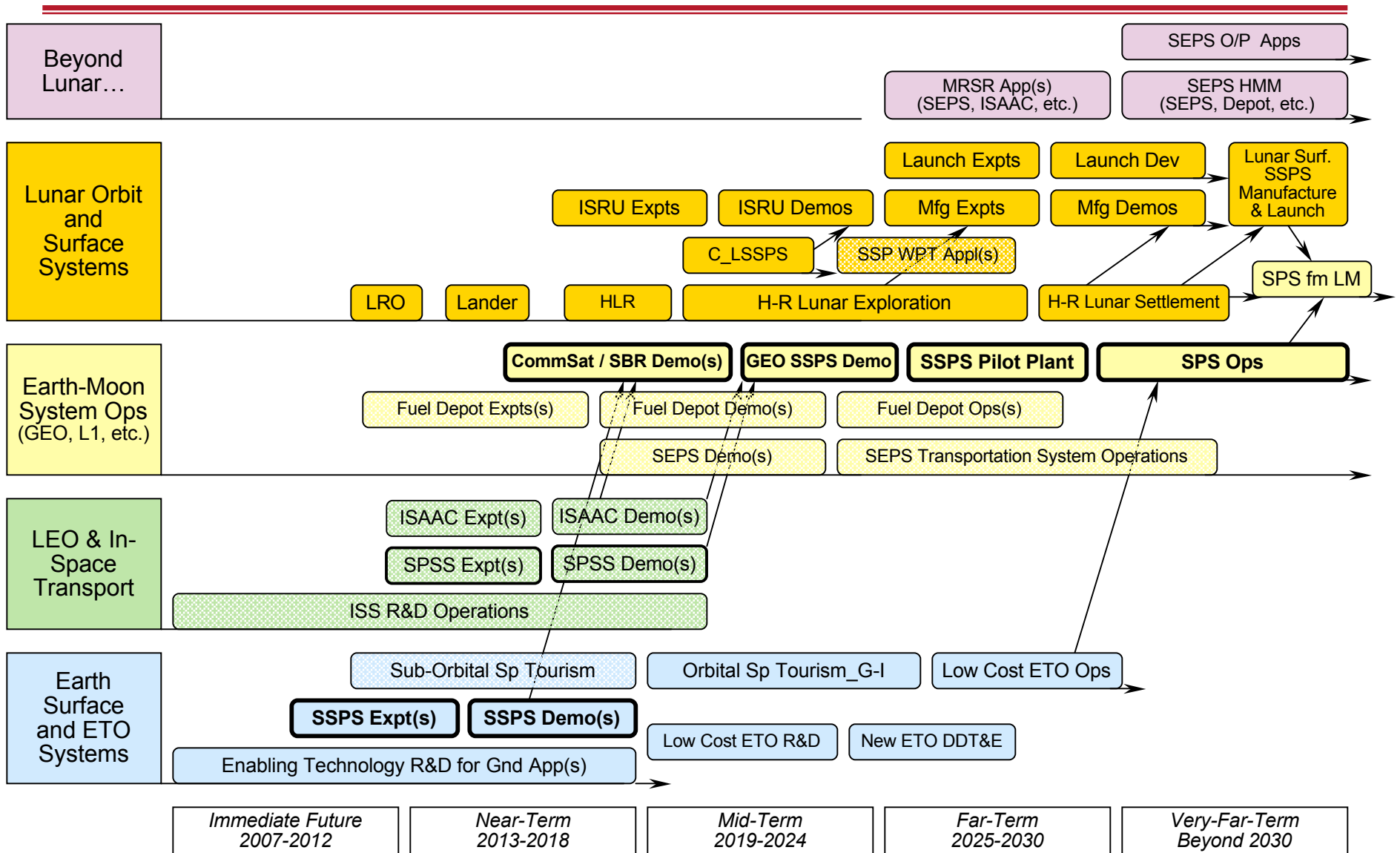
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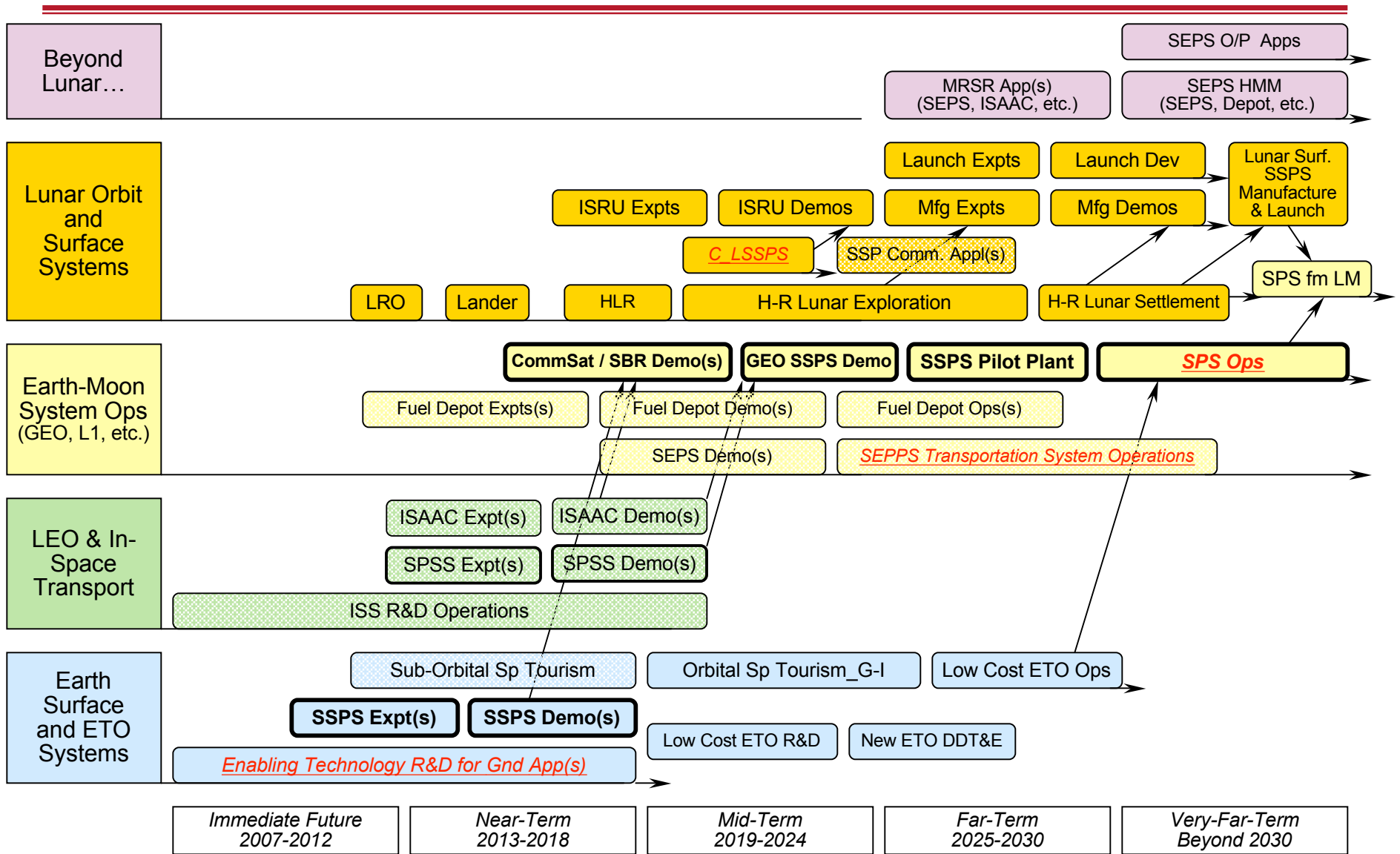
What are the Business Opportunities? Preliminary Synthesis



Space Solar Power Systems (SSPS) Industry Scenario-Based Road Map



Space Solar Power Systems (SSPS) Industry Scenario-Based Road Map



Business Opportunities

Representative Cases (1 of 4)

- Energy for Earth from Space — Solar Power Satellites
 - The Market Potential is Extremely Large @ \$100s B / year (with Large Existing demand, at low Prices)
 - Potentially up to \$T's per year (e.g., about 20% of the global economy)
 - Margins have traditionally been modest
 - Depends on demand and technology
 - Investment Type/Timeframe
 - Research: Early co-investment, government-industry, private
 - Development: Government (civil space, other), Industry
 - Operations: Later, industry / commercial capital
 - The nominal Timeframe for Market Infusion is the Far Term (2030 and beyond), with a full scale SPS Pilot Plant c. 2025
 - Variation: \pm 6-8 years
 - Risks
 - Technical Risk--significant perceptions/concerns (development, operations)
 - Price risk (e.g., related to government policies such as carbon credits)
 - Market Competition Risks (e.g., a breakthrough in a competing area)
 - Financial risk--e.g., potential need for debt support government policies
 - Public Perception Risks
 - Regulatory Risk due to spectrum allocation, etc.
 - Infrastructure-related risks (e.g., need for ETO and in-space systems)
 - Other Factors
 - Influence of corporate strategic planning (e.g., future business risks and/or directions); including corporate disruptive innovation decisions

Business Opportunities

Representative Cases (1a of 4)

- Energy for Earth from Space (SPS) — Risk Mitigation
 - Technical Risk--significant perceptions/concerns (development, operations)
 - Ground R&D
 - In-space demonstrations (e.g., using ISS)
 - Price risk
 - Government policies such as carbon credits
 - Market Competition Risks
 - Breakthrough in a competing area
 - Financial risk
 - Need for debt support government policies
 - Public Perception/Opinion Risk--significant perceptions/concerns
 - Ground and space demonstrations
 - Outreach/communications
 - Regulatory Risk due to spectrum allocation, etc.
 - Early / ongoing support for international spectrum allocations
 - Infrastructure-related risks
 - Need for consistent commercially-friendly decisions on designs, policies on development of ETO and in-space systems
 - Open architecture approaches (e.g., standards and interfaces, interoperability, etc.)

Business Opportunities

Representative Cases (2 of 4)

- Solar Power for Lunar Surface Operations (ISRU Focus)
 - The Market Potential is Small to Modest
 - @ <\$B's / year (with No Current demand outside occasional government missions)
 - Margins are modest
 - Low if government procurement type acquisition/regulation
 - Uncertainty: captive market, likely 'business-owned power'
 - Investment Type/Timeframe
 - Research: Early investments must largely be from government
 - Development: Government (civil space, other), Industry
 - Operations: Later, industry / commercial capital
 - The nominal Timeframe for Market Infusion is the Mid Term
 - Investment: Co-Fund DDT&E with Governments
 - Risks
 - Timeframe highly dependent on government programs
 - Government vs. Industry Competition
 - Technical uncertainty: no expert consensus on 'best approach' for initial power
 - Competing technology options (e.g., nuclear)
 - Financing Risks
 - Supporting infrastructure Development Risks

Representative Cases (2a of 4) Surface Power Opportunities

- Government Lunar Sortie Mission Power
 - Robotic, Human
- Government Lunar Surface Extended Duration Presence Power
 - Robotic, Human
- Mobile Power for Exploration
 - Robotic Rovers, Human Rovers
- Supporting Operations Power (e.g., telecommunications)
- **ISRU Operations Power (all types, stationary & mobile)**
- Lunar Surface Propellant Depot Power
- **Surface Manufacturing Power**
- **EM-Type Launch to Space Power**
- **Big-Science Power (e.g., Large Observatories)**
- Lunar Surface Based Energy for Earth (LSP)
- **Human-Robotic Settlement Power**
- Back-Up Power Supplies (all options are possible)

Business Opportunities Representative Cases (3 of 4)

- Solar Electric Power/Propulsion for Transport
 - The Market Potential is Moderate to High
 - Low @ \$B's / year (without SPS)
 - High @ \$10 B's / year (with SPS)
 - Margins are high to modest
 - Modest- to low-, competition dependent
 - "High" would depend on 'object' to be delivered (large, unique, etc.)
 - Investment Type/Timeframe
 - Research: Initial government investment needed; co-investment, government-industry, private
 - Development: Government (civil space, other), Industry
 - Operations: Later, industry / commercial capital
 - Nominal Timeframe for Market Infusion is the Mid Term
 - Risks
 - Market customers - markets are induced (not existing)
 - Infrastructure interdependencies (e.g., refueling, repair; open architecture issues and needs)
 - IP and system ownership issue
 - Competition from other technical solutions

Business Opportunities Representative Cases (4 of 4)

- Ground Energy Applications (technology, systems)
 - The Market Potential is Large
 - @ \$10s B / year (with large existing demand, at market prices)
 - Margins are modest to high
 - Depending on details of product/service provided; specific character of the business opportunity
 - Investment Type/Timeframe
 - Research: Private, limited government-industry; unique component of the business is associated with small business (including subsidiaries)
 - Development: Industry, Government (depending on the application)
 - Operations: Industry / commercial capital
 - The nominal Timeframe for Market Infusion is the Near Term, but continues indefinitely
 - Risks
 - Technical 'synergy' between space solutions and ground solutions
 - Government policies concerning R&D support and/or other incentives
 - Other Factors
 - Corporate benefits resulting from perception/public issues
 - Influence of corporate strategic planning (e.g., future business risks and/or directions); including corporate disruptive innovation decisions

New Space Industry / Government Interactions

Some Important Themes (1)

- Systems Concepts
 - Architecture and systems developed/deployed by governments must support, not inhibit “Broad as Possible” commercial markets
- R&D and Development
 - Co-funding of high-risk demonstrations & developments
 - Enabling services (e.g., transport) for commercial payloads
- Avoid direct competition of Government vs. Industry
 - And between government and universities, where appropriate (e.g., R&D)
- Privatization / Ownership
 - Need to assure planned transfer of key government systems and/or infrastructure to commercial ownership and use
- Policy
 - Government support for commerce-friendly legal / regulatory framework (e.g., in spectrum allocation for SPS, large-scale commercial launch)

New Space Industry / Government Interactions

Some Important Themes (2)

- Governance
 - Need for new systems development projects to be industry-led
 - Special international industry structures (e.g., ComSat Corp., etc.) for major projects -- early stages
- Access / Transportation
 - Government planning for use of commercial transport
- Technology
 - Early and ongoing attention to IP
 - Government support for commercial ownership of IP--even for government programs
- Sustainability
 - Emphasis on 'affordable and sustainable' decisions across the board
- Implementation of the Vision
 - This time 'to stay'

New Space Industry / Government Interactions

Some Important Themes (3)

- Lunar Surface Infrastructure
 - Government policy support for industry-oriented infrastructure road map: Experiments, Demos, 'Pilot Plants'
- Standards
 - Early, consistent, internationally-recognized standards
- Acquisition Practices
 - Government support for a level playing field (in particular, regarding entrepreneurial start-ups)
 - Support for procurement preference favoring 'fixed price' type vehicles, rather than 'cost plus' with change orders...
- Risk Mitigation
 - Government policy / programs to mitigate risks (e.g., backed bonds, tax incentives)
- Special
 - Need for *industry-developed* set of Themes and needed Actions concerning what really matters regarding Industry/Government interactions

Other Topics to Discuss Further...

- Near Earth Asteroid Related Power Opportunities
 - Resources
 - Detection
 - Threat Mitigation
- Nuclear Power Applications
 - When, where and how much will it cost?
 - Relationship to development, applications, solar...
- Location factors -- especially for the Moon
 - When, where to we need power, how much
- Need to develop serious 'scenario-based planning' for a number of these cases (particularly, lunar surface activities)
- The pace at which public space travel (LEO and Beyond) proceeds is a game changer -- needs more consideration (e.g., in a scenario based planning exercise)

Summary

- Very good discussion
- Diverse opportunities for 'solar power' in new space industries
- Need for various addition consideration
- Need for 'hard business meetings' in addition to more academic discussions
- T.Boone Pickens:
In the history of man, we'll use oil and gas for less than two hundred years...

WE NEED NEW OPTIONS

Back Up Charts

Information Splinter Group Key Messages

- Commercial space arena is one of the “next big things”
- Certain firms will proceed without NASA (or other government agencies)
- Don’t want to “war” with NASA (or others) over approach, messages, methods, priorities, etc.
 - Commercial successes should be helpful to government programs; not a threat
- Want to see NASA and other government programs as “essential partners” or players going forward; need to count on them for selected pioneering efforts
- The connections between government-driven space programs and “the average citizen” have not been effectively articulated
 - Must appeal to self-interests, emotion
- For commercial space: What are we selling? Who are we selling? And how?
- International government space programs have a similar awareness challenge, and similar demographics to deal with
- “What’s space do for me?”: space may not be the focus (e.g., GPS)

Other Comments

- Sylvano
 - Europe has less money but more time
 - Need to explore entire solar system, not just Moon
 - Need to maximally utilize that which has been done already (e.g., ISS, ELVs)

Information Space Splinter Group Comments/Questions for Other Splinters

- Near-term priorities:
 - Clarify your message on relevance
 - Enable some early commercial successes. This will raise awareness.
- Must have connection with people
 - Have each group explain what their area is doing (or going to do) for “average person”
 - Explain where space is heading. What does it all mean?
- Must tell a compelling story.
 - Are you willing to allow the “pros” to be on your team and do this correctly? To bring deals to the table?
 - Must eliminate roadblocks (access, data rights, bandwidth, etc.)
- Do you understand that we’re not just talking about NASA, ESA, JAXA, etc. as the only market?
 - Global commercial markets already bigger than government
 - Some commercial firms will go their own way anyway