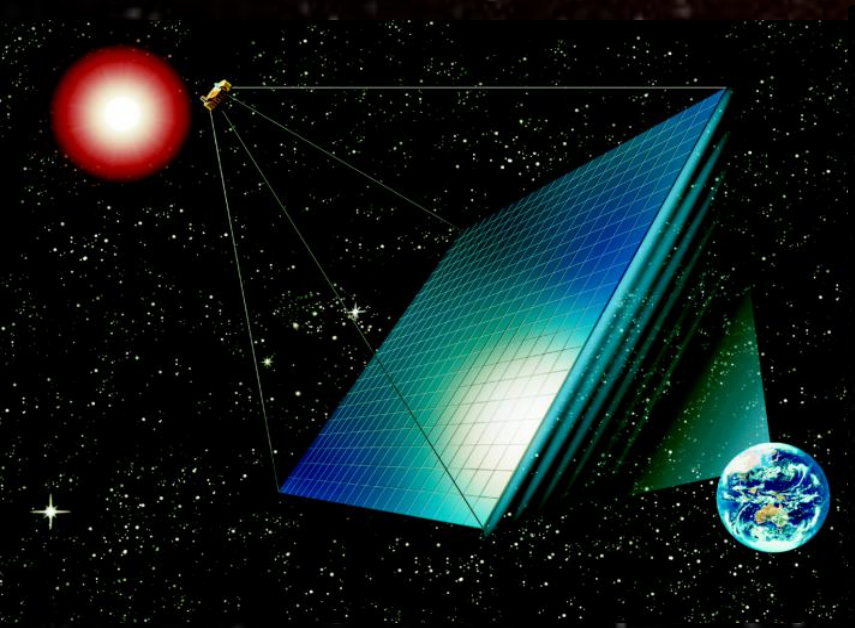
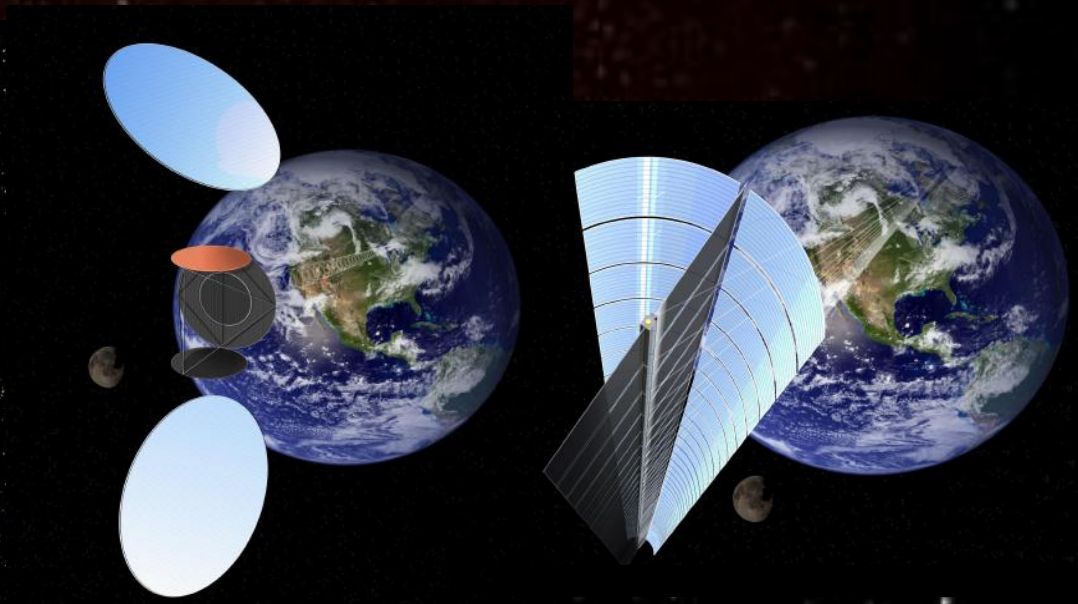
Technology Development Status for Space Solar Power Systems

- *Current technology level and target technology level for SSPS*
- *SSPS development roadmap*
- *Development scenario to fill the technology gap between the current level and target level*

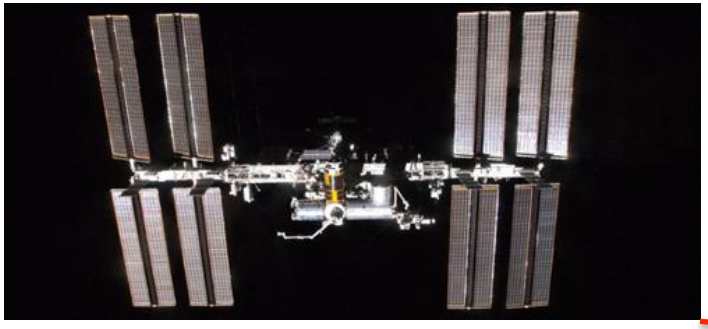




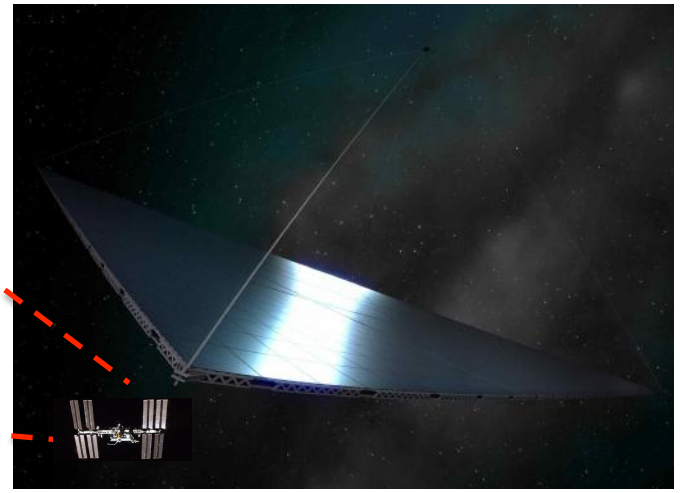
September 2012

Current and target level for SSPS primary technologies

Primary technology	Existing level	Target level	Order of magnitude
Solar power generation	100 kW (space)	1 GW	10,000
Microwave power transmission	10 kW (ground)	1 GW	100,000
Large space structure	100 m (space)	1 km	10
Space transportation	5,000-10,000 $/kg	100 $/kg	1/50-1/100



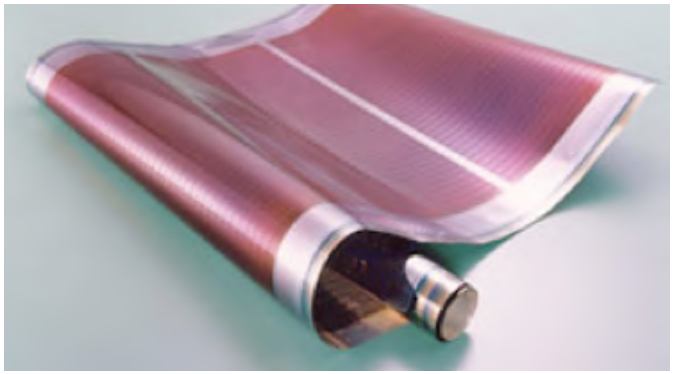
ISS 100m Scale～



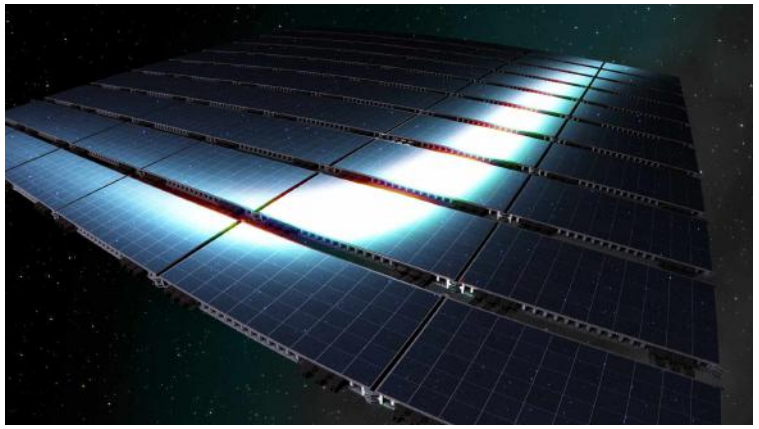
SSPS 1-2 km Scale～

Current technology level and target level for SSPS - Power Generation -

	Current	SSPS Target
Conversion Efficiency	15-30 %	35-40 %
Specific Weight	10-100 g/W	1 g/W
Life in Space	10 years	30-40 years
Cost	4-6 $/W	1-0.5 $/W



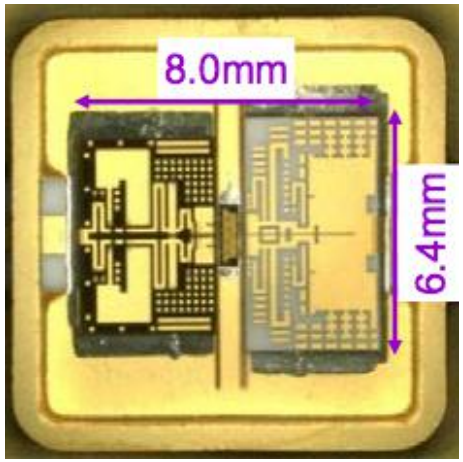
Light-weight thin film solar cell～



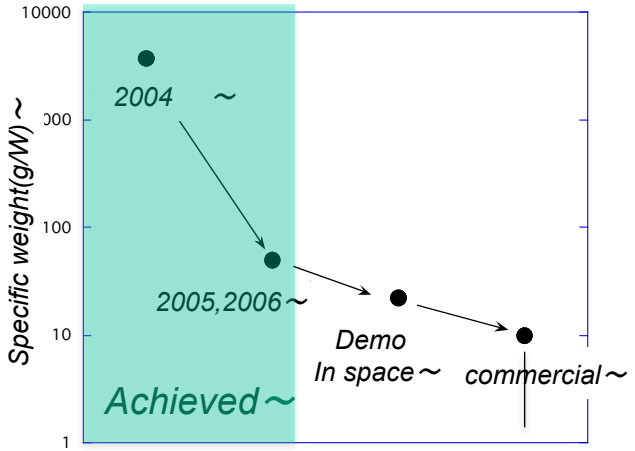
Installed on light-weight structure～

Current technology level and target level for SSPS - Power Transmission -

	Current	SSPS Target
Conversion Efficiency (DC to RF)	50-70 %	85 %
Conversion Efficiency (RF to DC)	60-80 %	85 %
Specific Weight	50-100 g/W	1-10 g/W
Life in Space	10 years	40 years
Cost	20 $/W	1 $/W



HPA for ground experiment
PAE more than 70%～



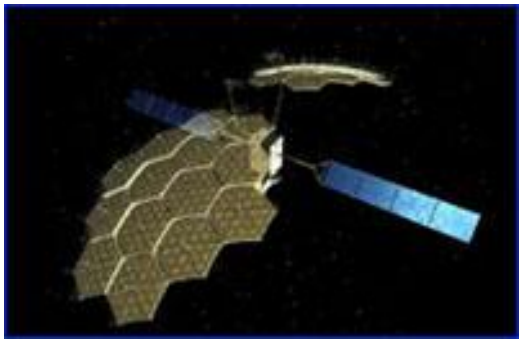
Reduction of specific weight
(g/W) in Japan～

Rectenna for rover experiment
Array efficiency more than 60%～

Current technology level and target level for SSPS - Large Space Structure -

	Current	SSPS Target
Two-Dimensional (manned)	100 m	1,000-2,000 m
Two-Dimensional (unmanned)	20-30 m	
One-Dimensional	20,000-30,000 m	5,000-10,000 m
Weight	400 tons	10,000-20,000 tons

ISS 110 m x 70 m (manned)～

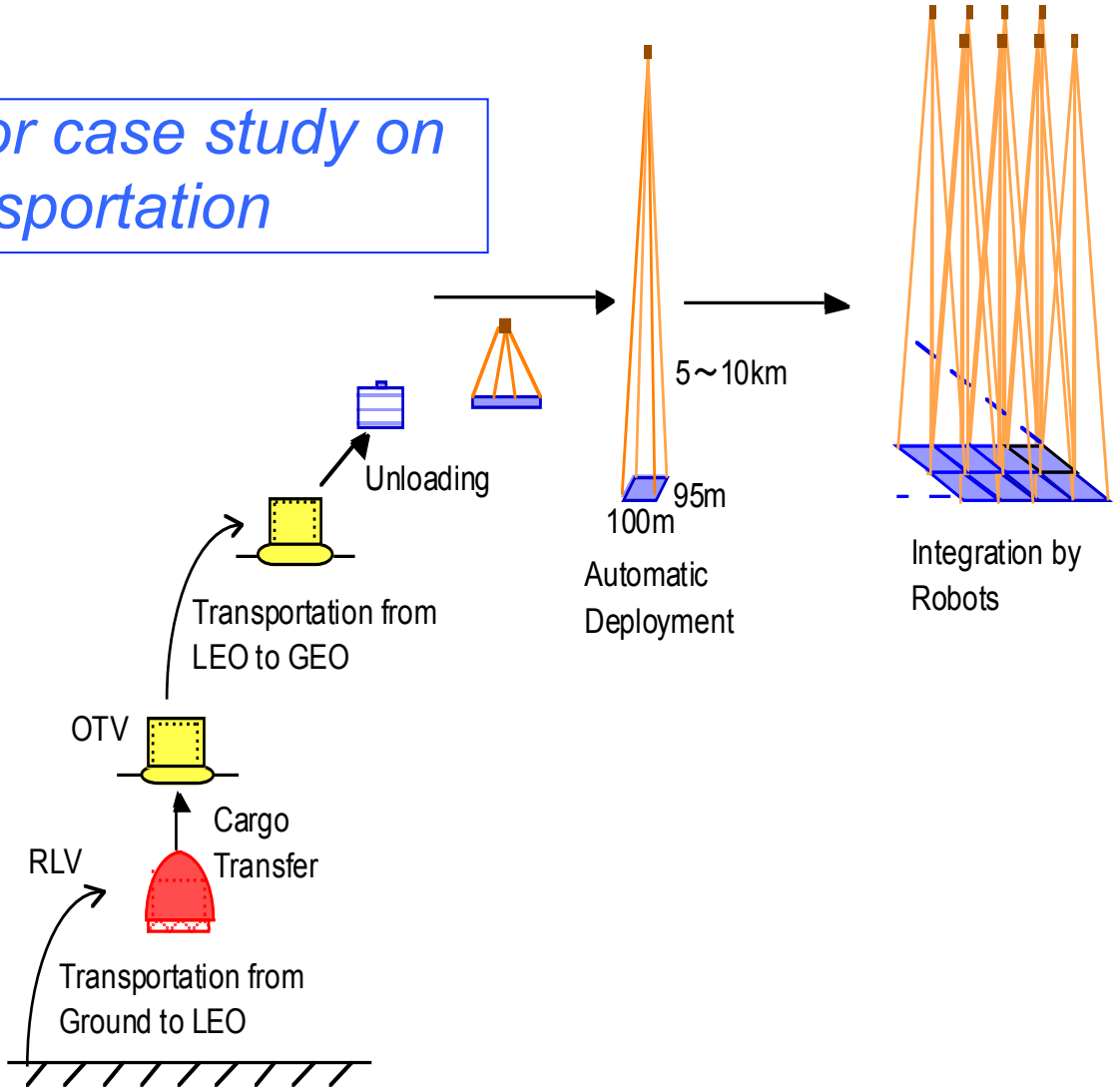


ETS-VIII Antenna 19 m x 17 m (unmanned) (2006)～

ESA YES2 Tether 31.7 km (2007)～

Current technology level and target level for SSPS - Space Transportation-

Example for case study on space transportation



Current technology level and target level for SSPS - Space Transportation-

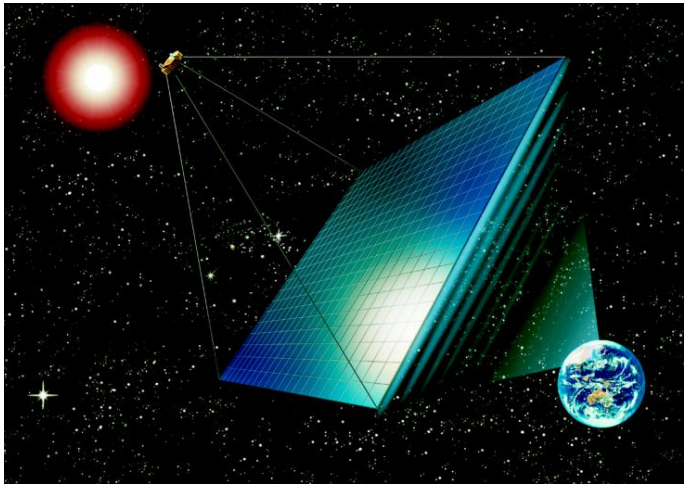
	Current	SSPS Target
Cargo Weight	30 ton	50 ton
Cargo into Space	Several hundreds tons/year	10,000 tons/year
Launch Vehicle	Expendable	Reusable
Transportation Cost (Ground to LEO)	5-10 k$/kg	100 $/kg
Orbit Transfer Vehicle	100 mN Level	100 N Level
Transportation Cost (LEO to GSO)	No reliable data	10-50 $/kg

Falcon Heavy
Commercial, low cost, heavy weight lifting, to be launched soon ～

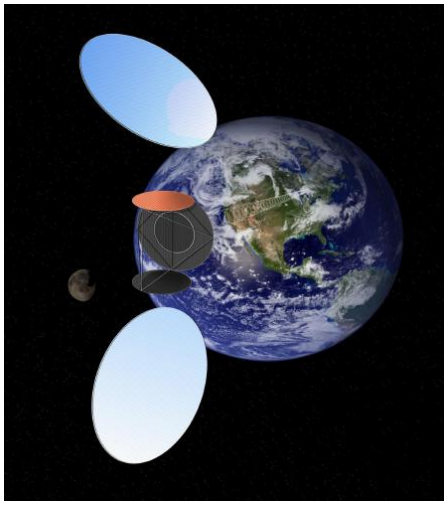
JAXA/ISAS RTV
Reusable vehicle testing underway～

SpaceShip 2
Reusable suborbital plane prepared for operation soon～

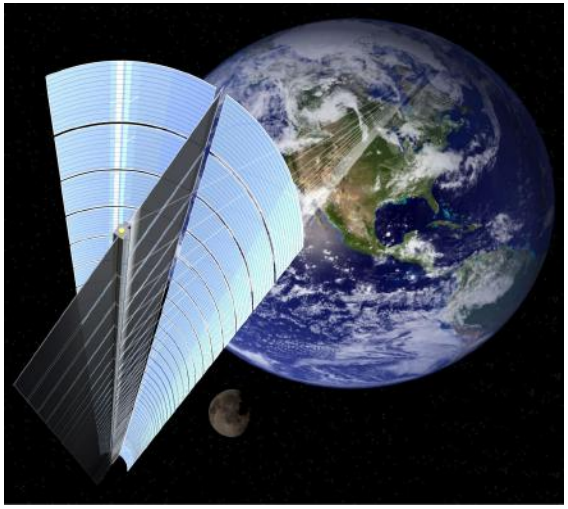
Commercial SSPS Concepts Currently Studied in Japan



Basic Microwave-type Model (Jspacesystems/ METI)



Advanced Microwave-type Model (JAXA/MEXT)



Laser Model (JAXA/MEXT)

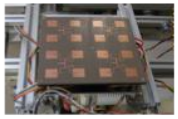
Jspacesystems(former USEF)/METI:Japan Space Systems/ Ministry of Economy, Trade and Industry
JAXA/MEXT:Japan Aerospace Exploration Agency/ Ministry of Education, Culture, Sports, Science and Technology

SSPS Development Roadmap～

Research Phase

11 12 13 14 15 16 17 18 19 20

Ground demonstration



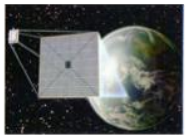
Small-scale on orbit demonstration


100kW class on orbit demonstration～


Development Phase

21 22 23 24 25 26 27 28 29 30

2MW class demonstration ～

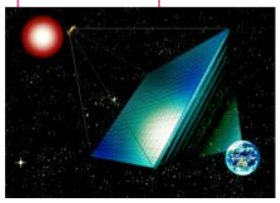
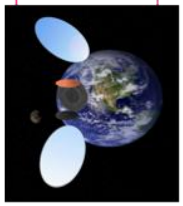



200MW class plant

Commercial Phase

31 32 33 34 35 36 37 38 39 40

1GW class first commercial model

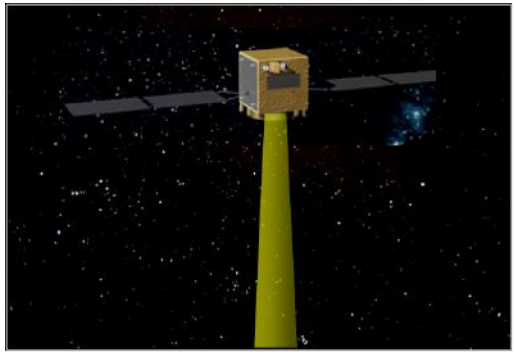
Commercial SPS（1SPS/year）

Major Milestones towards Commercial SSPS

In a few years～

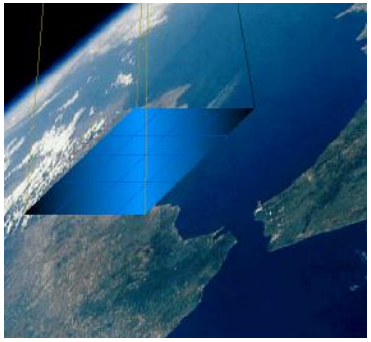
On the ground
Transmission Power: 1.6kW
Range: 50m max
Pointing Precision: 0.5°

5 years～



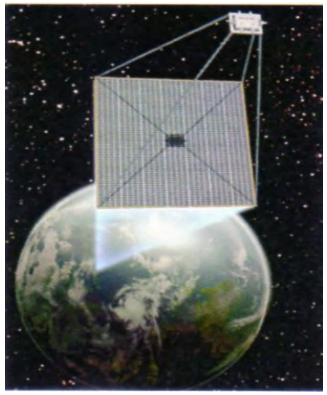
Orbit: Low Earth Orbit (370 km)
Satellite Weight: 500 kg
Transmission Power: 3.8 kW(example)

10 years～



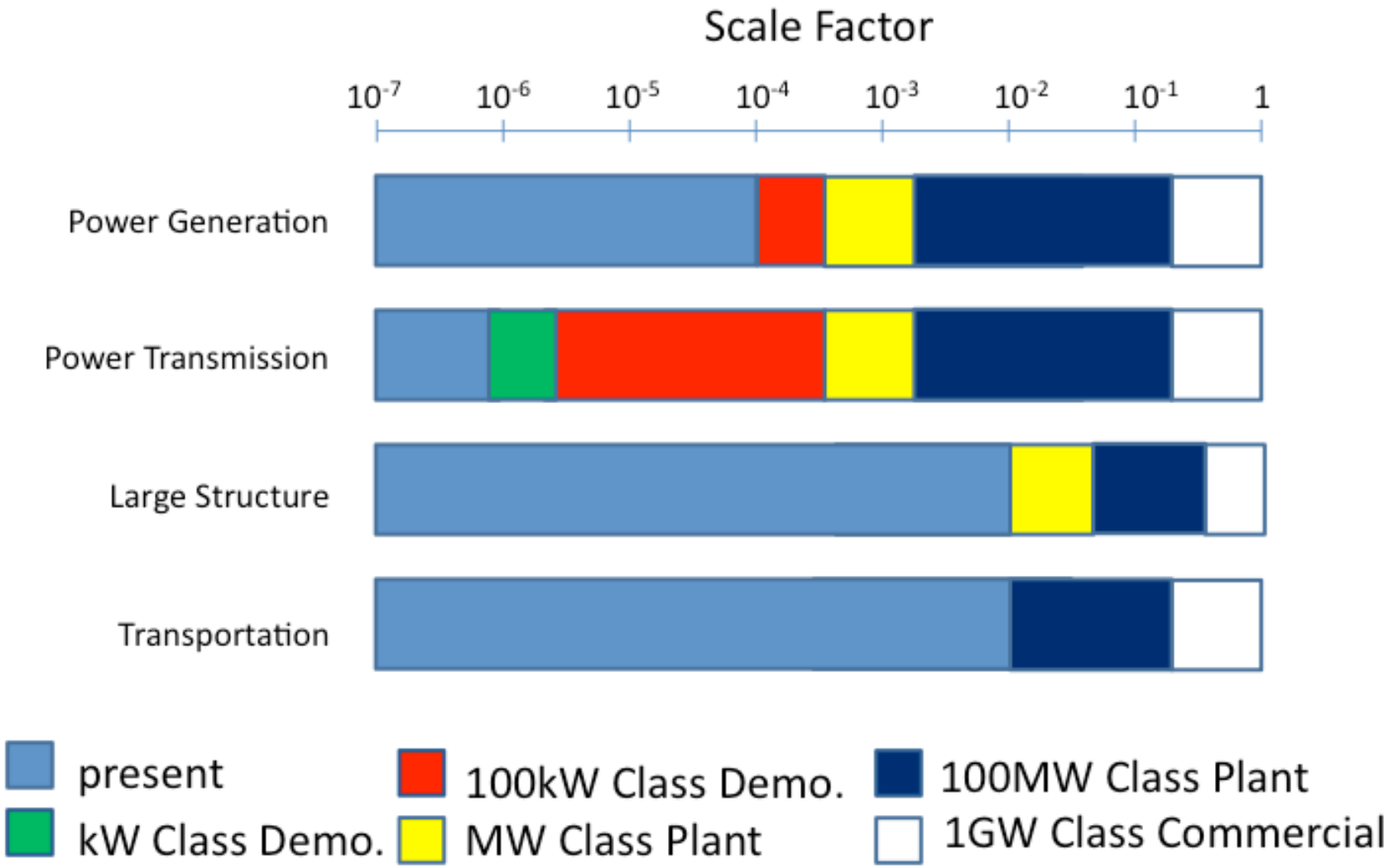
Orbit: Low Earth Orbit (370 km)
Satellite Weight: 10-15 tons
Transmission Power: 100-400 kW(example)

15-20 years～



Orbit:1000 km, GSO
Satellite Weight: 50-4000 tons
Transmission Power: 2MW-200MW(example)

Technology Gap at Each Milestone in Roadmap~



Summary and Conclusion~

- *Construction of the SSPS requires 4 major system-level technologies; power generation, wireless power transmission, large space structure, and space transportation.*

- *It is concluded that a large progress is required for the power transmission in the first 10 years from now, a new progress is required for the large space structure targeting in the next 10 years, and an innovative advancement for the space transportation is required targeting in the last 5 years. ~*