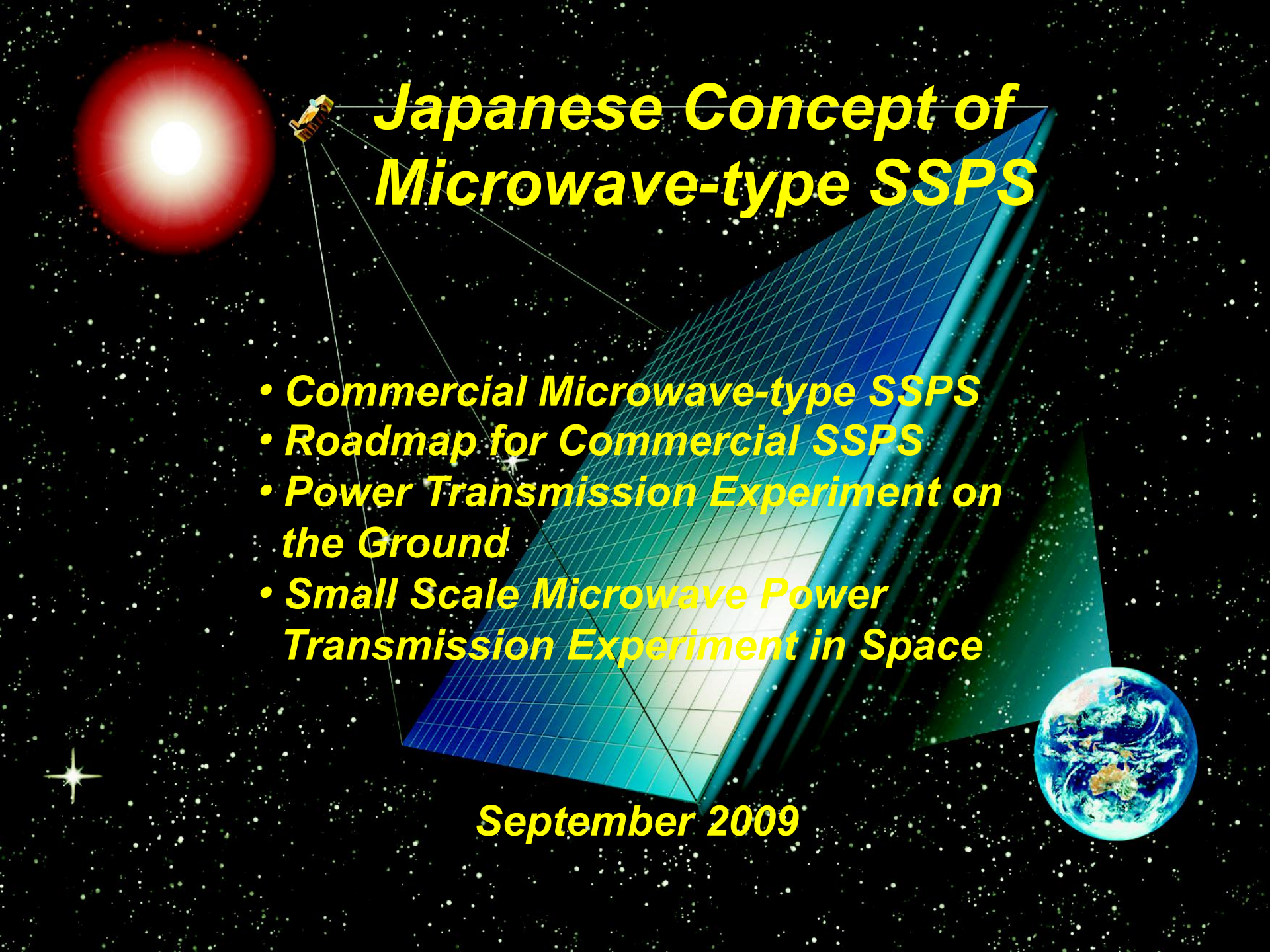


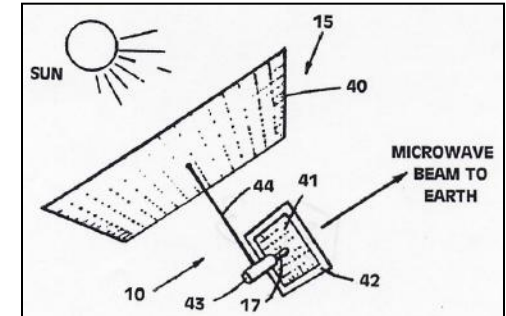


Japanese Concept of Microwave-type SSPS

- ***Commercial Microwave-type SSPS***
- ***Roadmap for Commercial SSPS***
- ***Power Transmission Experiment on
the Ground***
- ***Small Scale Microwave Power
Transmission Experiment in Space***

September 2009

SSPS Classification



Solar Power Satellite

Non-concentrator

Concentrator

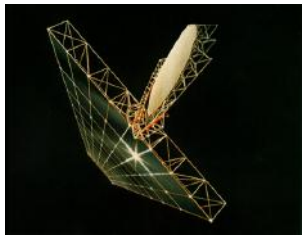
Bus Power

Separated Power

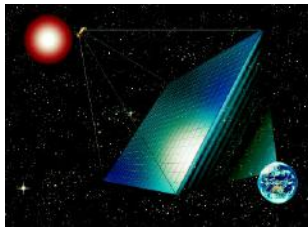
Bus Power

Separated power

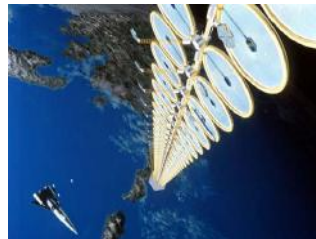
Laser Direct Excitation



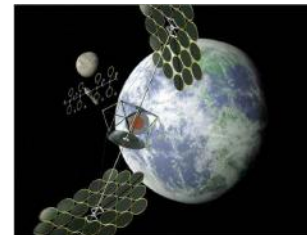
**NASAREference
Model**



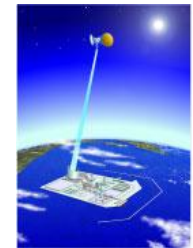
**USEF Tethered-
SPS**



NASASun Tower

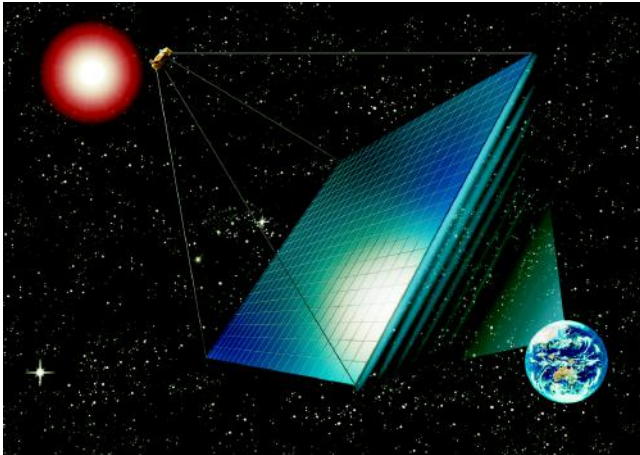


NASA ISC Model

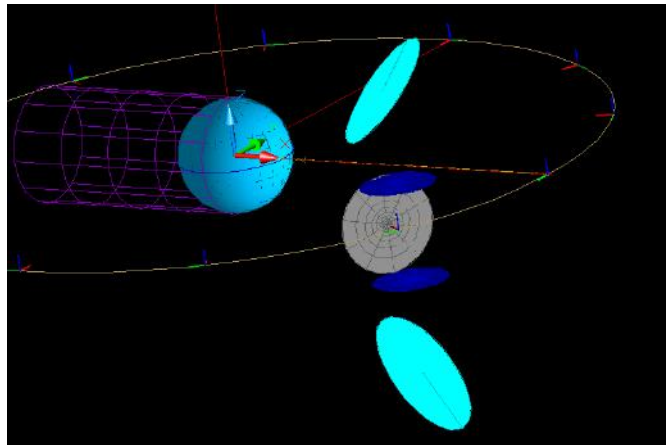


**JAXA Laser-type-SSPS
Model**

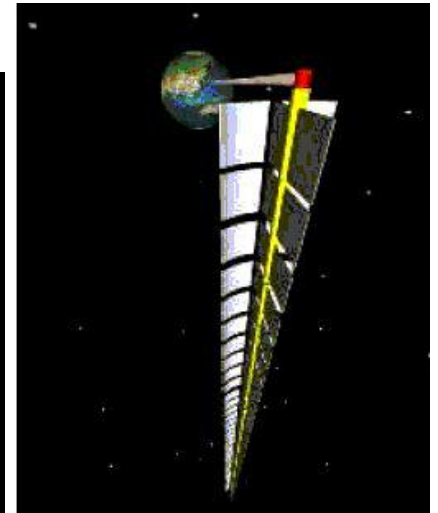
Commercial SSPS Currently Studied in Japan



***Basic
Microwave-type
Model
(USEF/METI)***



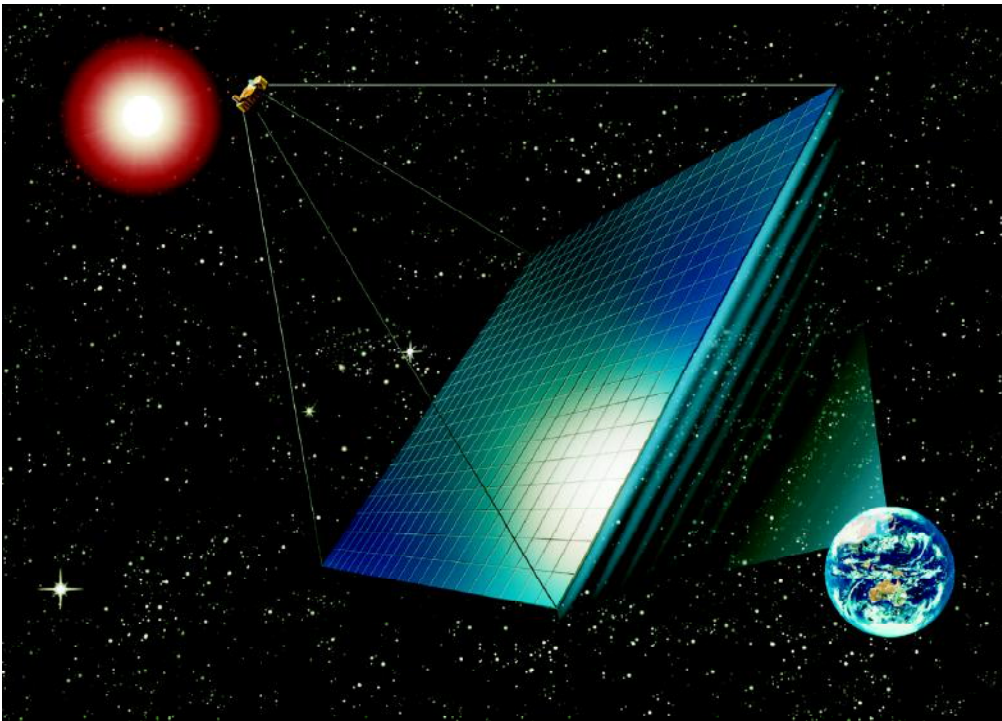
***Advanced
Microwave-type
Model
(JAXA)***



***Laser Model
(JAXA)***

Microwave-type SSPS (Basic Type)

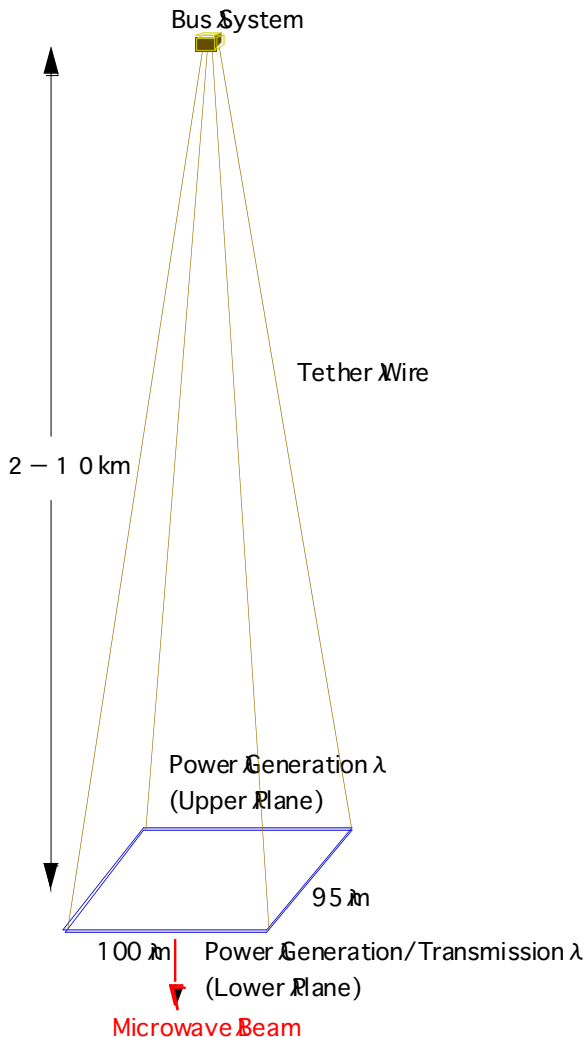
Tethered-SPS (Single-Bus Model)



Earth pointing SSPS
Power generation/transmission
Panel 2kmx1.9kmx(2-10)cm^t
Suspended by tether wires of
5-10 km
Unit panel 100m x 100m size
Total weight 20,000 tons

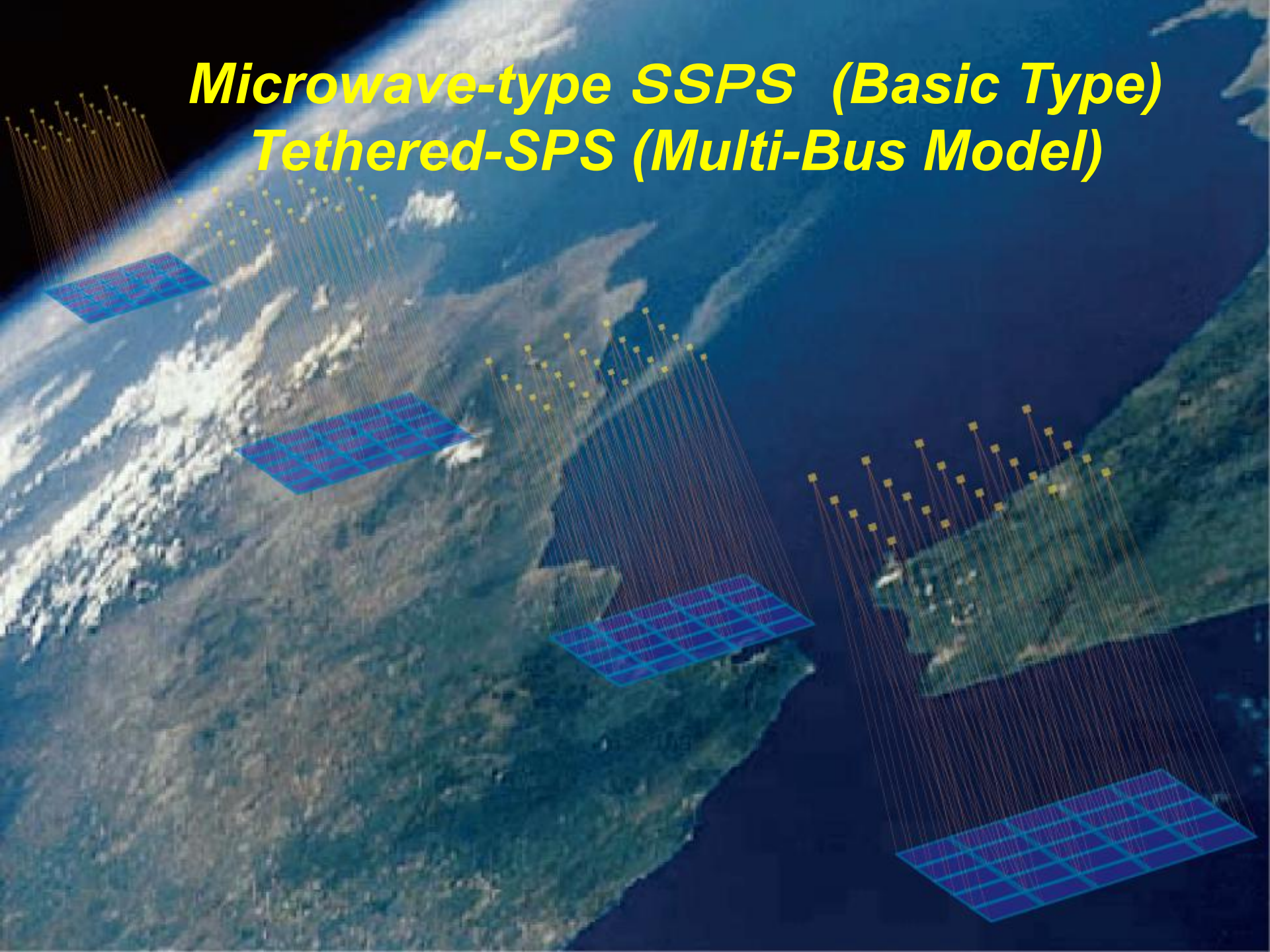
Simple but low rate power
collection (64%)

Unit of Tethered-SPS with Existing Technologies



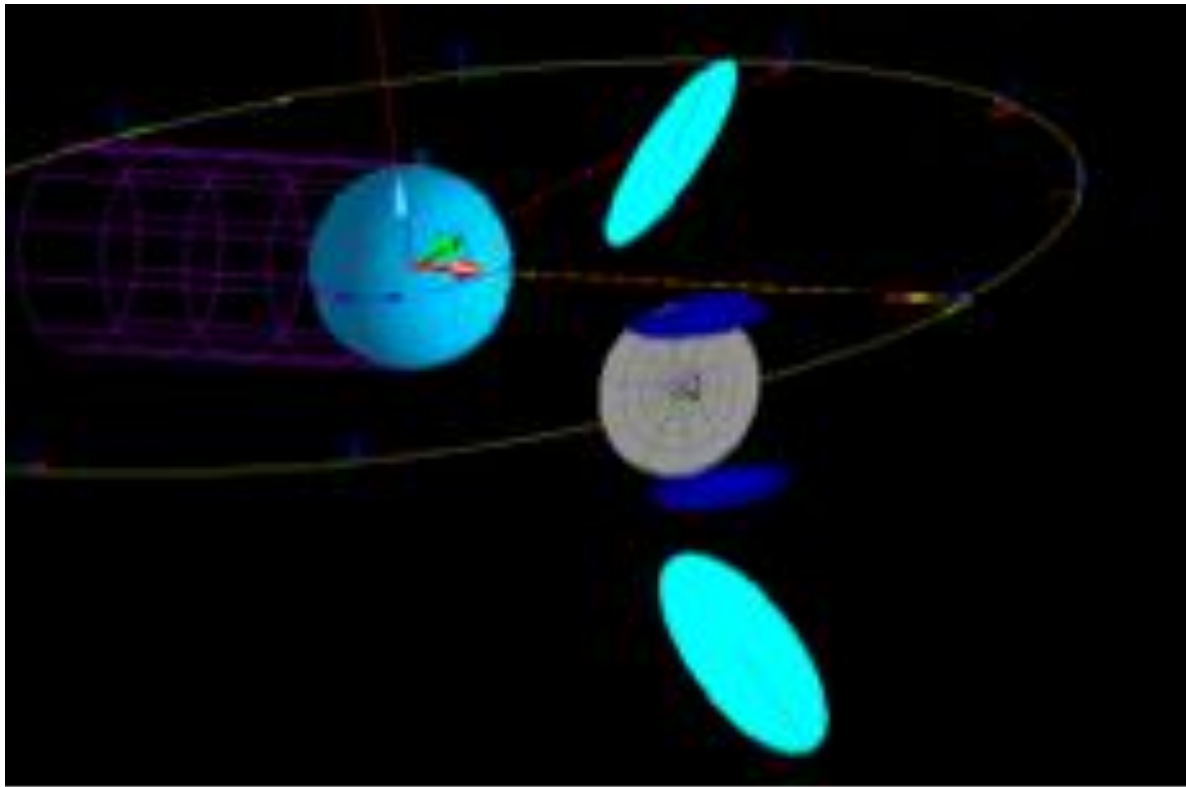
Basic Technology	Technology Level
Space tether Technologies (2~10km)	Deployment of tether more than 4 km have been conducted 5 times so far; SEDS-1(20km,1993), SEDS-2(20km,1994), TSS-1R(20km, 1996), TiPS(4km,1996), ATEEx(6km, 1999)
Deployment of large panel (100mx100m)	Solar array paddle 4.6mx32m(2000)

Microwave-type SSPS (Basic Type) ***Tethered-SPS (Multi-Bus Model)***



Microwave-type SSPS (Advanced Type)

Current Model



Sun pointing SSPS

***Reflection mirrors
(free flying) : 2.5 km x
3.5 km***

1000 tons x 2sets、

***Power generation:
100~300g/m²***

1.25 km Φ x 2 sets

Power transmission:

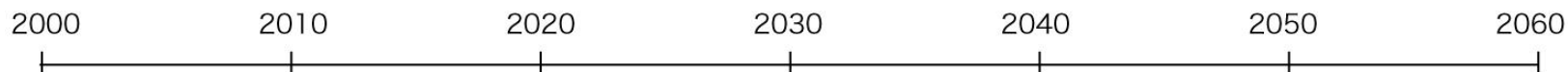
1.

8 km Φ

***Total weight: 10,000
tons(target)***

***Complicated but high
rate power collection***

Japanese Roadmap for SSPS



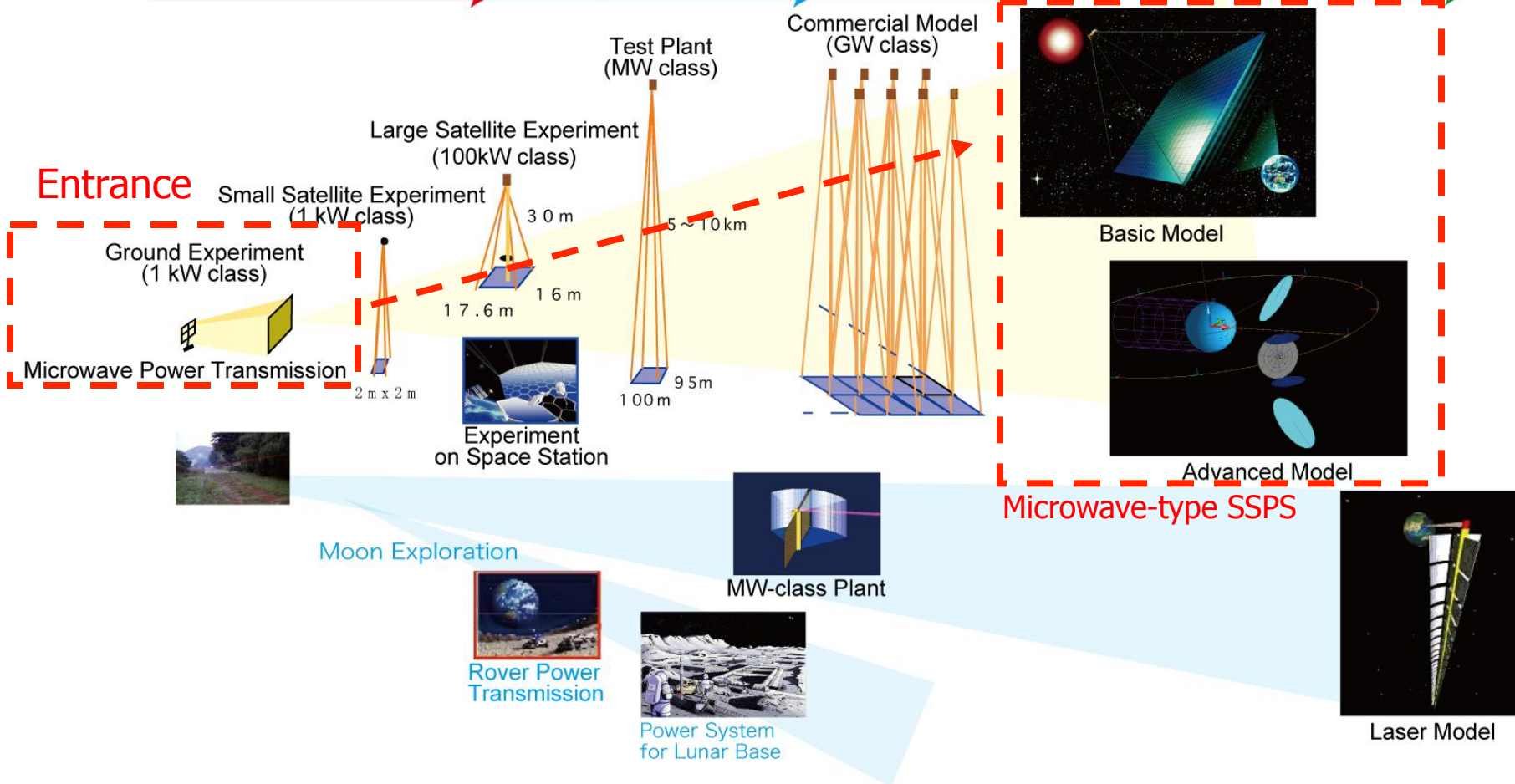
Basic Research Phase

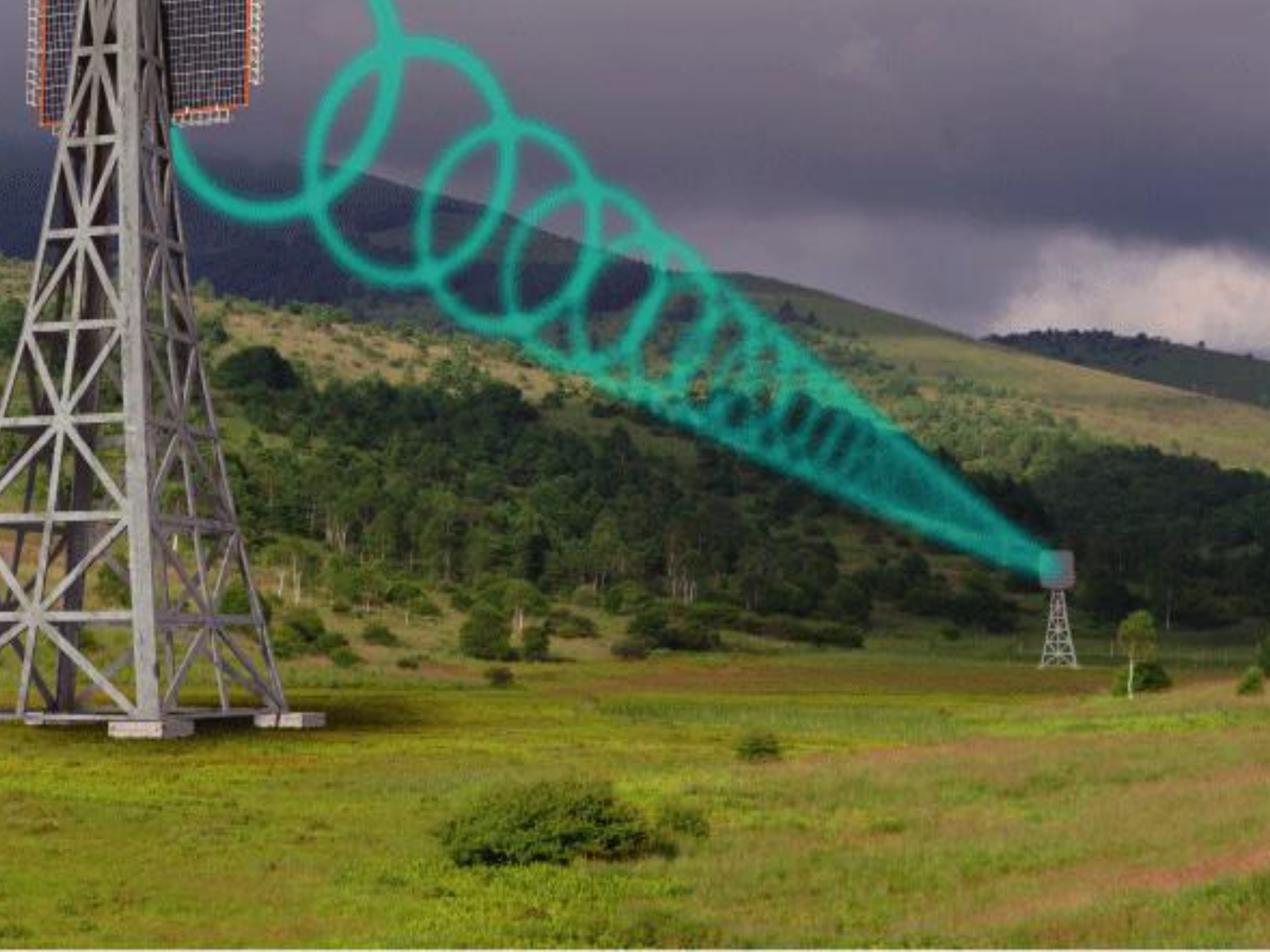
Development Phase

Commercial Phase

Exit

Entrance





Microwave Power Transmission Experiment on Ground

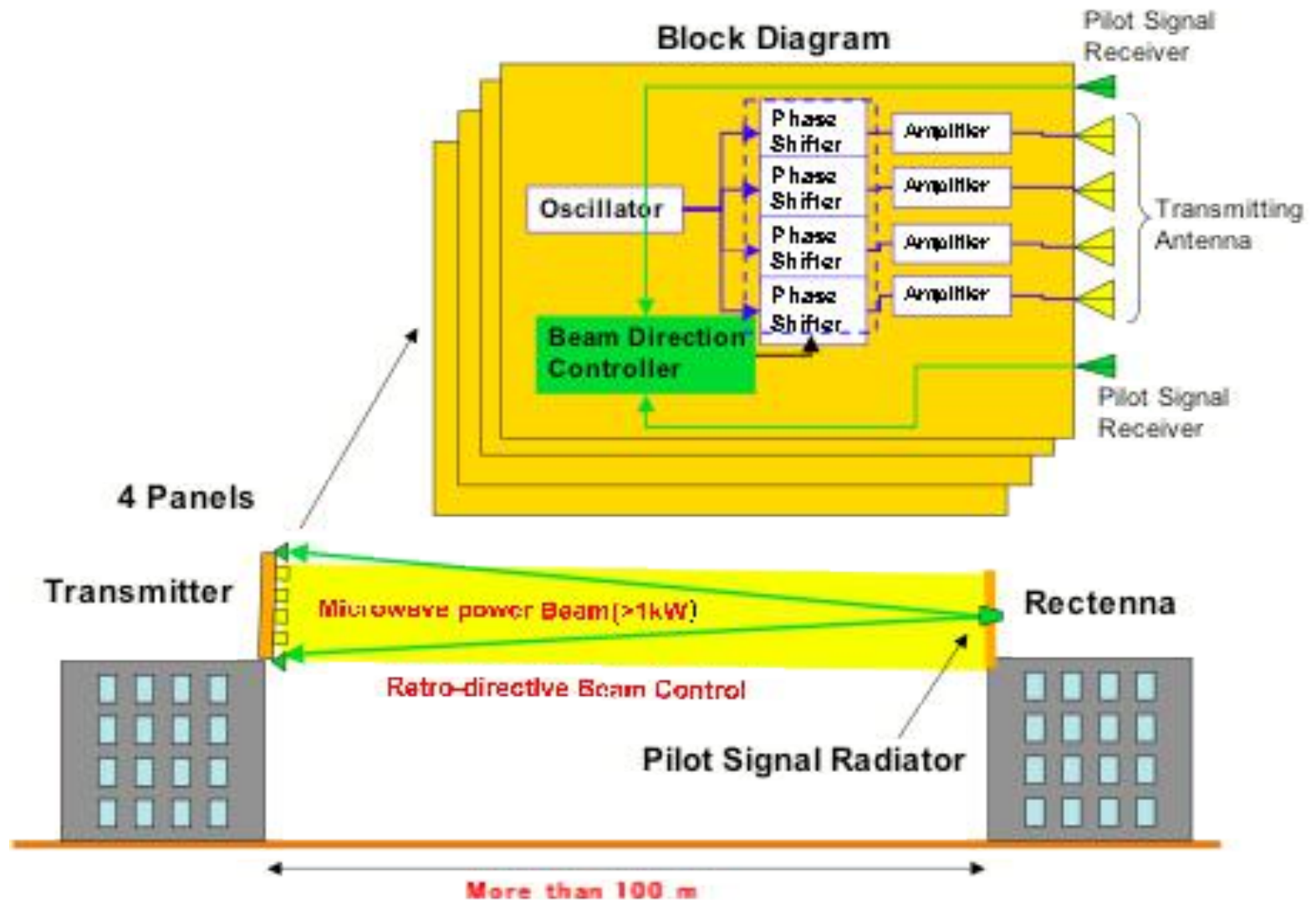
General Concept

- Transmission of a kilowatt-level microwave to a rectenna located typically at 100 m apart from the the phased array transmitting antenna***
- Beam direction control by a pilot signal from the rectenna site***

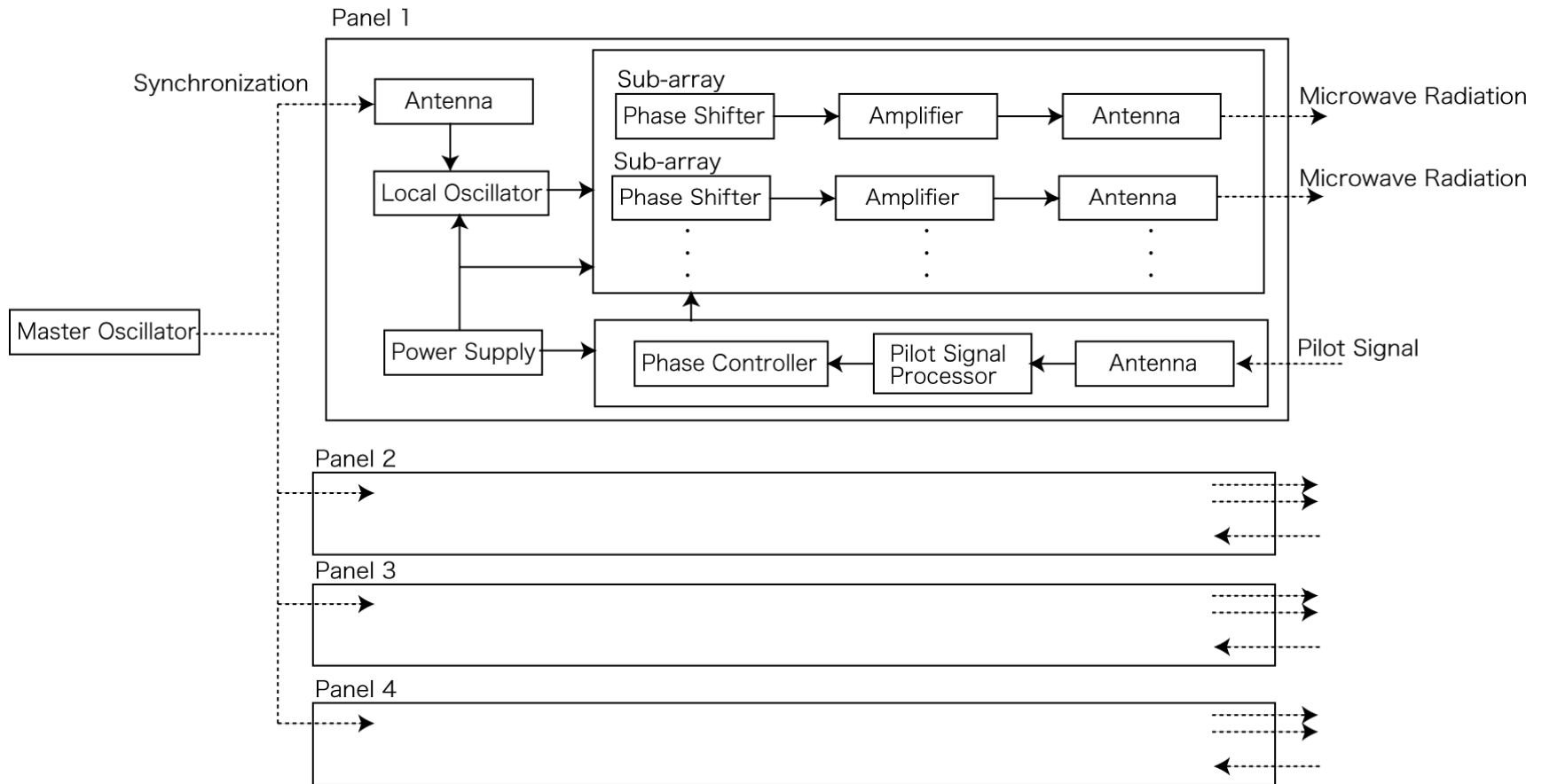
Objectives

- to establish technologies to control a microwave power beam directing at a target rectenna,***
- to establish technical readiness for the space experiment in the near future.***

Configuration of Microwave Power Transmission Experiment



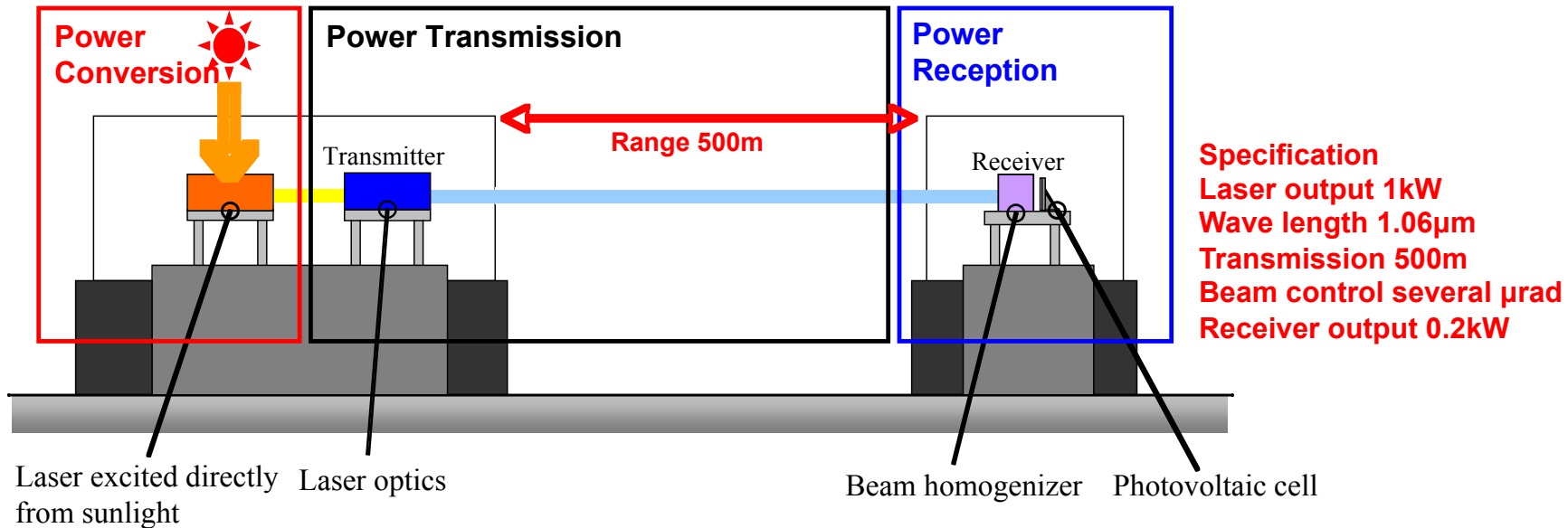
Block Diagram of Microwave Transmitter



Characteristics of Microwave Transmission Experiment on Ground

Transmitter configuration	4 panels movable to each other. 700W/panel, 30 kg/panel (typical),
Microwave transmission panel	169 sub-array/panel, 4 antennas/sub-array, 80 cm x 80 cm, 2-10cm thick microwave conversion efficiency 40 %
Microwave amplifier	5.8 GHz, 4.5 W, efficiency 50 %
Antenna configuration	0.65 λ spacing
Microwave beam control	Retro-directive control using a pilot signal from rectenna site
Phase control accuracy	4 or 5 bits
Rectenna configuration	16 flexible panels, 2m x 2m/panel, DC conversion efficiency 75 %
Transmission range	100 m (typical)

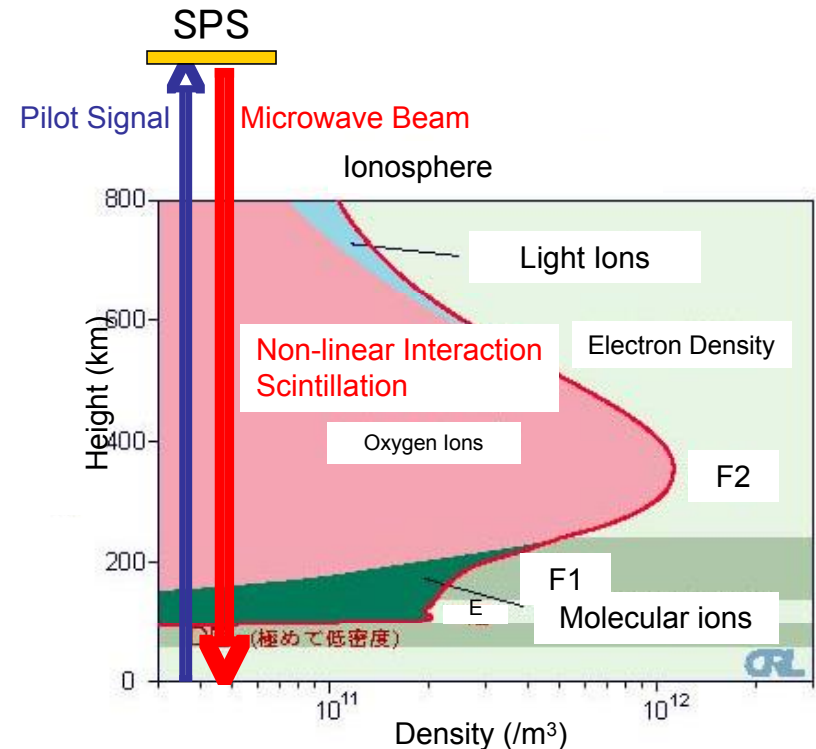
Laser-SPS Demonstration Experiment on Ground(1kW class)



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

Microwave Transmission Experiment in Space

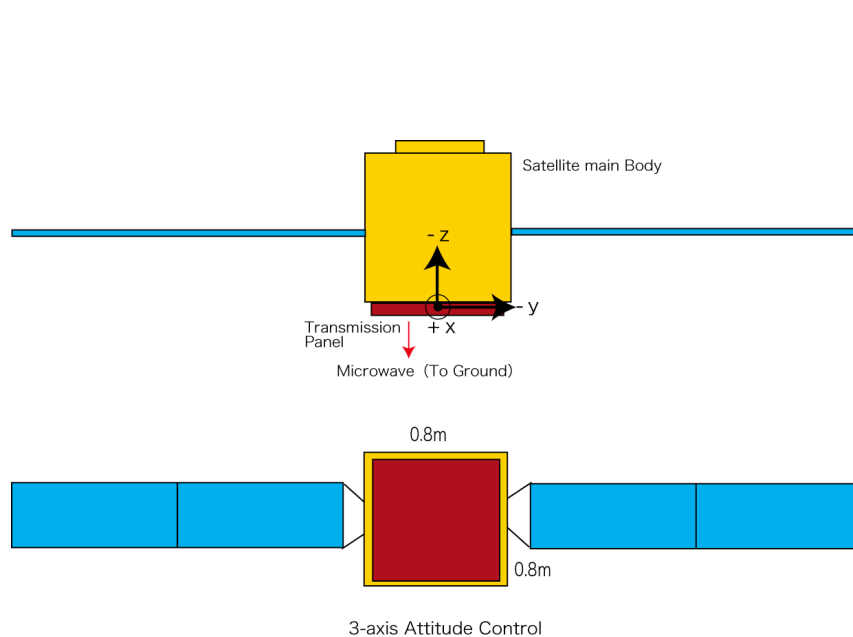
- (1) demonstration of the microwave beam control precisely to the target on the ground from the antenna in orbit, P
- (2) verification of microwave power transmission ($\sim \text{kw/m}^2$) through the ionosphere,
- (3) evaluation of the over-all power efficiency as an energy system, F
- (4) demonstration of the electromagnetic compatibility with the existing communication infrastructure.



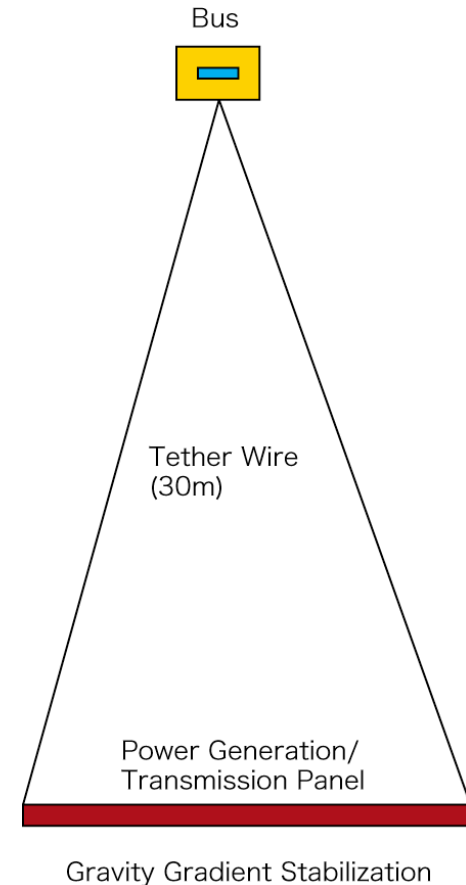
System Characteristics of Demonstration Model (Option B)

Mission	Period	1 year
System	Configuration	Power generation/transmission panel suspended by 4 wires
	Panel size	1.6m x 1.6 m x 0.1m
	Tether wire length	30 m
	Total weight	200 kg
	Attitude stability	$\pm 1^\circ$
Power generation	Thin film solar cell array	350 W (85 W/module)
Power transmission	Frequency	5.8 GHz
	Phase control	5 bit
	Number of module	4
	Beam control	Retro-directive/Computer control, $\pm 10^\circ$
	Output power	700W/module, 2.8kW(total)
	Power density	1,100W/m ² (antenna) 1.4 μ W/m ² (ground)
Ground stations		JAXA ground stations International experiment sites

Experimental Configuration using Small Satellite

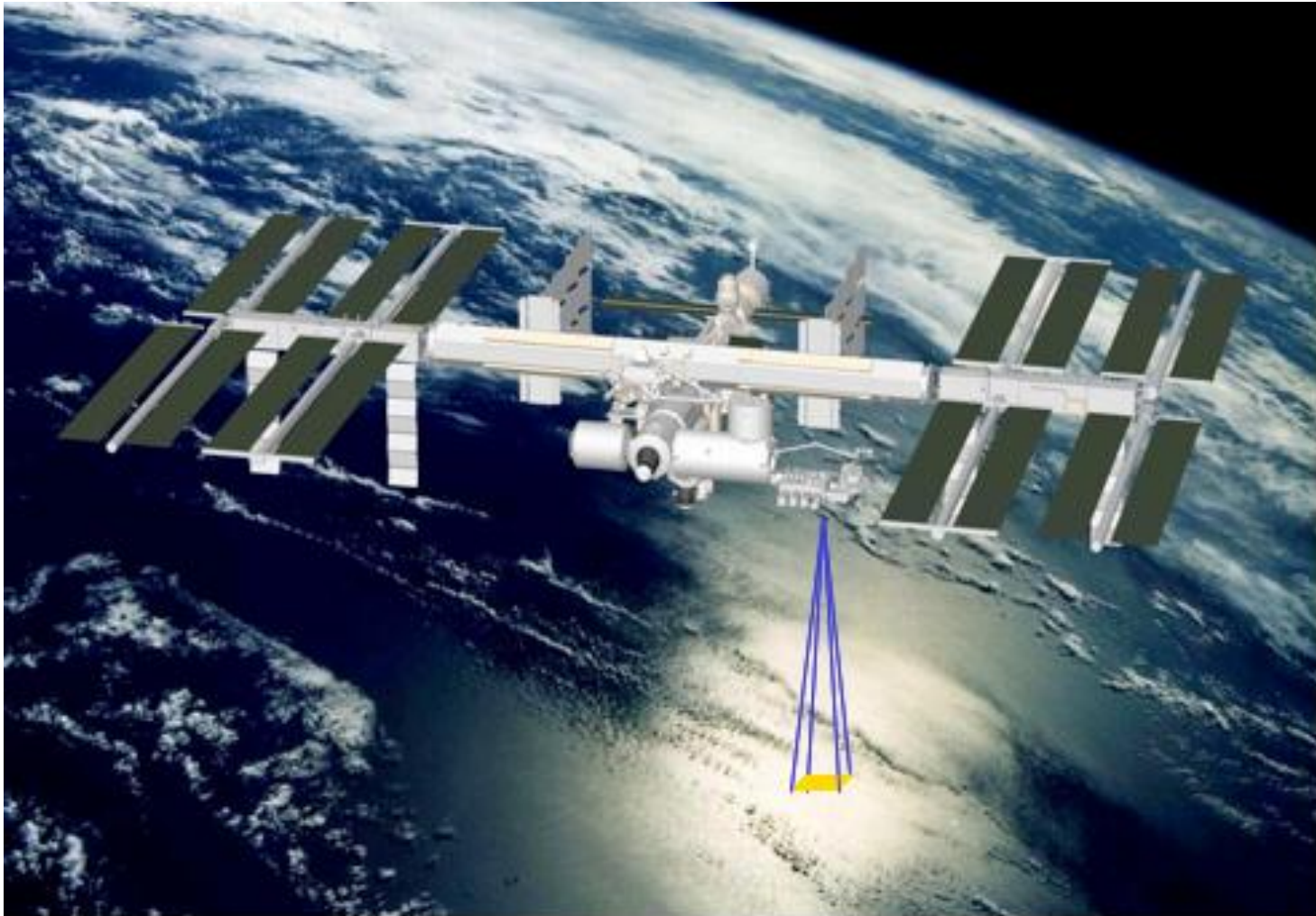


Option A (700W, 65 kg)



Option B (2800W, 200 kg)

Experimental Configuration using JEM on Space Station



Summary and Conclusion

- Two commercial models of microwave-type SSPS currently studied in Japan, basic type and advanced type, are introduced.***
- As the first demonstration on the ground towards the commercial models, high-precision microwave beaming at 1kw class with 100 m range will be conducted within several years.***
- Immediately after the ground demonstration experiment, we will perform a small-scale experiment in orbit to transmit a 1 kW class microwave power to the ground .***
- This approach is now reflected on the basic plan on space by the government's space development strategy headquarter.***