

Solar Power Satellite

- Toward Unexplored Frontier with Nobel Technologies -

Naoki Shinohara

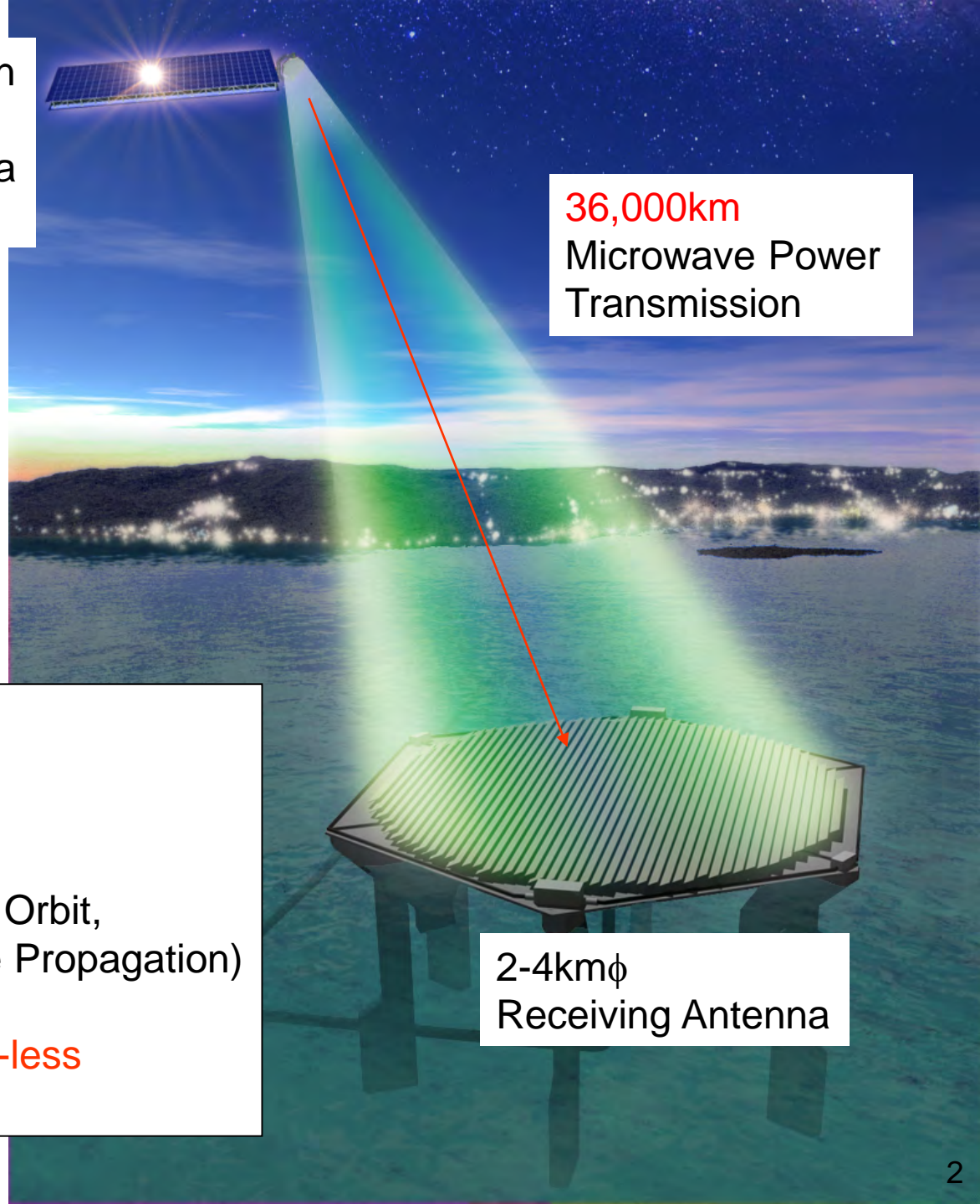
Professor, Kyoto University, Japan

1GW Solar Power Station
2km ϕ Solar Cells
2km ϕ Microwave Antenna
< 10,000 ton weight

Solar Power Satellite (SPS)

Energy Availability Factor
Ground PV
: < 15% (Night, Rain...)
Space PV (SPS)
: >90% (No Night in 36,000km Orbit,
No Rain by Microwave Propagation)

-> SPS is huge, stable, and CO₂-less
future power station



36,000km
Microwave Power
Transmission

2-4km ϕ
Receiving Antenna

Significance of SPS

Mile Stone toward Future Space Development
(Huge Space Satellite (Structure))

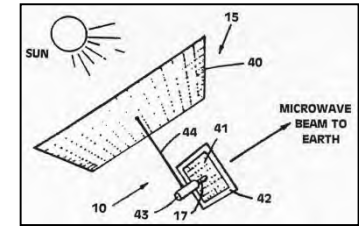
Future Stable Solar Power Station without CO₂
(Huge Solar Power from Satellite)

[Key Technologies for SPS]

- Economical Launch System (Reusable Rocket, OTV, etc.)
 - Totally <10,000 tons Space Segment
- Construction/Maintenance of Huge Space Segment (by Robots)
 - > 2km Structure in space with Solar Cells and WPT
- Power Management in Plasma
 - > 1 Million kW (1GW) Power (> 10-100kV in Plasma)
- Wireless Power Transfer Technology (by Microwave, Laser)
 - 36,000km WPT with > 50% (Electricity -> WPT (>90%)-> Electricity)

Various SPS Models

First SPS (Glaser, P.E.)



Solar Power Satellite

Non-concentrator

Concentrator

Bus Power



NASA Reference Model



SPS2000 (Experiment)



NEDO Grand Design

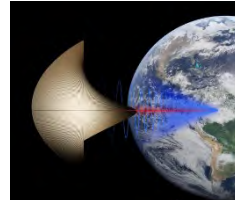


MR-SPS (CAST, China)

Distributed Power



USEF Tether SSPS



CASSIOPeiA (UK)

Bus Power



NASA Sun Tower

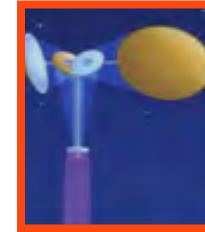


NASA ISC



JAXA M-SSPS

Distributed Power



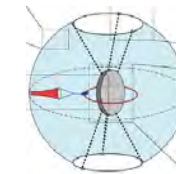
NASDA 2001



IAA Study Model

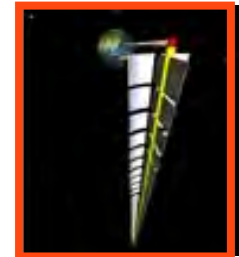


SPS-alpha (US)



SPS-omega (China)

Laser Direct Excitation



JAXA L-SSPS

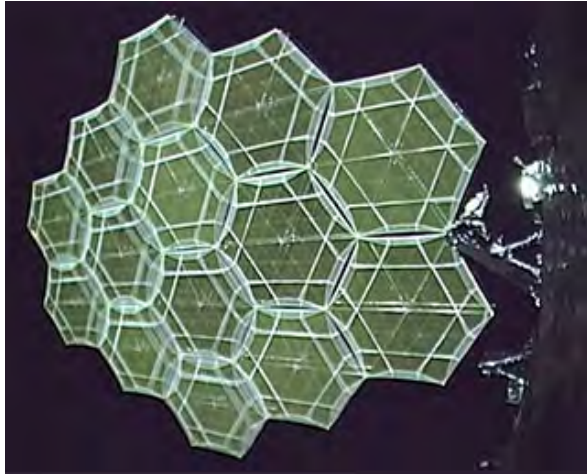


Designed in Japan

System Size is the same
(1GW power, a few km size,
< 10,000 tons satellite)
-> Required Technology is similar.

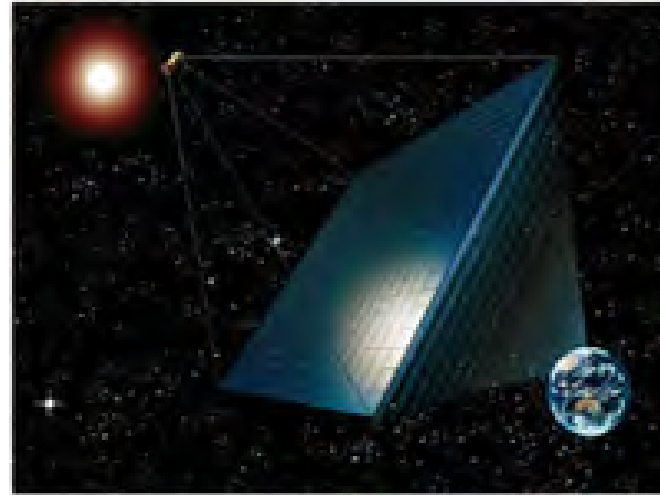
Scale of Space Structure

_____ 10 m _____ 100 m _____ 1 km _____ 10 km _____ 100 km _____



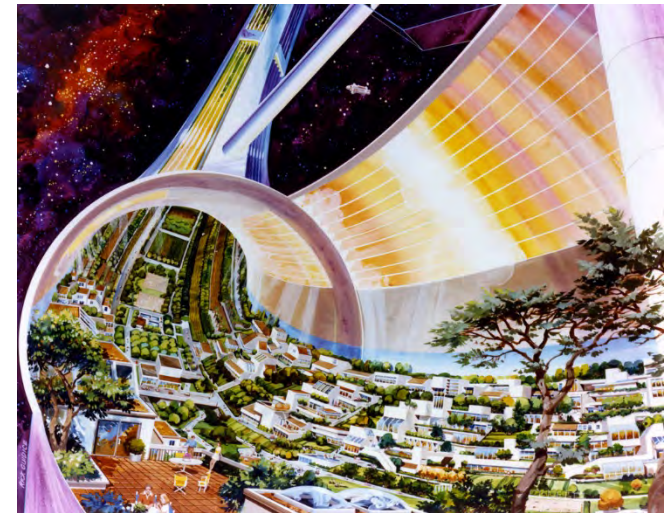
Modular Reflector

International
Space Station



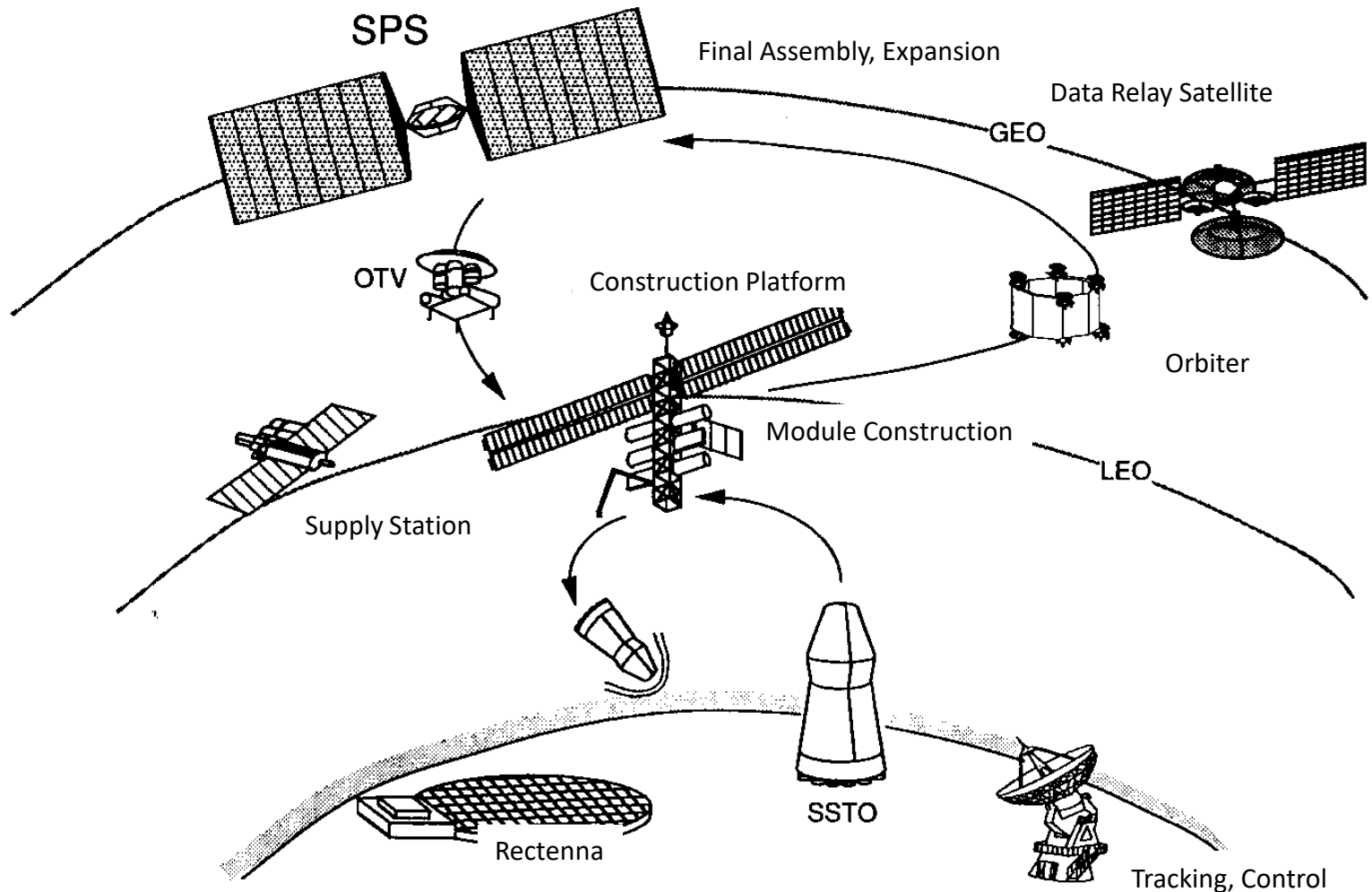
SPS

Space Colony



How to Launch > 10,000 tons Space Segment

2 Step Launch (Ground→LEO(400km), LEO→GEO(36,000km))



How to Construct/Maintain > 2km Space Structure by Robot for SPS Construction/Maintenance

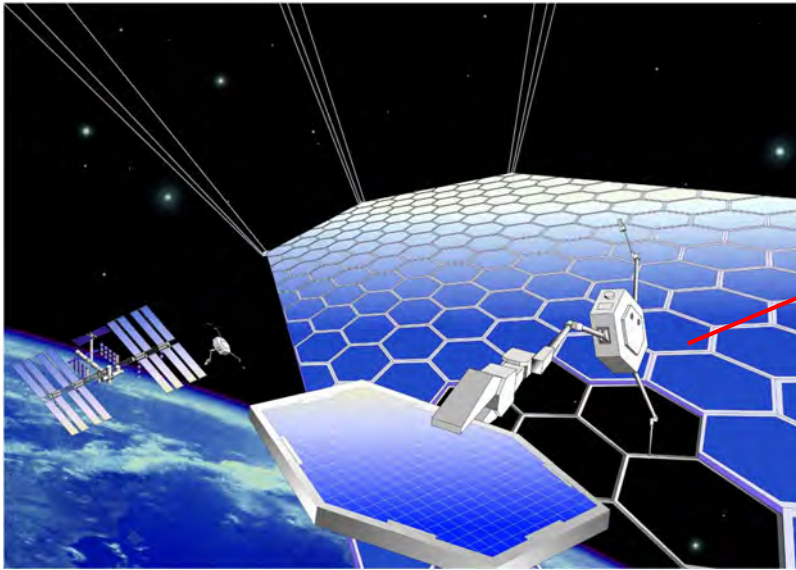
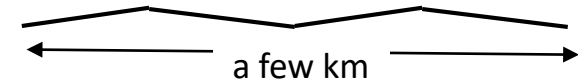


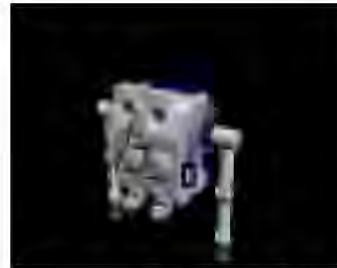
Image of SPS Structure (Solar Cell, WPT)
(Easy Construction)



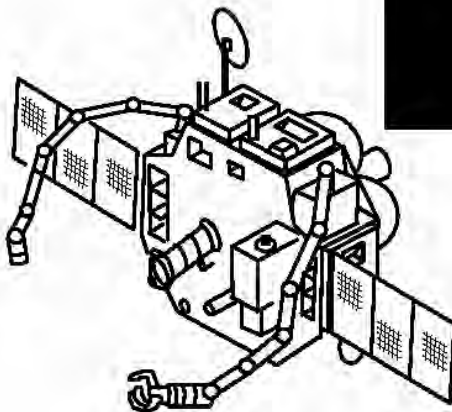
Unit Structure (Micro : Rigid, Macro : Soft)
Actively Fluctuated Structure

Structure Friendly Robot
Robot Friendly Structure

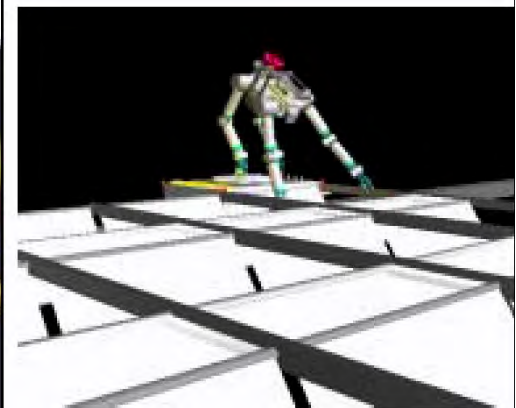
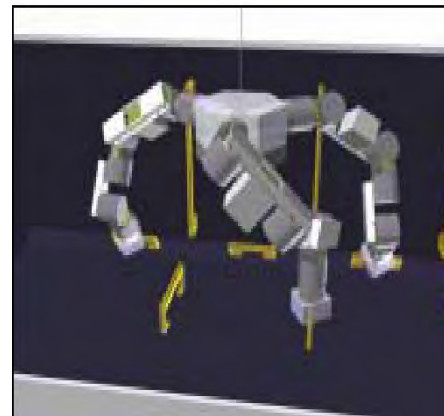
**Robot
in Space**



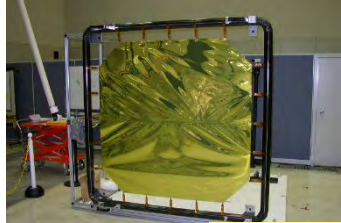
Storage



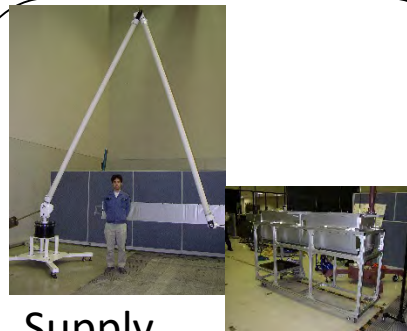
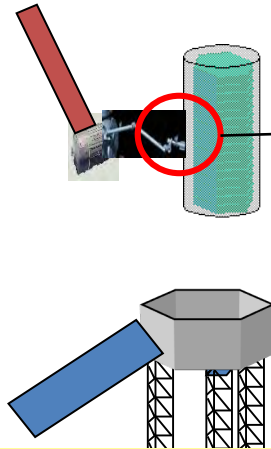
Robot on Structure



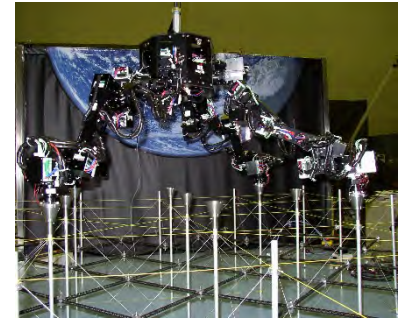
Test Bed of Automatic Construction of SPS Structure on Ground



Inflatable S
Constru



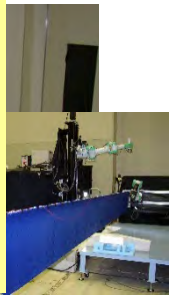
Supply,
Parts Transportation



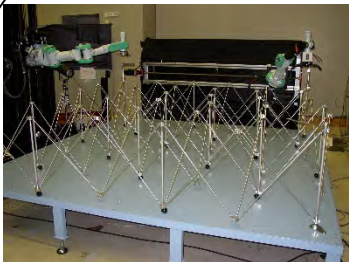
Move, Transportation
on Soft Structure

[Future Works]

- Move, Transportation on Soft and Light Structure
- Construction of Soft Structure
- Remote Control / Self-Reliance Operation



Connection of Soft Structure



Expansion
Support of Expansion
of Structure



Storage



Construction of Large Structure



JAXA, SSPS Robot WG 2004

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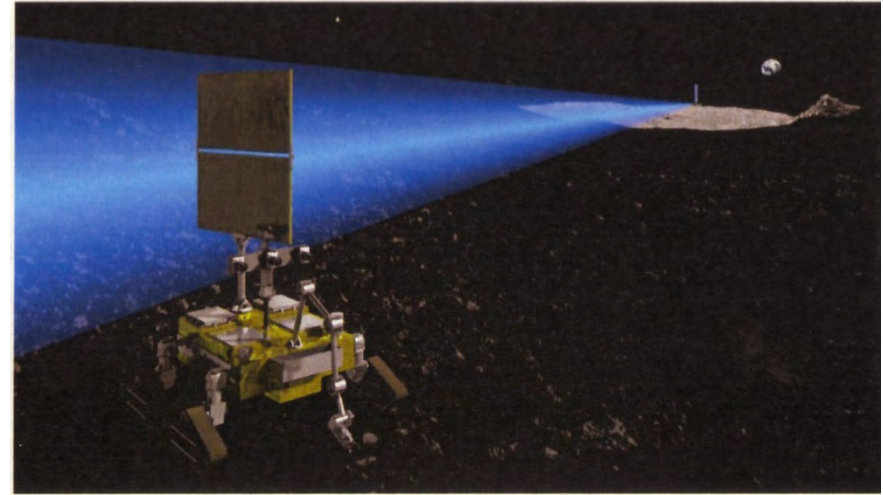
Spin Off/In Technology for/from Commercial WPT

Proposal of Spin-off / Landing Applications of SPS by JAXA (2017)

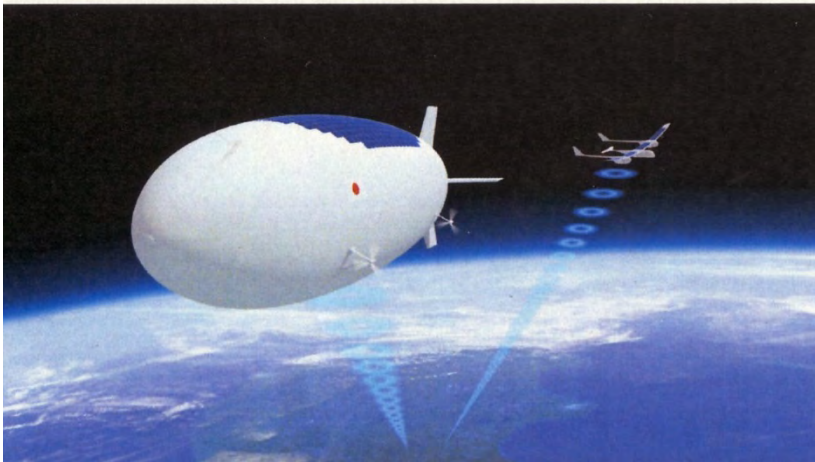
- Laser Power Transfer to Flying Drone



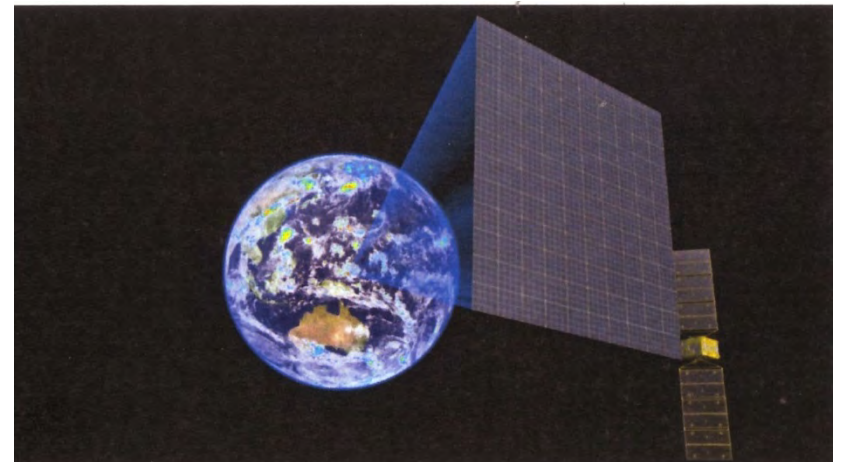
- Laser Power Transfer to Driving Rover on Moon



- Microwave Power Transfer to Stratospheric Platform (>MW)



- Radar Rain Gauge with Large Expanded Structure (> 30m)



Beam WPT via Radio Wave in Japan

[R&D Project toward SPS by METI (2017 - 2018)]

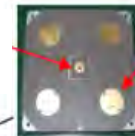
- MPT to Flying Drone with Developed (2015) Phased Array



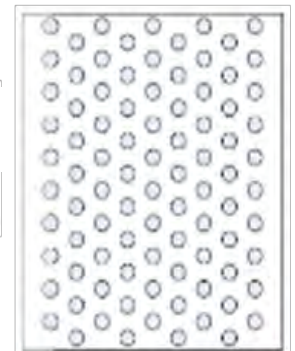
Rectennas

Payload on Drone
(Pilot Signal Transmitter + Rectennas))

Signal Monitor



Pilot Signal Transmitter



- 5.8GHz,
- 1.6kW Power (Max)
- REV
(Rotating Electric-field Vector Method)
+ Retrodirective Beam Direction Control
- Height 10m, 30m

Transmitter

Beam Direction Control
(Pilot Signal Receiver)

