



Lunar Power & Light Company

Orchestrating the Technology Development, Demonstration,
and Deployment (TD³) Missions needed to foster
electrical utilities for Cislunar space

National Space Society's 36th Annual
International Space Development Conference

Space Solar Power Symposium

St. Louis, MO

May 26, 2017

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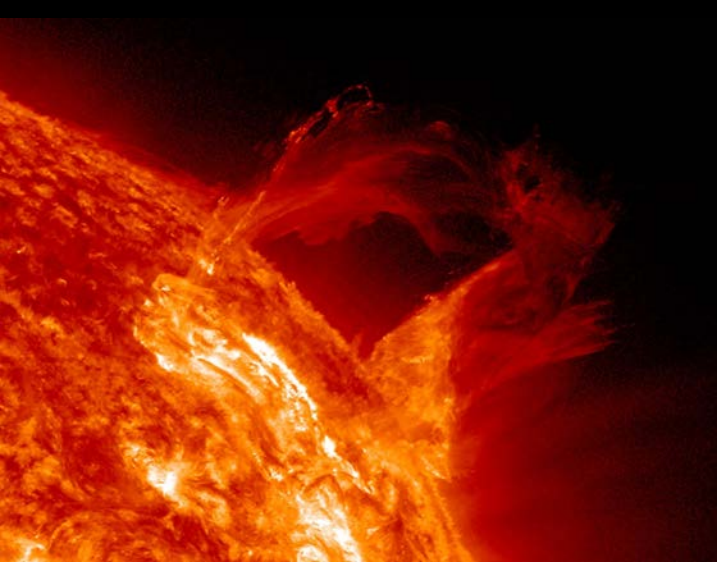
OUTLINE

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INTRODUCTION

- This work is the intersection of the XISP-Inc Space-to-Space Power Beaming Mission development effort and the ULA Cislunar Marketplace workshop initiative Energy subgroup presentation given by XISP-Inc at this years Space Symposium.



Space Energy Key Considerations

Sectors → There are no unilateral sector options

Products/Services → Cislunar Electrical Utility that leverages the economies of scale

Customers → Near term service degraded systems

→ Mid term enhanced new systems

→ Long term immortal systems infrastructure

Supplier/Resources → Trading the state-of-the-art vs. Satisfactory & Sufficient vs. optimal both a systems engineering and an economics challenge. Robotics and advanced automation are essential to meeting both challenges

Transportation → Foster the market – government(s) role as NACA/IACA and first customers

Investment/R&D → Matching investment tranches, staging, perceived & actual cost/schedule/technical risk, and returns

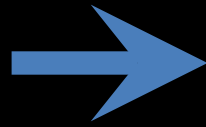
Infrastructure → Elements, linkages, and operational procedures must be defined

Regulation → Create a regulatory framework that is informed and driven by the confluence of interests necessary to grow the market

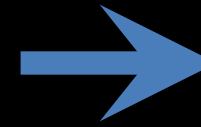


Energy TD³ Milestones

Technology Development



Technology Demonstration



Technology Deployment



Space Solar Power

- Space-to-Space
- Space-to-Luna
- Space-to-Earth
- Space-to-NEO
- Space In situ
- Luna-to-Luna
- Earth-to-Earth

	2018	2020	2024	2029	2038	2047
	ISS TD ³	LEO TD ³	GEO TD ³	GEO TD ³	GEO TD ³	SSP's >
	3-6 KW	~100 KW	~100 MW	~2 GW	10 GW	50 GW
	SSP Testbed	SSP LEO Demo	SSP GEO Demo	Full SSP		
	NASA/DOD	NASA/DOD/DOE	NASA/DOD/DOE	Electrical Utility		
	Commercial	Commercial	Commercial	Commercial		
	Co-orbiting Test	ComSats Recovery	ComSats Primary	→ \$\$\$	→ \$\$\$\$	
	Platform Model	Platform TD ³	Platform Ops	→ \$\$\$	→ \$\$\$\$	
	Spectrum Model	Spectrum Apply	Spectrum Allocation			
	Orbit Slot Model	Orbit Slot Apply	Orbit Slot Allocation			
	LP&L Seed/Angel	LP&L Series A/B/C	LP&L IPO	→ \$\$\$	→ \$\$\$\$	
	Co-orbiting Tests	Co-orbiting Labs	Co-orbiting Facilities	→ \$\$\$	→ \$\$\$\$	
		Lunar Test(s)	Lunar Operations	→ \$\$\$	→ \$\$\$\$	
		NEO Test(s)	Asteroidal Assay	→ \$\$\$	→ \$\$\$\$	



Energy Challenge Questions

Sectors → Orchestration is essential in a cooperative+collaborative+competitive market.

Products/Services → Cislunar Electrical Utility demand will scale with demonstrated supply.

Customers → As soon as energy is available it will be used - Are customers really ready?

Supplier/Resources → Establish standards, make economic sense and scale - reality check!?

→ Robotics, advanced automation, and human involvement needed.

→ System trades require iterative and recursive Technology Development, Demonstration, and Deployment (TD³)

Transportation → Match to mission requirements, be sustainable, and affordable to use.

Investment/R&D → Each increment of investment needs to lead to actual customer use.

Infrastructure → Elements, linkages, and operational procedures need definition & buy-in.

Regulation → Consistent long term government commitment to foster the market and help mitigate perceived and actual cost, schedule, and technical risk.



What's Next?

Lunar Power & Light Company an XISP-Inc Consortium



Don't wait for the future, help us build it!
www.xisp-inc.com

The LP&L Plan Forward

- TD³ Mission Development
 - Concept → Commercial Electrical Utility Consortium
- Consortium Creation
 - Commercial mission based on public private partnership & space act authority
 - Commercial/Government/University/Non-profit/Individual Participants
- Define Addressable Markets in Cislunar space
 - Karman Line (100 km) to lunar surface
 - Customer requirements focused → frequency agnostic
- Cash Flow Models for serving each addressable market
 - Emergency → Augment → Backup → Primary Power
 - Power Generation/Transmission/Delivery Utility model
 - Overlay with Comm, Data, Navigation, Time

*Investment Prospectus for
LP&L is forthcoming soon*



BACKUP CHARTS - Energy

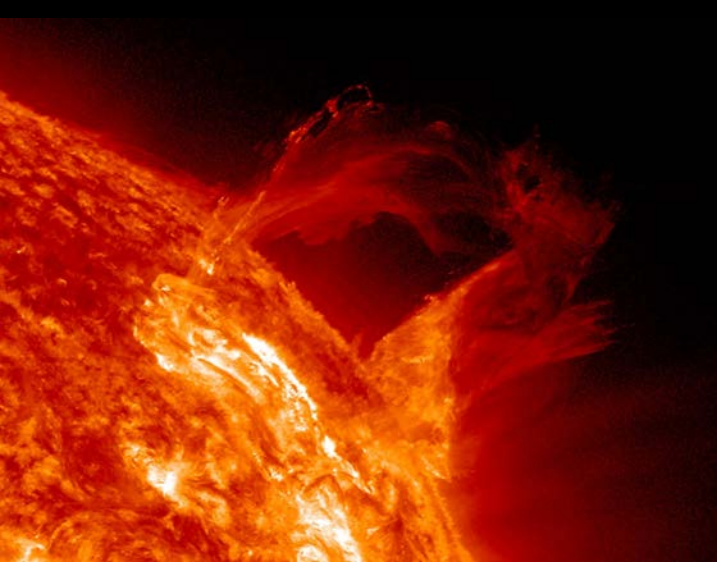
- Sectors
- Products/Services
- Customers
- Supplier/Resources
- Transportation
- Investment/R&D
- Infrastructure
- Regulation



BACKUP - SECTORS

- International Governmental Consortia
- Government Consortia
- Government-Commercial Consortia
- Government-Not for profit Consortia
- Commercial Consortia

→ THERE ARE NO UNILATERAL SECTOR OPTIONS



BACKUP – PRODUCTS/SERVICES

Cislunar Electrical Utility

- Earth-to-Earth Wireless Energy
- Space-to-Earth Wireless Energy
- Space-to-Space Wireless Energy
- Space-to -Luna Wireless Energy
- Space-to-Asteroid Wireless Energy
- Space Power Generation (insitu)

Product Catalog

- Emergency Power
- Backup Power
- Auxiliary Power
- Primary Power
- Indirect/Direct Momentum Transfer
- Allied Utilities (Comm, Nav, Data, etc.)

→ Leverage Economy of Scale



BACKUP – CUSTOMERS “Earth”

Earth

- Other Electrical Utilities (existing & new)
 - less than 10 cents/kwh delivered to the grid
 - environmentally benign
 - scalable to meet world demand
 - accessible near where it is needed
 - limited security issues
- Military Logistics → cost per kwh is fungible provided that the required power is available where it is needed, when it is needed, with no exceptions
- Emergency Response Logistics → readily deployable, reasonable to operate, relatively low cost,
- Remote Infrastructure Alternative → where SSP is a cost effective alternative to other available options
- Transportation Vehicles → where SSP is a cost effective mission appropriate options
- Kinetic storage, water desalination, synthetic fuel production → very low cost surplus power

The baseload power market is driven by the delivered cost per kwh to the grid.

All other categories of power demand trade off cost to some extent to accommodate one or more other objectives.



BACKUP – CUSTOMERS “Space”

Space

- Transportation Vehicles
- Propulsion Augment (resistojets, etc.)
- Debris Mitigation

Bit Gathering/Processing/Transfer

- Constellation Systems
- Fractionated Systems
- Multi-Use/Customer Platforms
- Integrated Platforms
- Stand alone Spacecraft

Human and/or Robotic Facilities

- R&D Facilities
- Manufacturing Facilities
- Intermodal Facilities
- Processing Facilities (fuel, ores, etc.)
- Mining Facilities (water, ores, etc)
- Hospitality Facilities (tourist)
- Habitation Facilities

Near term - Degraded Legacy Systems

Mid Term - Enhanced Systems

Long Term - Immortal Systems



BACKUP – CUSTOMERS “Lunar”

Lunar

- Electrical Relay Infrastructure (new)
 - Exploration Vehicle Support
 - Emergency Response Logistics
 - Remote Infrastructure Alternative
 - Transportation Vehicles
- Bit Gathering/Processing/Transfer*
- Allied Utilities (Comm, Nav, Data, etc)

Human and/or Robotic Facilities

- R&D Facilities
- Manufacturing Facilities
- Intermodal Facilities
- Processing Facilities (fuel, ores, etc.)
- Mining Facilities (water, ores, etc)
- Hospitality Facilities (tourist)
- Habitation Facilities

*All services are mission enhancing
if not mission enabling*



BACKUP – Suppliers/Resources

Logistics

- Earth Launch Systems
- Transfer Systems
- Luna Launch Systems

Low Mass Power Generation

- Photovoltaic
- Solar concentrator
- Solar Dynamic

Radiant Energy Beaming

- Microwave
- Frequency Agnostic
- Laser

Other Technologies

- Robotic Assembly Assets
- Control & Damping of Large Structures
- Piece Part Manufacturing in Space
- High temperature tolerant electronics
- Radiation tolerant electronics
- Modular structures
- Network Control Architectures

*Trade State-of-the-art vs.
satisfactory and sufficient vs.
optimal*



BACKUP – Transportation

- Earth to LEO
- LEO to Earth
- LEO to LEO/MEO/HEO
- LEO to GEO
- LEO to Lunar Orbit
- LEO to NEO
- GEO to GEO
- GEO to LEO
- GEO to Lunar Orbit
- Lunar Orbit to Luna
- Lunar Orbit to Lunar Orbit
- Lunar Orbit to GEO
- Lunar Orbit to LEO
- Lunar Orbit to NEO
- NEO to NEO
- NEO to Lunar Orbit
- NEO to GEO
- NEO to LEO
- Luna to Lunar Orbit
- GEO to NEO

Foster the market – Government(s) as the NACA/IACA and first customers



BACKUP – Investment/R&D

- Low cost launch
- Low cost transfers
- Low cost mass production
- High efficiency solar power generation
- Control and Damping of large structures
- Demonstration of Power Beaming
- High Temperature Solar Cells
- Luna/Lunar manufacturing

Match between tranches of investment, staging of effort, perceived and actual cost/schedule/technical risk and returns is critical to success.



BACKUP – Infrastructure

- Transportation System
- Network of Space Solar Powered Satellites
- Ground Station "Rectennas" (receiving antennas)
- Maintenance Capability
- (As an exception) crewed teams for repairs
- Asteroid Manufacturing
- Lunar Manufacturing

Elements, linkages, and operational procedures must be defined and built.



BACKUP – Regulation

- Spectrum regulation
- Inspection of System for Compliance with Outer Space Treaty
- Space traffic Control
- International Indemnification
- Debris Management and Mitigation
- Zoning on Earth Rectennas
- WHO compliance for Health and Safety

We need to create a regulatory framework that is informed and driven by the confluence of interests necessary to grow the market.

