International Symposium on Solar Energy from Space

The Vision & Challenge of Solar Power Satellites

Abundant & Affordable Solar Power on Earth & in Space

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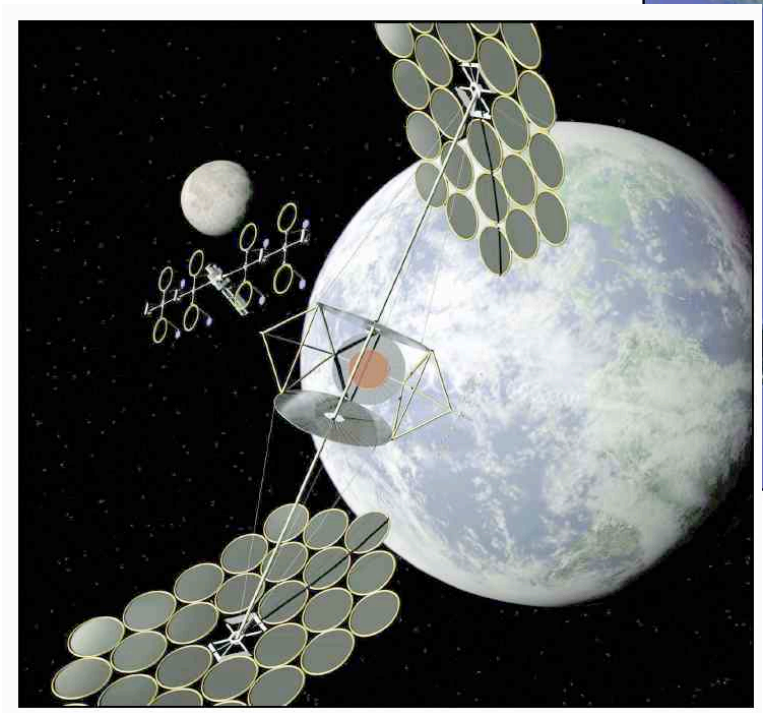
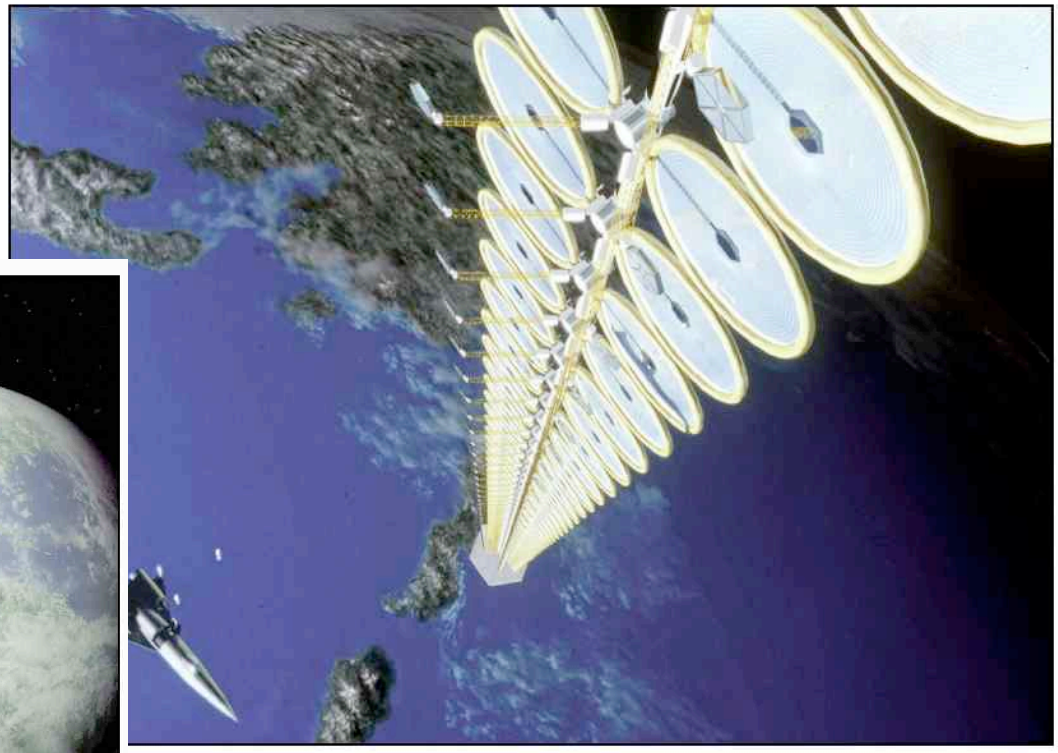
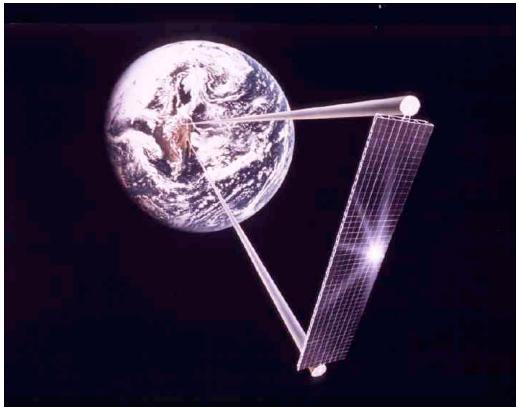
The Vision

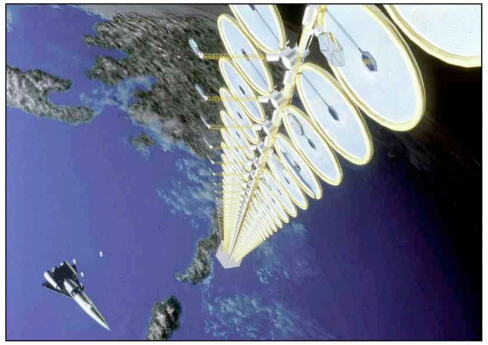


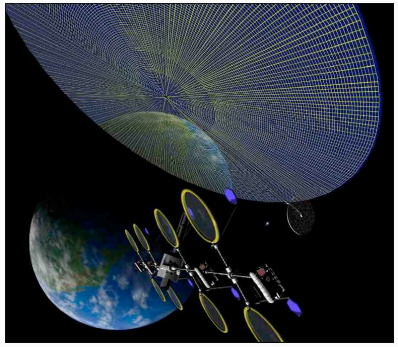


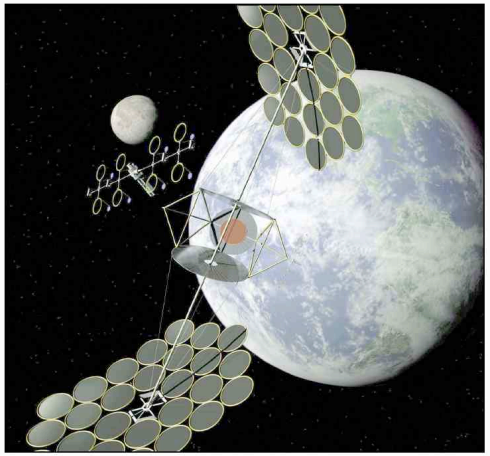
Clean, safe, affordable and virtually limitless solar energy 24/7

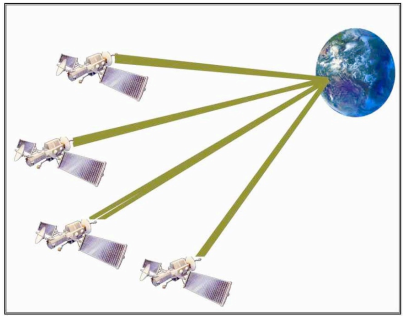
The Challenge





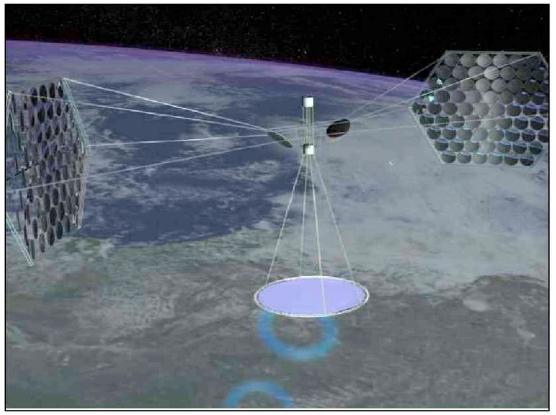






Many Possible Paths…

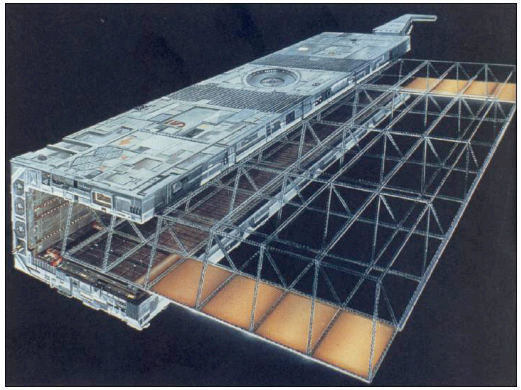
Complex Engineering Choices…

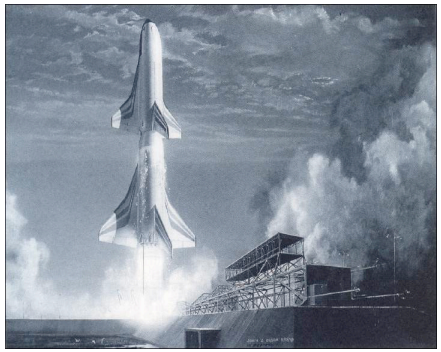


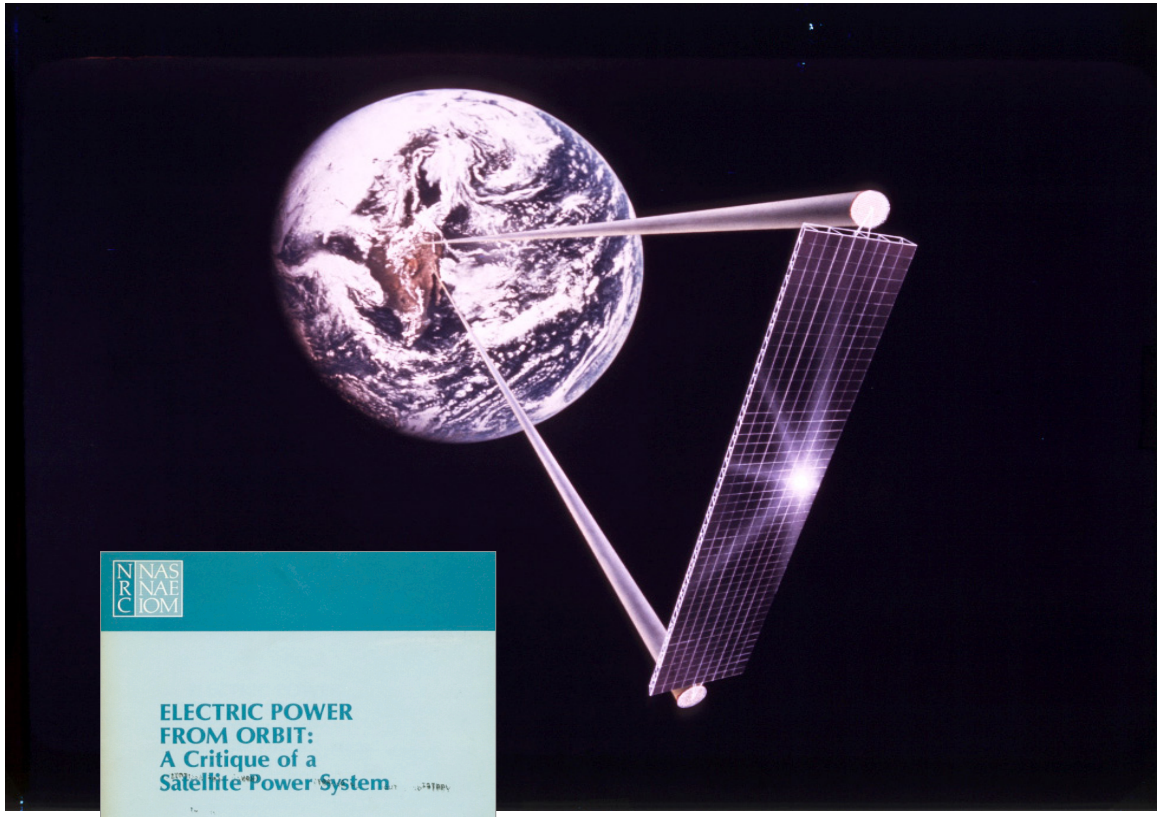
Technical Challenges

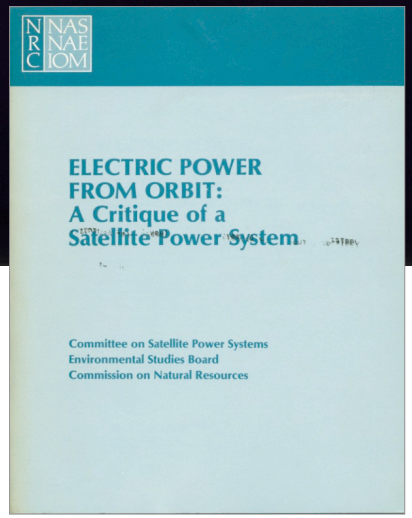
The Technical and Economic viability of SSPS depends on (1) end-to-end Efficiency, (2) total Mass, and (3) the Cost to deploy / operate…

1979 SPS Reference Concept in GEO





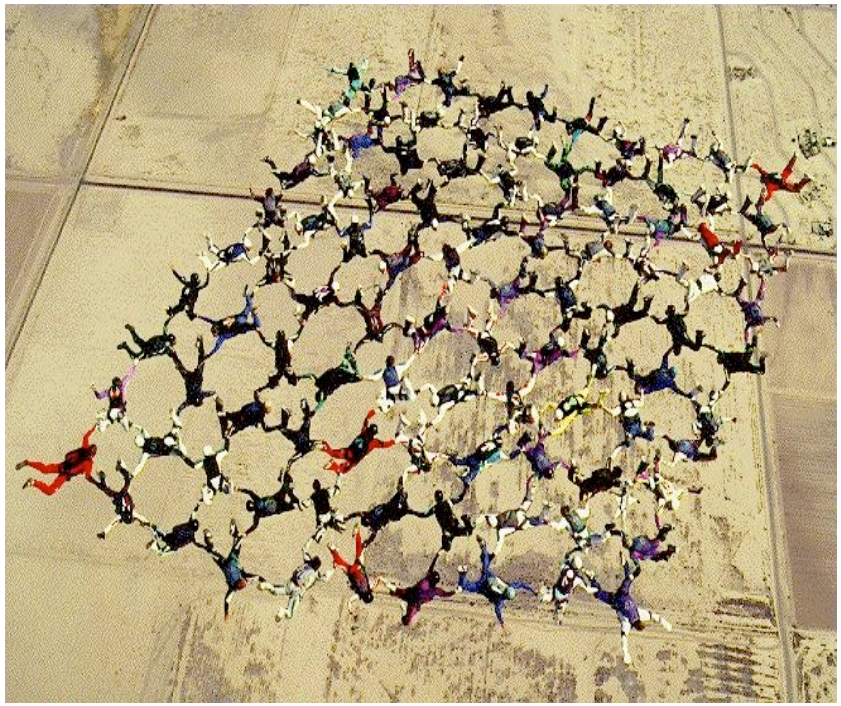


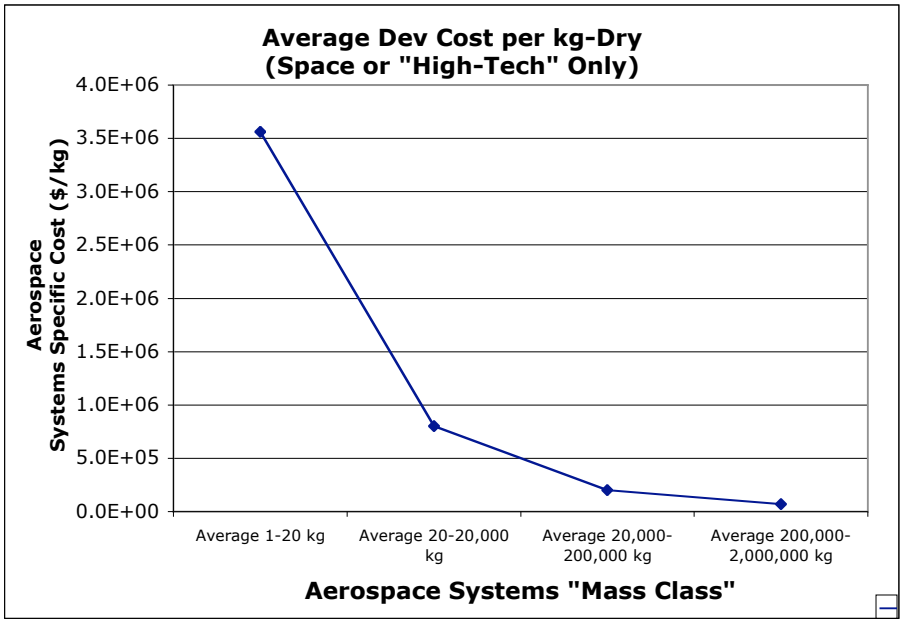


What Has Changed?

1979	2009
• Solar Power Generation	• Solar Power Generation
– Efficiency @ ~ 10%	– Efficiency @ ~ 40%, going to 50%
• Wireless Power Transmission	• Wireless Power Transmission
– Solid State Amplifiers, with Efficiency @ ~ 20%	– Solid State Amplifiers, with Efficiency @ ~ 80 - 90%
– Mechanical Pointing, 200 meter gimbal carrying 7 GW to 1 km array	– Electronic Beam Steering, with no mechanical gimbal
• SSPS Power Management Req'ts	• SSPS Power Management Req'ts
– Voltages @ ~ 50,000 Volts	– Voltages @ < 1,000 Volts
• SSPS Space Launch Req'ts	• SSPS Space Launch Req'ts
– Unique Reusable Heavy Lift, with payloads @ 250 tons	– Any Commercial Launcher, with payloads @ ~ 25 tons
• Space Robotics	• Space Robotics
– Degrees of Freedom @ ~ 3	– Degrees of Freedom @ ~ 30++
– Control ~ Programmed/Teleoperated	– Control ~ Autonomous/Telesupervised
• Space Assembly	• Space Assembly
– 100's of Astronauts	– No Astronauts
– Large Space Factory Required in GEO	– No Space Factory Required

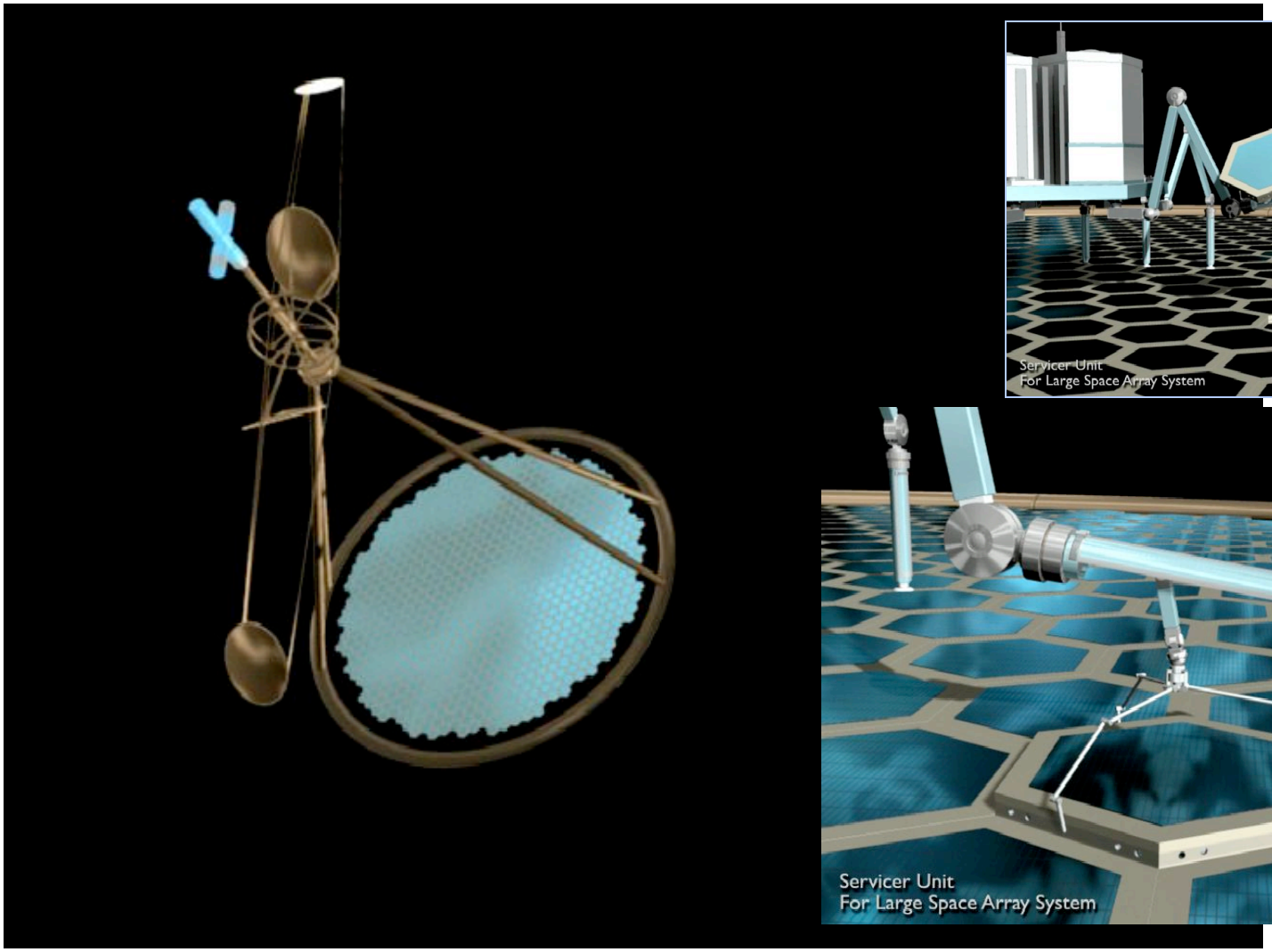
How SPS Economics Might be Achieved…



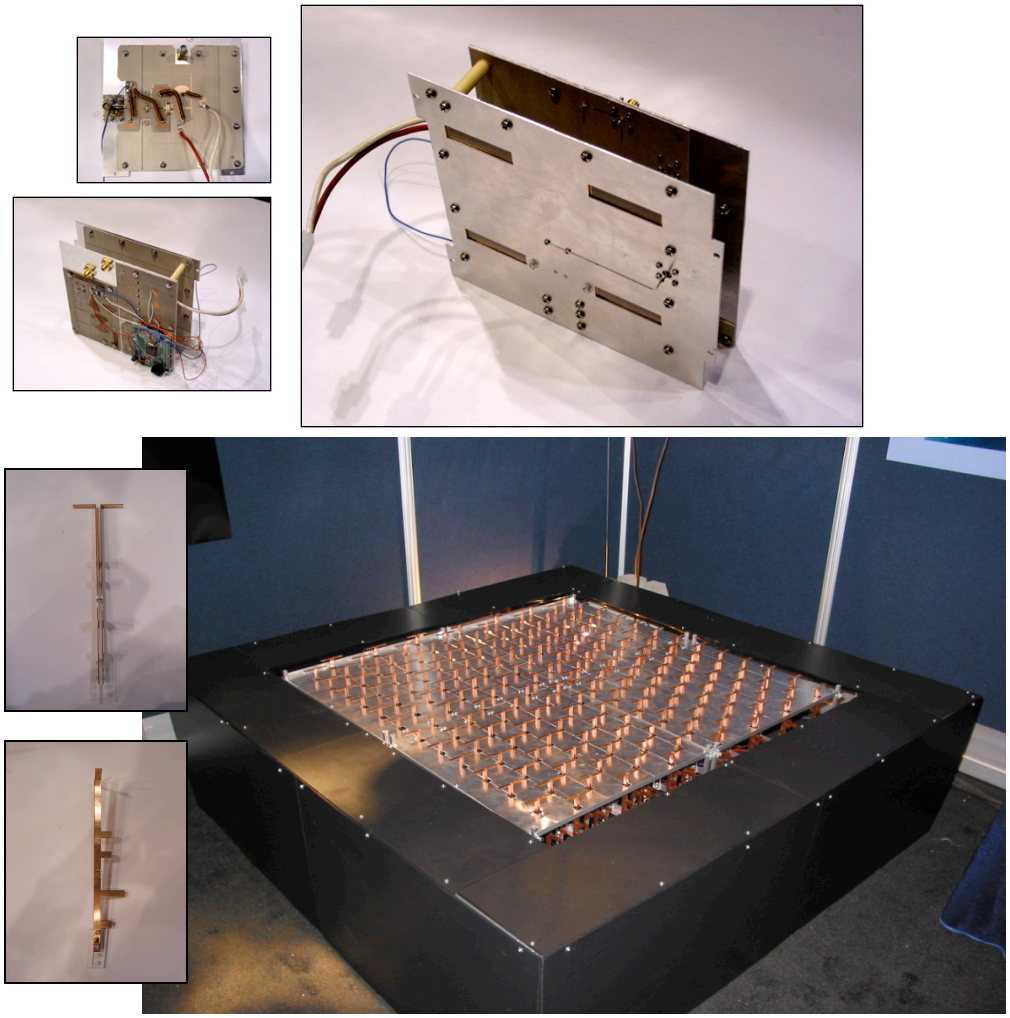


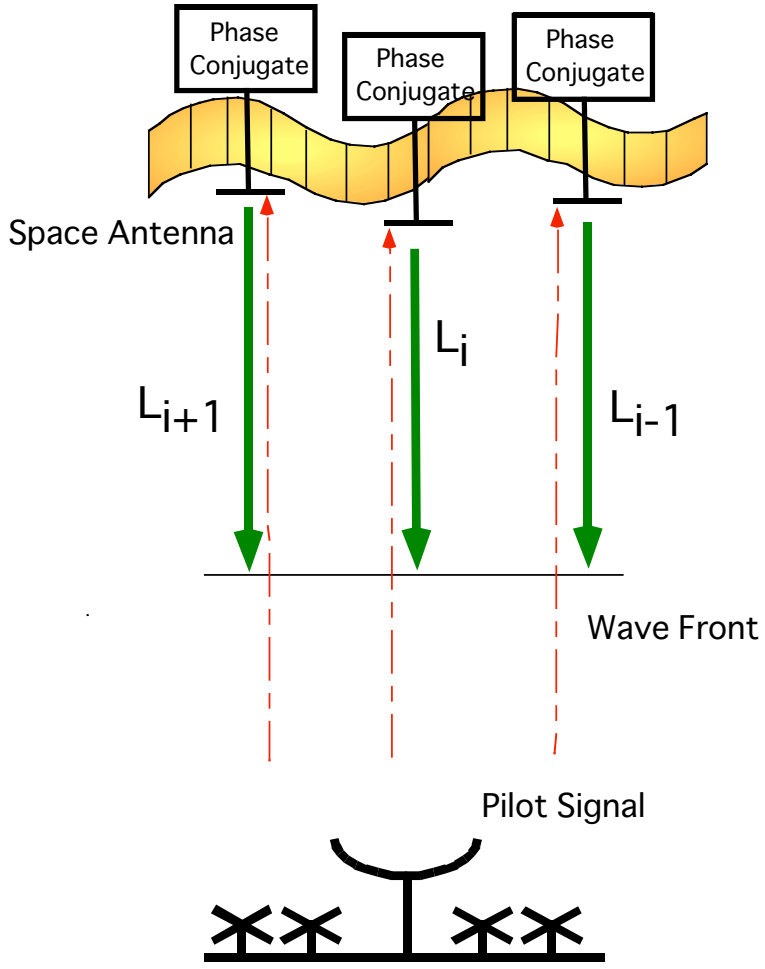
- Large systems, assembled out of identical intelligent (and reconfigurable) elements, have the potential to radically reduce the cost of space operations--for the right applications
- At the same time, such 'fractionated spacecraft' can radically reduce launch risks and costs…

One Promising Approach
Integrated Symmetrical/Modular SPS



A Potential Key to Microwave SPS:
Retrodirective Phased Arrays...





Recent SBSP Progress
Wireless Power Transmission Tests (2008)

Today: Another Step Forward…

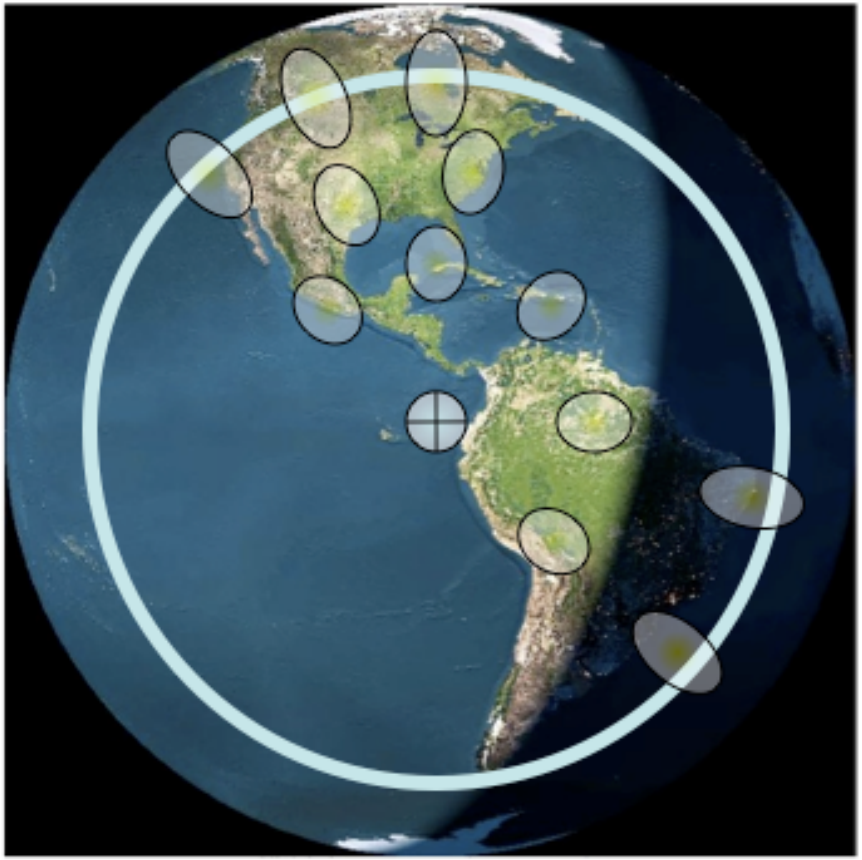
- Demonstration of a "NextGen" Retrodirective Phased Array Approach for Wireless Power
  - Prof. N. Kaya and team; of Kobe University
- Key SPS / WPT Functions to be demonstrated…
  - Low-cost, high-power amplifier phased array modules
  - Pilot Signal Control of the phased array – dispatchable energy
  - Dynamic pointing to / tracking of a moving target
  - Automatic recovery from dislocation of array elements

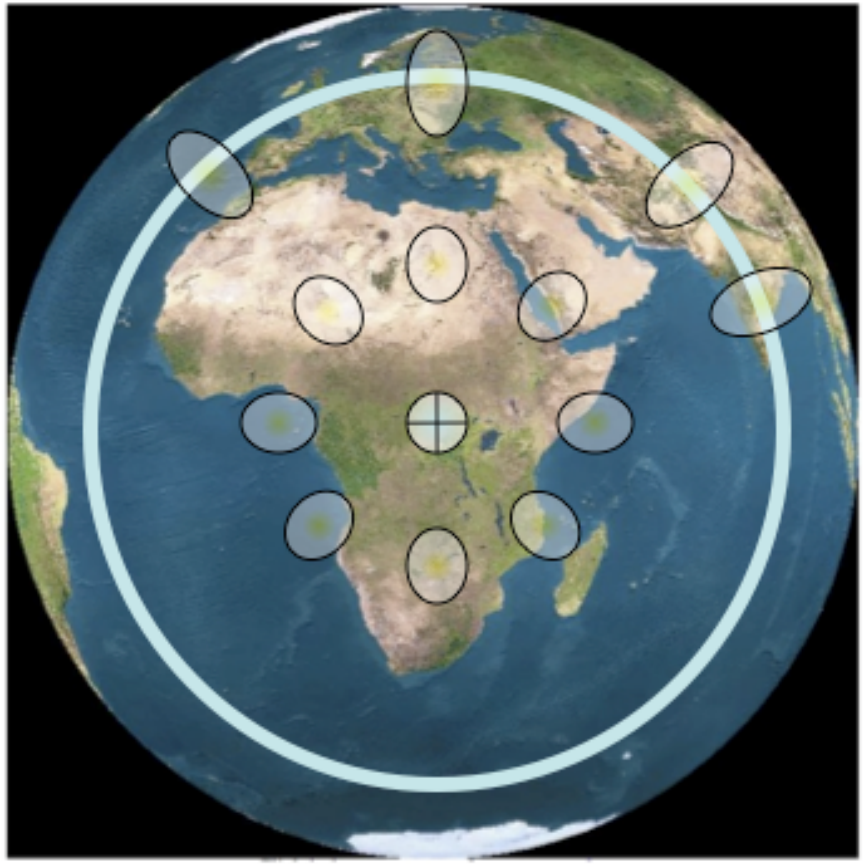
Closing

- Fundamentally new approaches are needed to meet the Emerging Challenges of global Energy, including
  - Accelerating per capita Energy Consumption (China, India, etc.)
  - The Urgent Need for Assured Global Energy Security
  - Strong concerns about environmental impacts (climate change, pollution, carbon sequestration, etc.)
  - Sometimes Uncertain Stability of Key International Energy producing regions
  - "Coming Soon": Peak Oil / Natural Gas
  - Inherent limits on ground-based renewable energy (day/night cycle, biofuels competition with agricultural production, etc.)

Space Solar Power could realize the Vision of sustainable, affordable, safe solar energy – worldwide & 24-7…

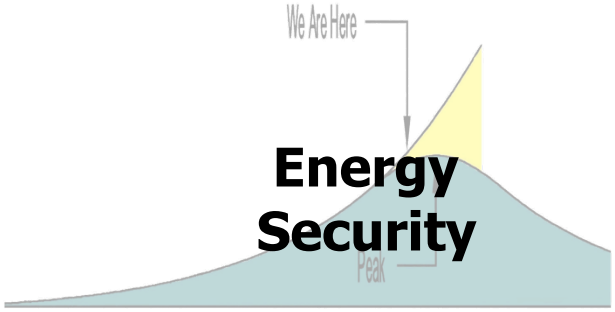
Affordable / Dispatchable Solar Energy 24-7





The Vision
Affordable / Dispatchable Solar Energy 24-7

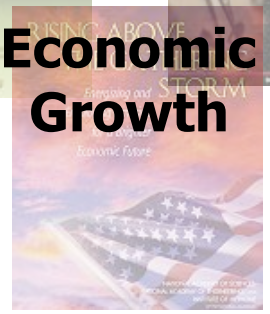
Space Solar Power – A Unique Opportunity



Energy Security

Environmental Sustainability

SPACE SOLAR POWER



Economic Growth

Space Applications