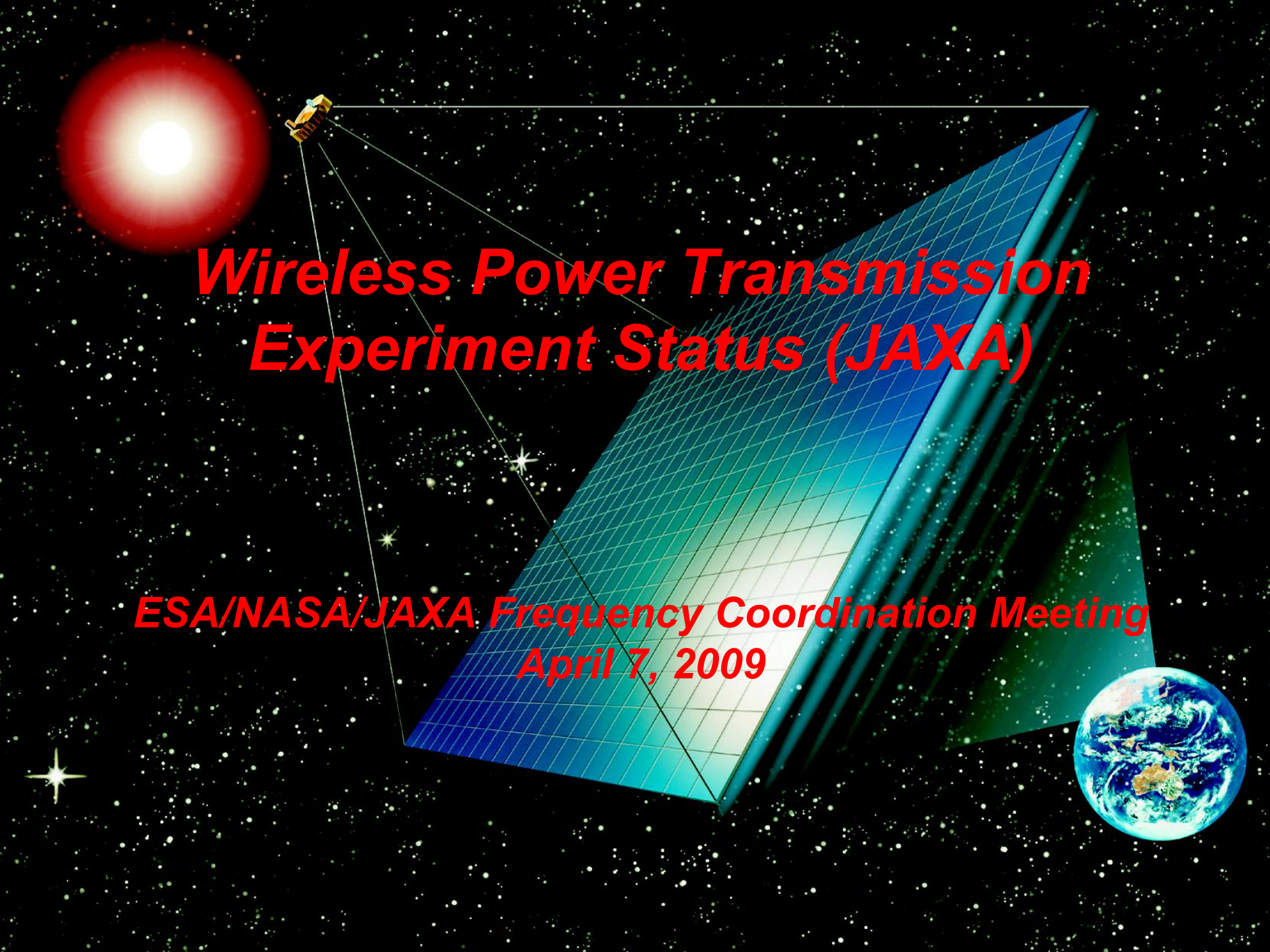
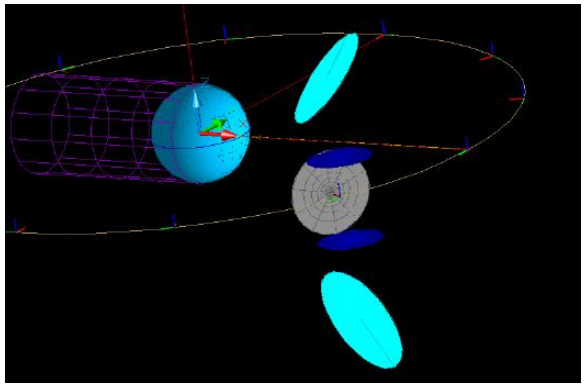


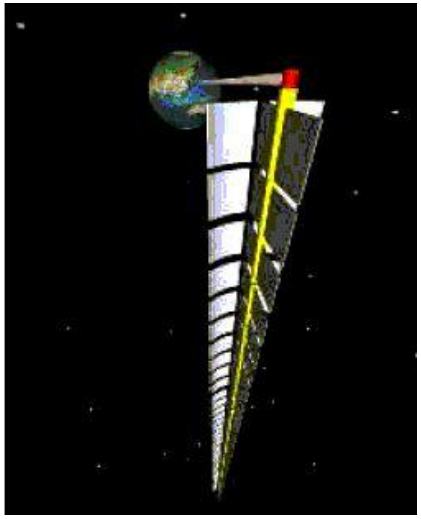
Wireless Power Transmission Experiment Status (JAXA)

ESA/NASA/JAXA Frequency Coordination Meeting
April 7, 2009

Wireless Power Transmission for SSPS

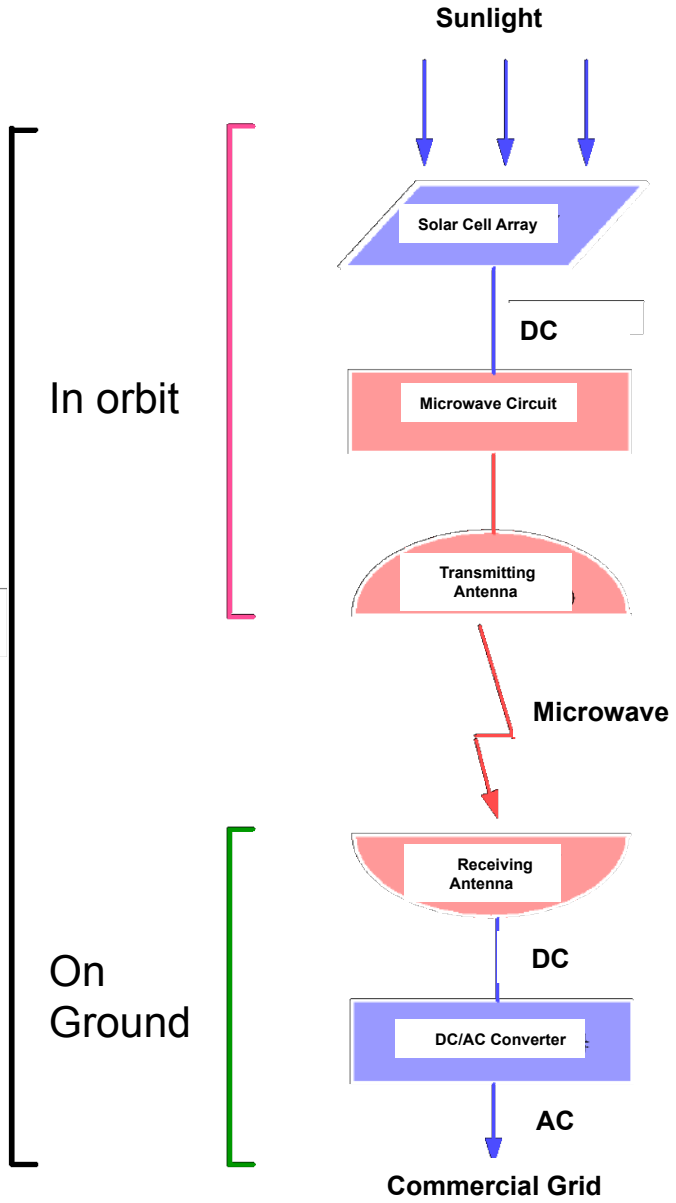


Microwave-Type SSPS



Laser-Type SSPS

SSPS

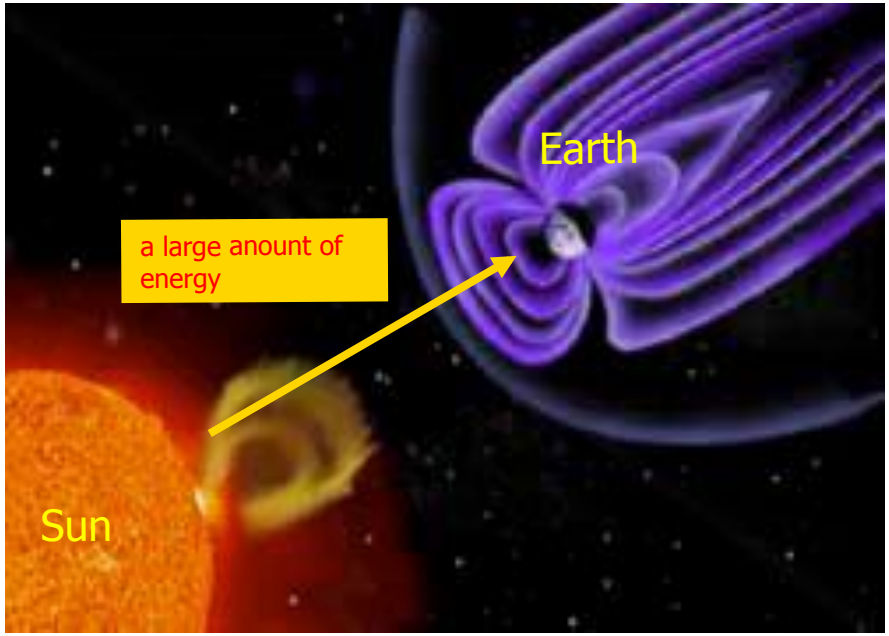


Laser directly excited by condensed sunlight is another candidate for wireless power transmission.

Why SSPS?

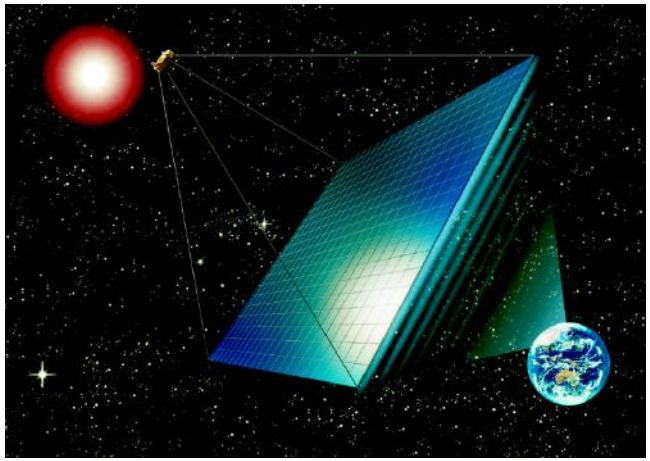
Why Solar Power?
Power from Sun to Earth: 1.77×10^{17}Watt
10,000 times more than total power consumption
⇒large potential for power source for human activities

Why Space?
Power density in space: 1,350W/m^2
Power density on ground: 100～200W/m^2
due to night, whether dependence, atomospheric loss
⇒Space is preferable to catch solar power, if we have efficient method to transfer the energy from space to ground.



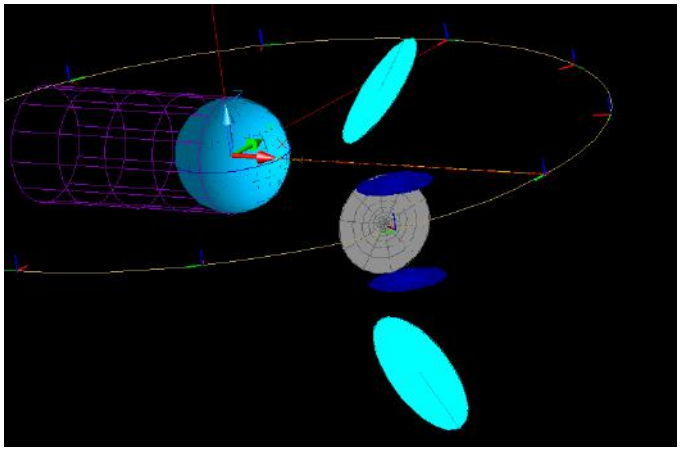
⇨ ***Space Solar Power Systems(SSPS)***

SSPS Models in Japan



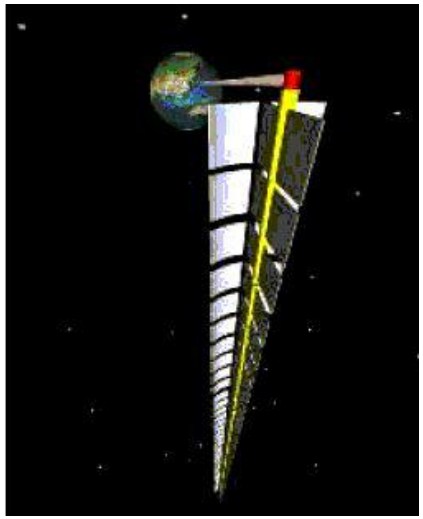
Basic Model

Earth pointing, microwave-type
Power generation/transmission panel
2kmx1.9kmx(2-10)cm thick
Stabilized by gravity gradient force by tethers
Modular structure composed of 100mx100m panels
Total weight:20,000 tons
Simple, but low power collection rate(64%)



Advanced Model

Sun-pointing, microwave-type
Reflective free-flying mirrors:
2.5 km x 3.5 km,
Solar Array:1.25km diameter
Light concentration:4 times
Transmitter:1.8km diameter
Total weight:10,000 tons (target)
Complicated, but high power collection rate(100%)



Laser Model

Sun-pointing, laser-type
System:100 modules, 12km length, 10MW、50tons/module, 5000 tons/1GW (target)
Reflective mirror:100mx100mx2/module
Radiator:100mx100m/module
Laser module:120m scale
Light concentration:500-1000 times
Compact size, but complicated, whether-dependent for power transmission

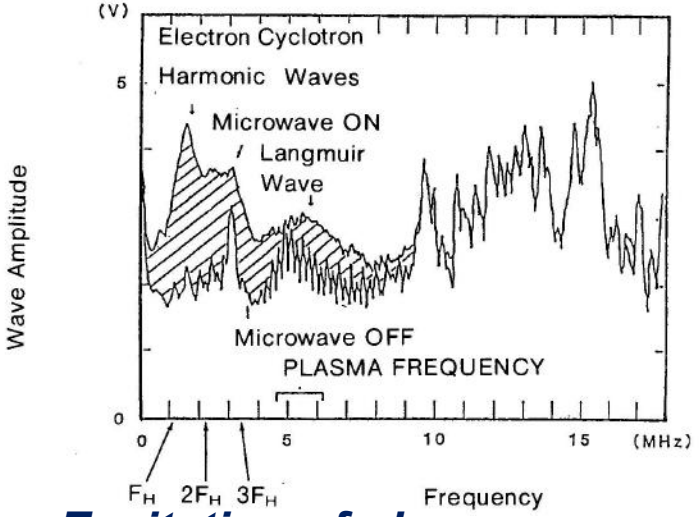
History of Wireless Power Transmission Research in Japan

1983	MINIX　Experiment（Space experiment to study the interaction of microwave with the ionosphere by sounding rocket） (2.45GHz)
1992	MILAX Airplane experiment（Microwave power transmission to small airplane） (2.45GHz)
1993	ISY-METS experiment（Space experiment to study the interaction of microwave with the ionosphere by sounding rocket） (2.45GHz)
1994～	Microwave garden experiment (Microwave exposure experiment for plant growth, Advanced Industrial Science and Technology) (2.45, 5.8GHz)
1995	ETHER experiment（Microwave power transmission to an airship） (2.45GHz)
1998 ～	NASDA SSPS study (JAXA SSPS Study)
2000 ～	USEF SSPS study
2006	Sounding rocket experiment for antenna deploy and active phased array
2009	Microwave power transmission experiment from an airship(2.45GHz)

Microwave Transmission Experiment in Space

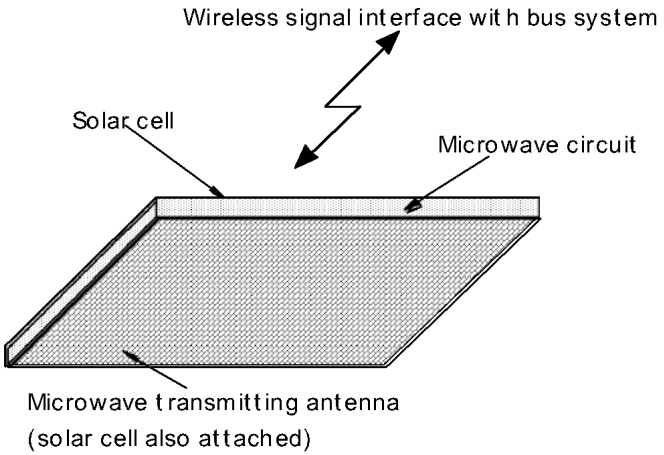
Sounding rocket experiment(2.45GHz)

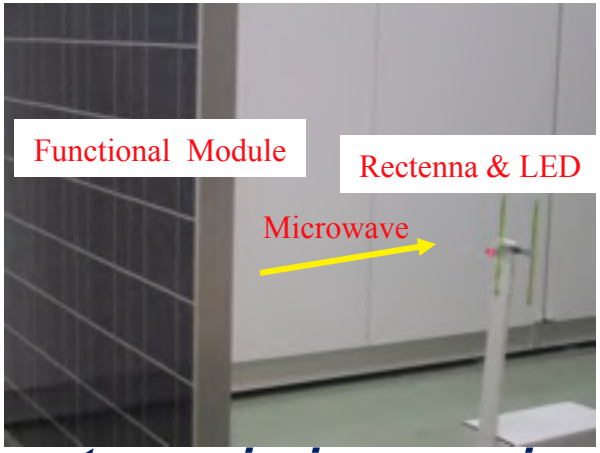
Payload configuration



Excitation of plasma waves

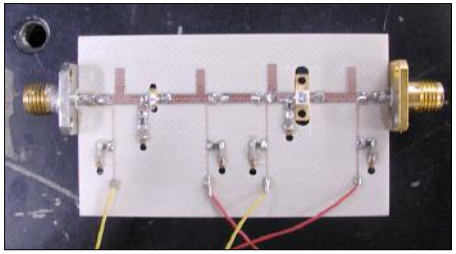
Engineering Research at JAXA for Wireless Power Transmission



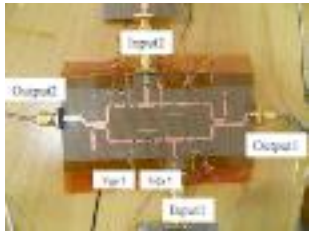


Beam transmission experiment(2.45GHz)

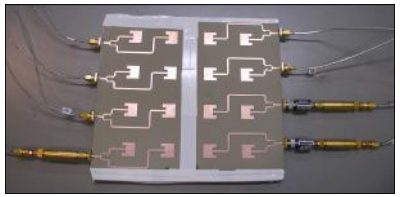
GaN high-efficiency Amplifier (5.8GHz)



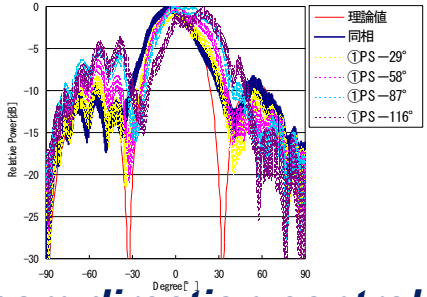
2-stage high power amplifier



Phase control circuit



8 Antenna Array



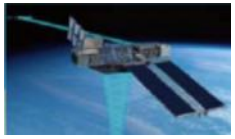
Beam direction control

Roadmap towards Commercial SSPS (tentative)

2000 2010 2020 2030 2040 2050 2060

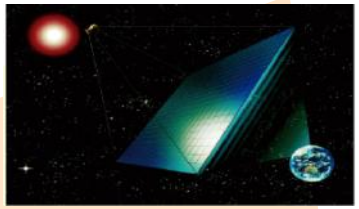
Basic Research Phase **Development Phase** **Commercial Phase**

Large Satellite



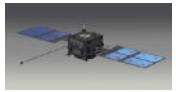
Test Plant

Commercial Model



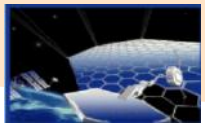
Basic model

Small Satellite

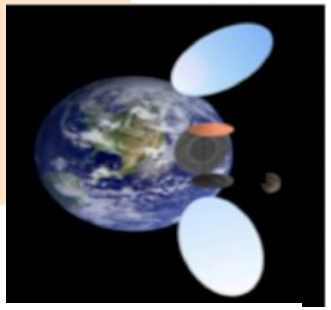


Transmission Exp. on ground

Microwave transmission Exp.

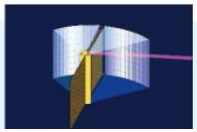


Experiment on space station



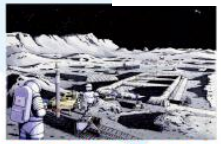
Advanced model

Laser transmission Exp.

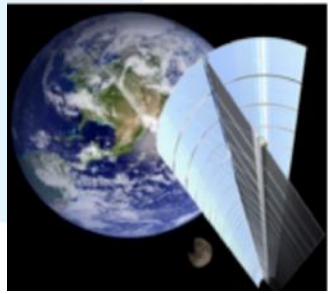


Test Plant

Rover

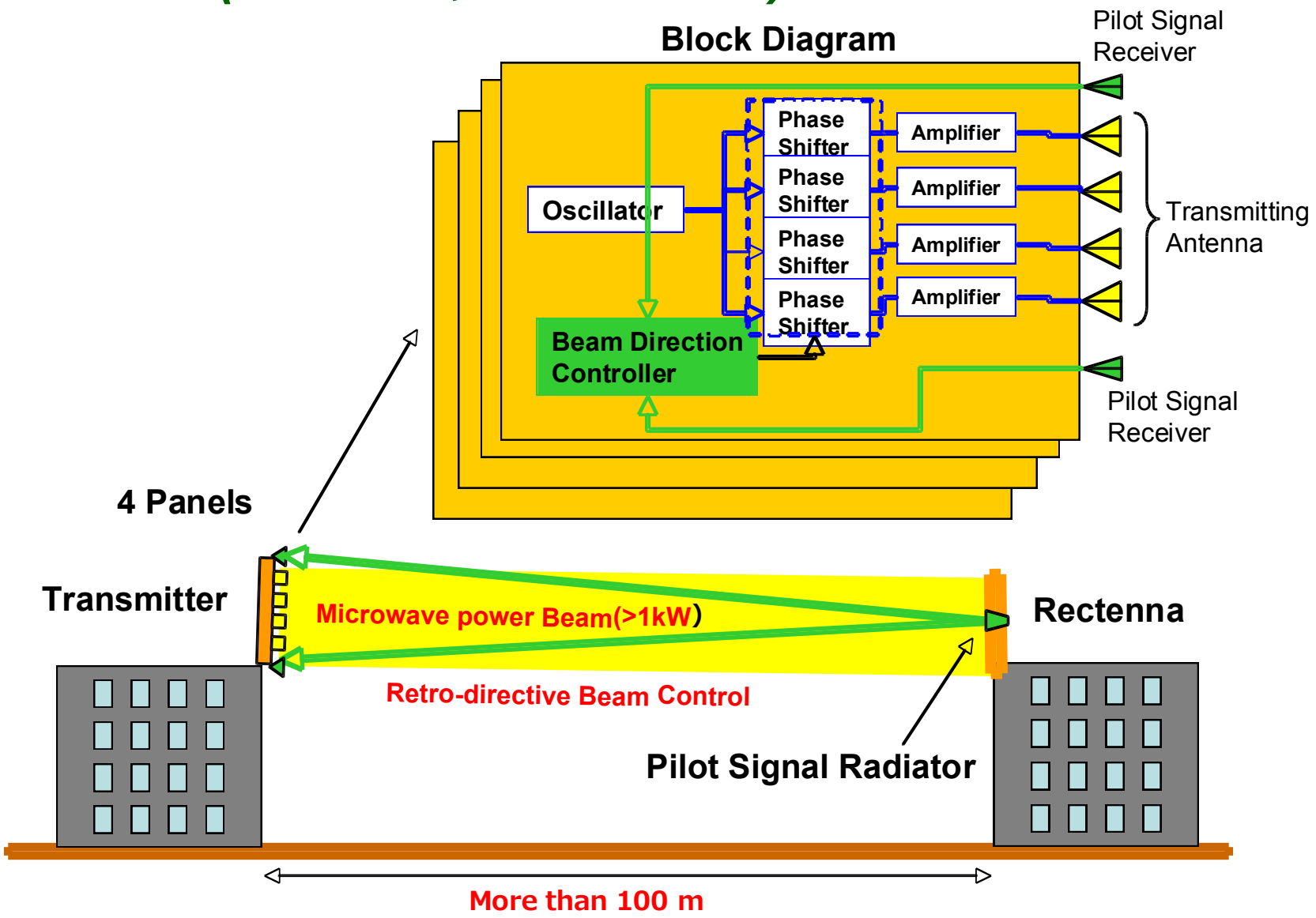


Lunar base

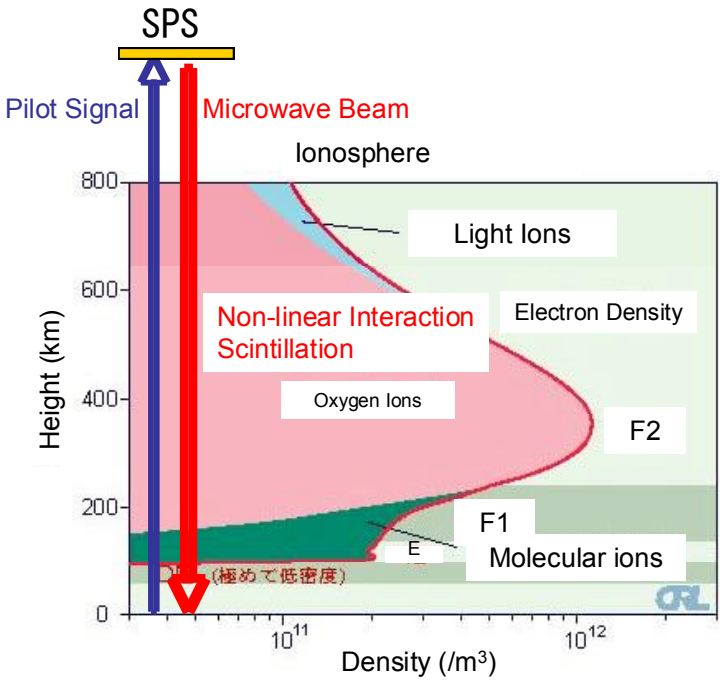


Laser model

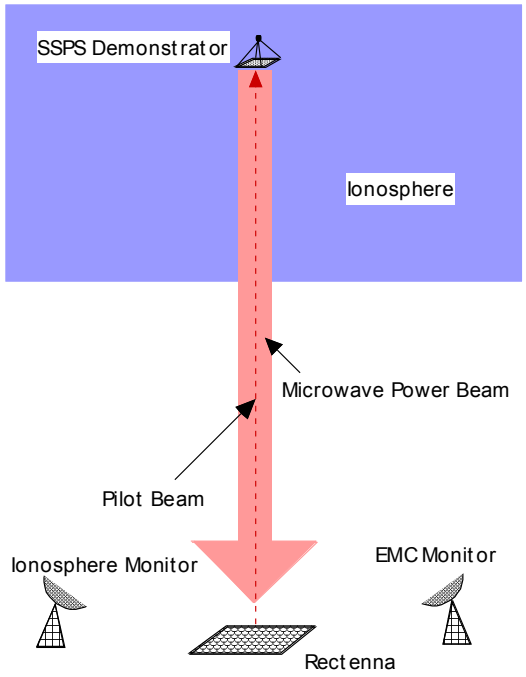
Microwave-SSPS Demonstration Experiment on Ground (5.8 GHz, 3kW class)



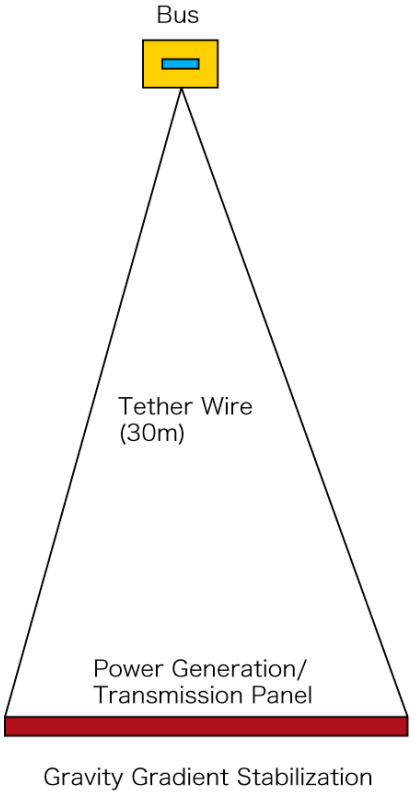
SSPS Demonstration Experiment in Space (3kW class, proposal)



Interaction between intense microwave and the ionosphere

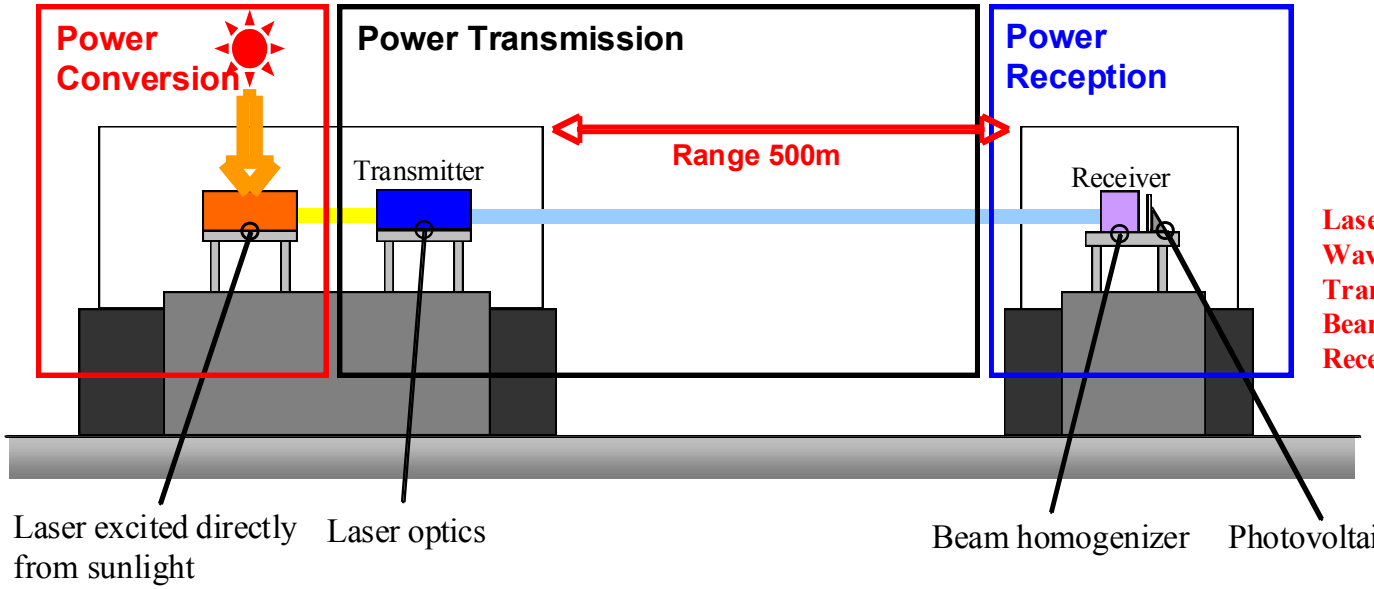


Concept of experiment in space



Demonstrator (mission:200kg)

Laser-SSPS Demonstration Experiment on Ground(1kW class)



Specification
Laser output 1kW
Wave length Å@1.06µm
Transmission 500m
Beam control Å@several µrad
Receiver output 0.2kW

Laser Power Transmission experiment(200W class) at Kakuta/JAXA

Frequency Concerns

1. 2.45 GHz and 5.8 GHz (ISM bands) have been considered as potential candidates for wireless transmission for SSPS.
2. ISAS（a division of JAXA from 2003) got license early 1990' for SSPS research(microwave garden experiment).
3. SSPS-related experiments are usually conducted in shield rooms.
4. For the kw class demonstration experiment, JAXA will obtain the license for the radio station from the Minister for Internal Affairs and Communications.
5. WP 1A/ITU considered contributions from JAXA related to power transmission via radio frequency beam (March 2009).

Summary

1. JAXA has conducted wireless power transmission research since 1980'.

2. We just started development of 1-3 kw class wireless power transmission system for ground demonstration.

3. Based on the results of demonstration experiment on ground, we will enter the new phase to start the demonstration experiment in space, hopefully within 5 years.