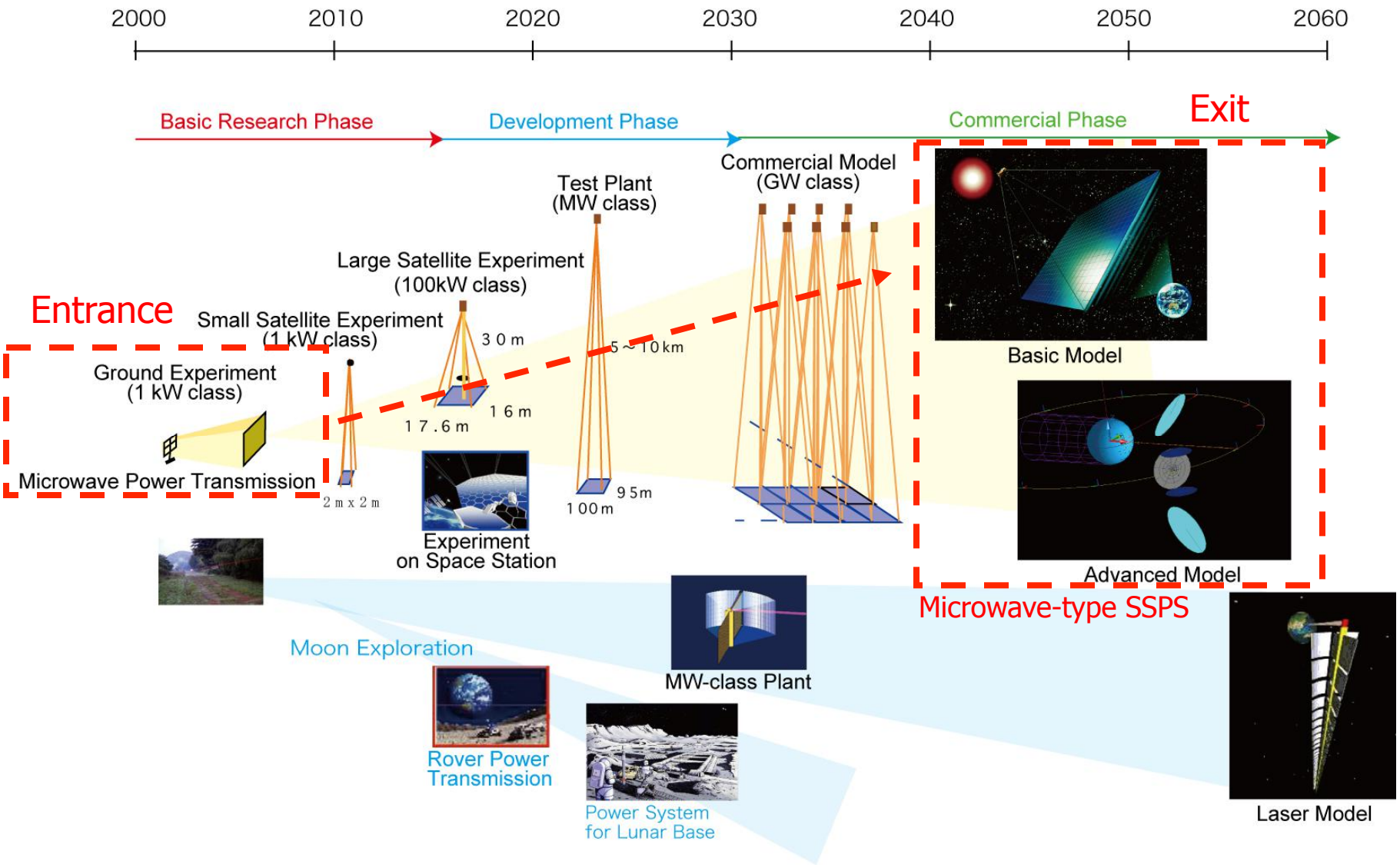
Microwave Power Transmission Experiment on Ground for SSPS Demonstration

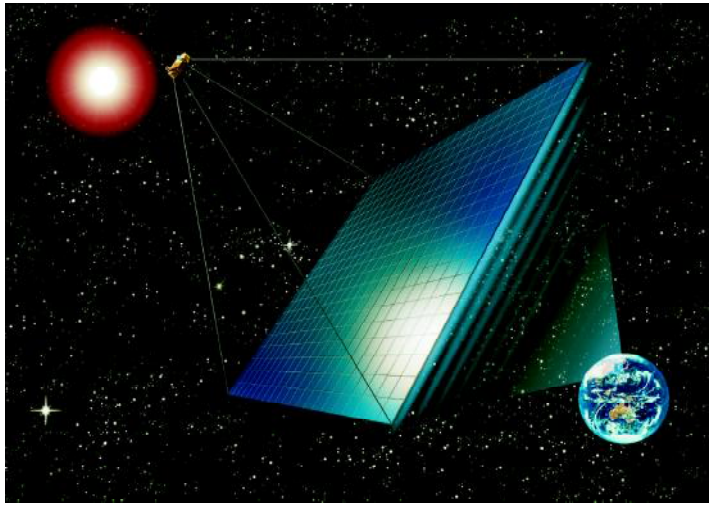
- Microwave-type SSPS in Japan
- Ground Demonstration Experiment
  - Objectives
  - System Configuration
- Follow-on Flight Demonstration

June 2009

Japanese Roadmap for SSPS

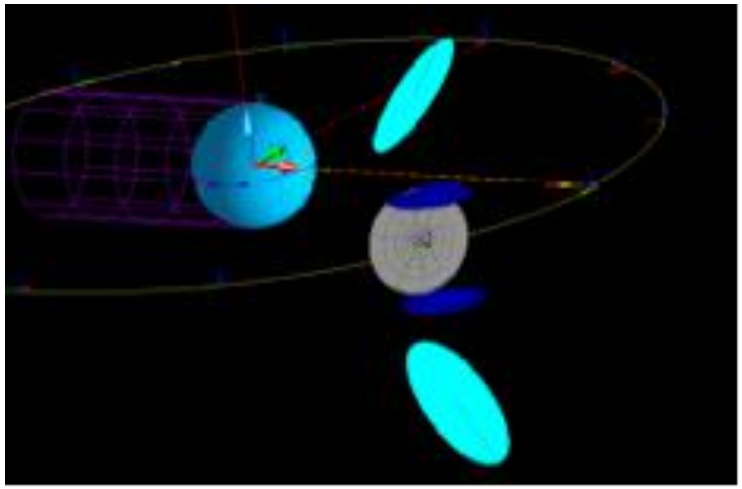


Microwave-type SSPS



Basic Type

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%)

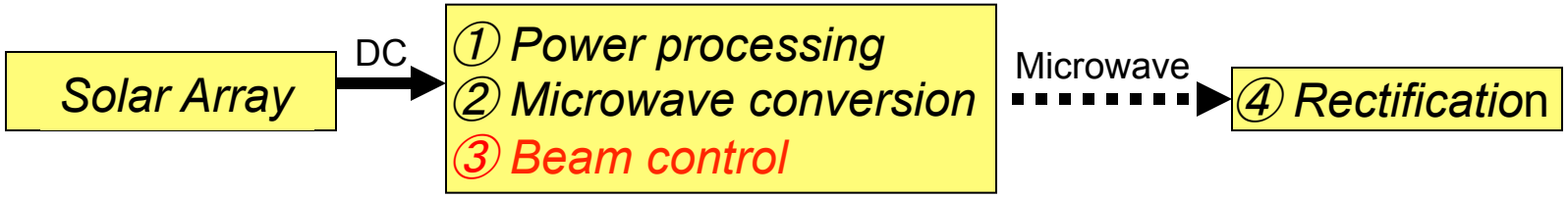


Advanced Type

Sun pointing SSPS
Reflection mirrors (free flying) ：2.5 km x 3.5 km
1000 tons x 2sets、100~300g/m^2
Power generation: 1.25 kmΦx2 sets
Power transmission: 1.8 km Φ
Total weight：10,000 tons(target)
Complicated but high rate power collection

Essential technologies commonly required for microwave-type SSPS

① High-efficiency energy transfer from solar array output to microwave circuit,
② High-efficiency microwave circuit
③ Precise control of microwave beam shape and direction
④ High-efficiency energy conversion from microwave to DC



Microwave Power Transmission Experiment on Ground

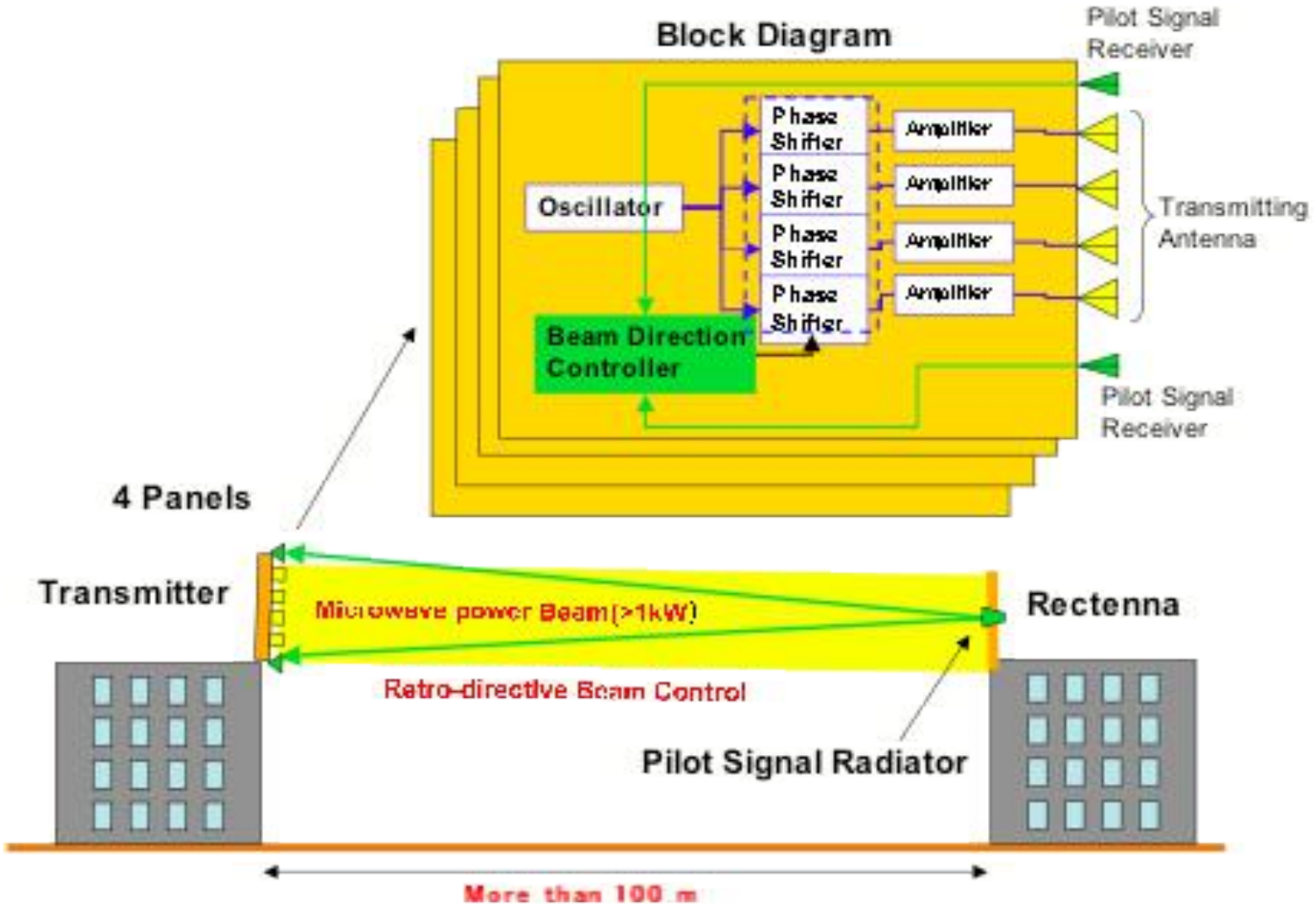
General Concept

- ***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***

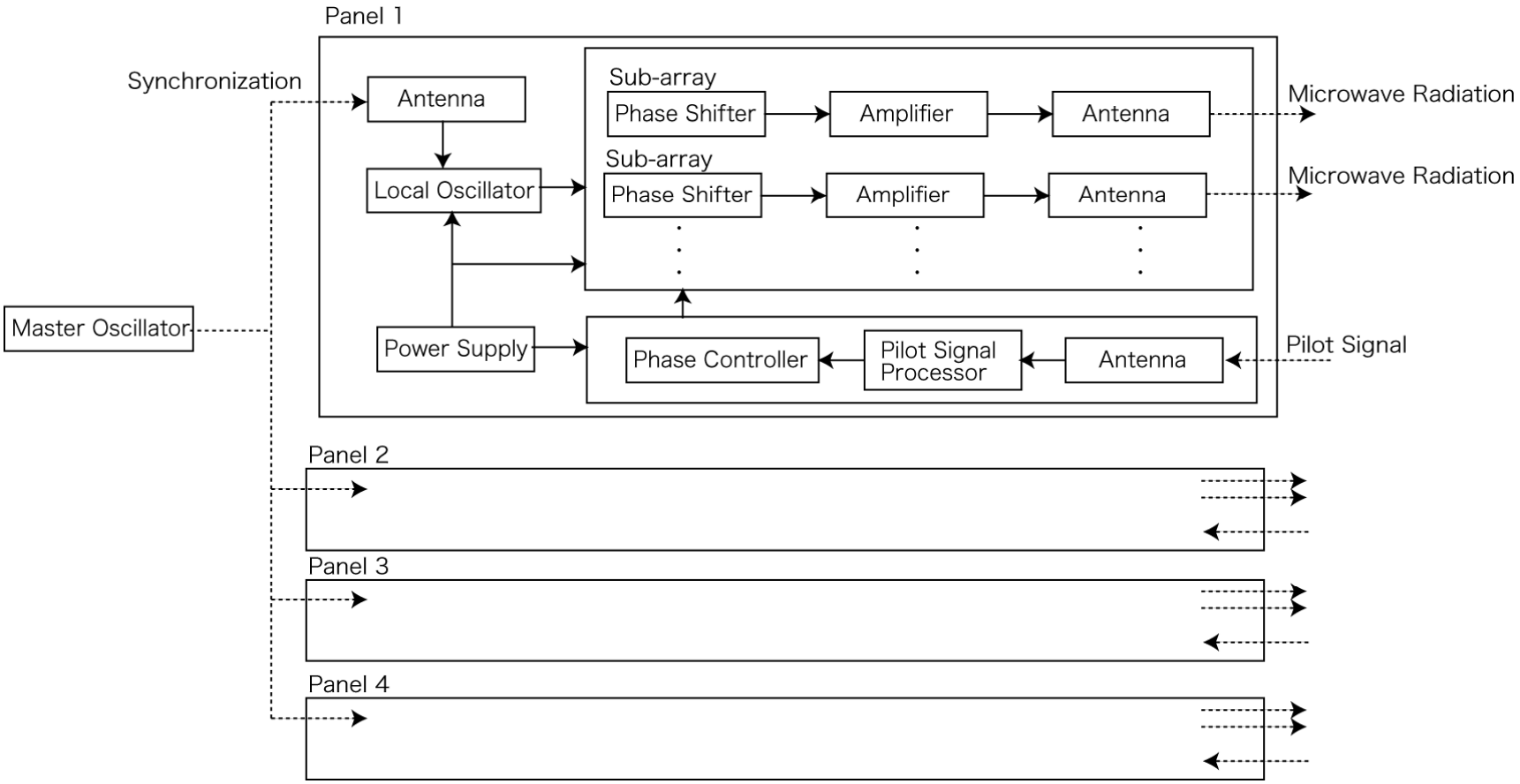
Objectives

- ***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)

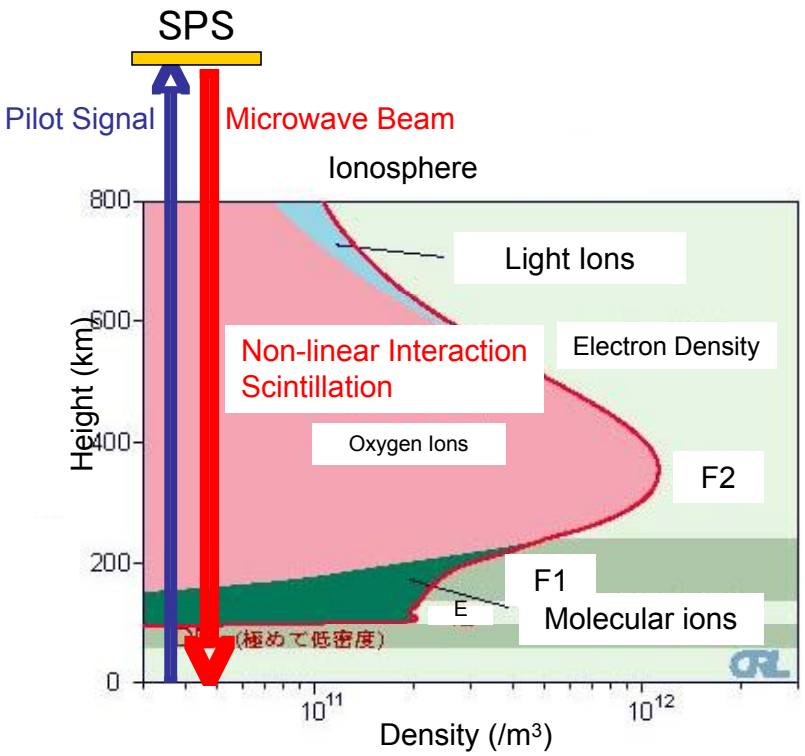
Follow-on Experiment in Space

(1) demonstration of the microwave beam control precisely to the target on the ground from the antenna in orbit,

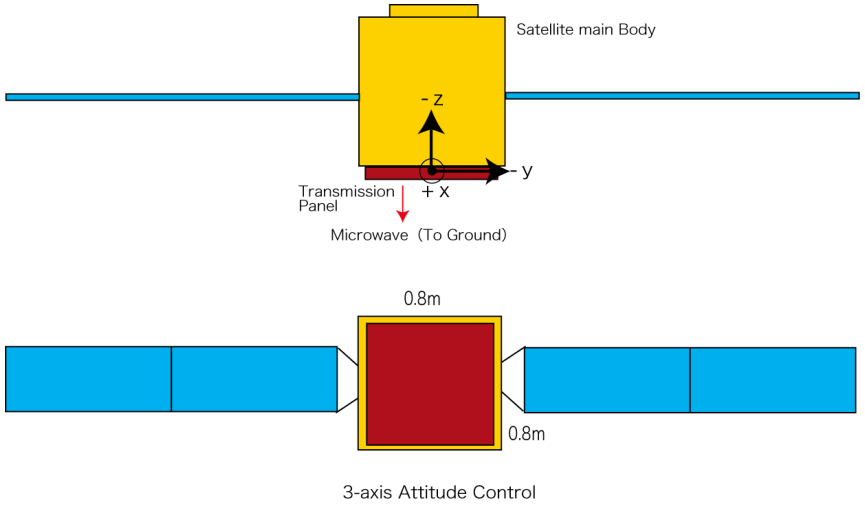
(2) verification of microwave power transmission (~kw/m^2) through the ionosphere,

(3) evaluation of the over-all power efficiency as an energy system,

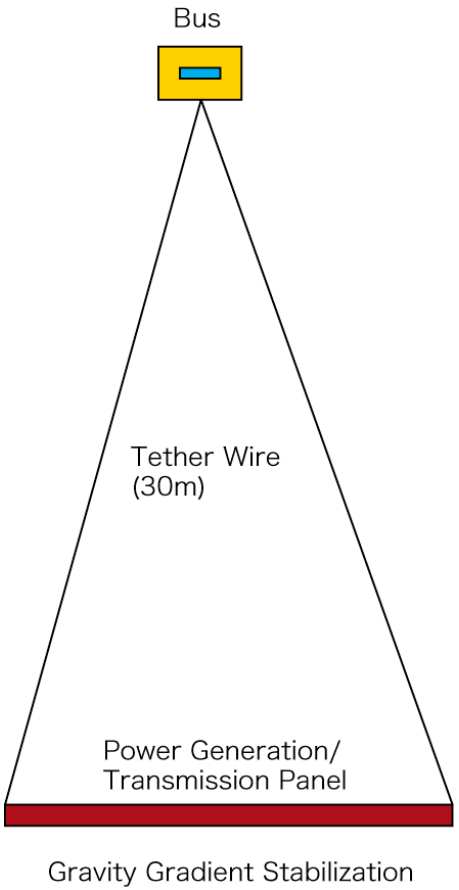
(4) demonstration of the electromagnetic compatibility with the existing communication infrastructure.



Satellite Configuration



Option A（700W, 65 kg）



Option B（2800W, 200 kg）

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	±1°
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, ±10°
	Output power	700W/module, 2.8kW(total)
	Power density	1,100W/m^2 (antenna) 1.4μW/m^2(ground)
Ground stations		JAXA ground stations International experiment sites

Summary and Conclusion

- *A microwave transmission experiment, kWatt class, on ground currently prepared in Japan is introduced.*
- *It will demonstrate the retro-directive technology for microwave beam transmission in a long distance.*
- *The power transmission system developed and verified in the ground demonstration will be used for the power transmission experiment in orbit in the next step.*
- *This approach is now reflected on the basic plan on space by the government's space development strategy headquarter.*