

Feasibility study of a large-scale WPT system formed by a modular structure

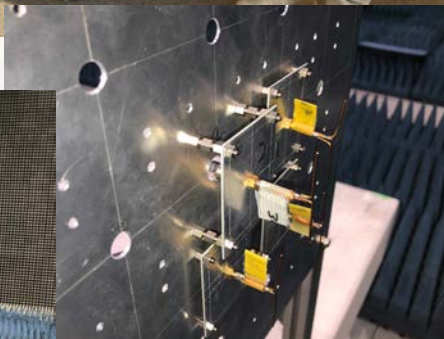
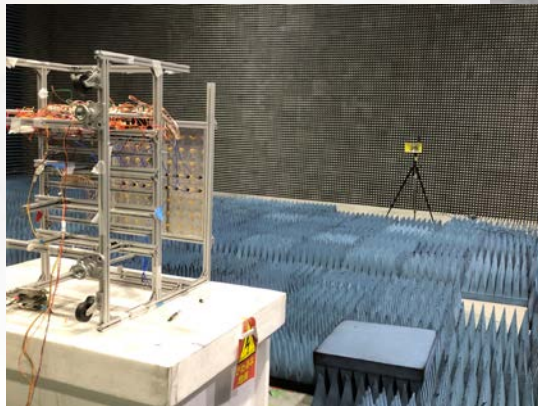
Tanaka laboratory

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Supervisor : **Koji Tanaka** (SOKENDAI, ISAS/JAXA)



About us



We are...

“Tanaka laboratory Members”

What is Tanaka laboratory...?

Our laboratory is in ISAS / JAXA

Our main research subjects are...

- 1. Study of WPT**
- 2. Study of Structure of SPS**
- 3. Study of Discharge Phenomena and more...**

Members

**Our members are from several universities.
Therefore, we have many backgrounds.
And we are the educational volunteer of SPS
for high school students.**



Backgrounds

Over 15 years have passed since the birth of Tethered SPS model, in Japan.

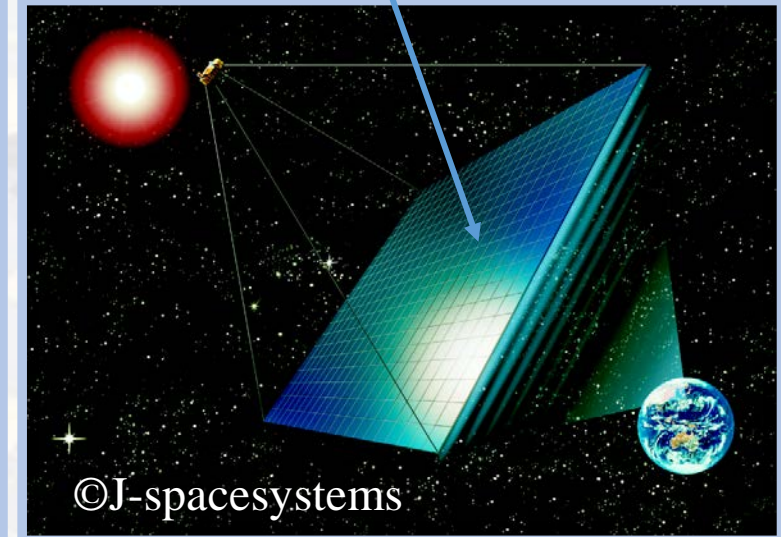
Tethered SPS was proposed

Many R&D activities

1968, Power from the Sun: Its future

The latest technologies

- ✓ 2,375,000 Generation/Transmission panels,
- ✓ All panels are equivalent spec and independent.



Commercial SPS

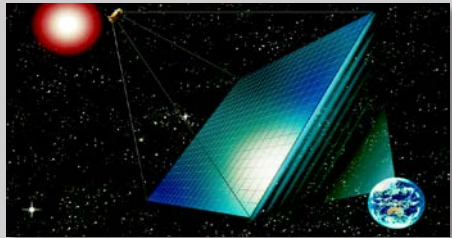
We are facing the phase;
to review the ever R&D activities,
to clarify unsolved issues and promote the development toward the commercial system.



What is our project?

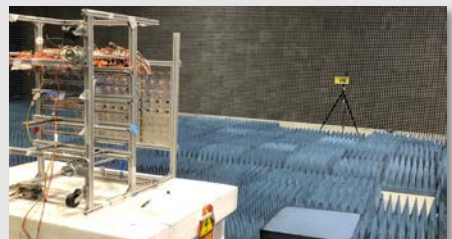
The purposes and goals of this project is:
to clarify unsolved issues from our feasibility study,
to promote the development of the WPT system,
toward the realization of a large-scale modular structure SPS.

Our steps toward goals



Feasibility study

- Step①: **Summarize** the original concept of the Tethered SPS
- Step②: **Reviewing** the recent R&D activities
- Step③: **Clarifying** unsolved issues of modular WPT system



Promotion R&D

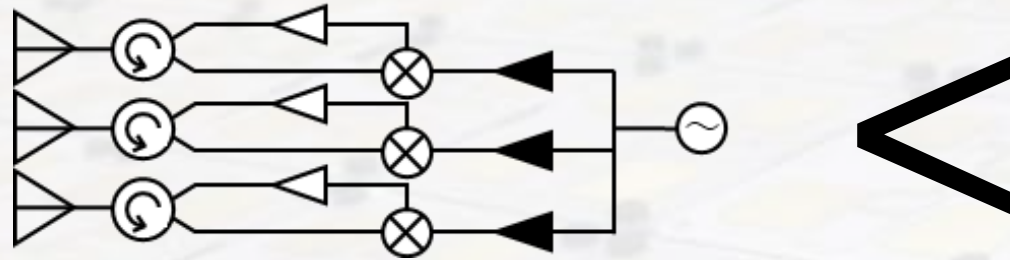
- Step④: **Apply** the latest technologies for system improvement
- Step⑤: **Study** of a new method regarding WPT in ISAS/JAXA



Recent technologies regarding the WPT

Mainstream

Hardware retro-directive



Software retro-directive



- Generate phase conjugation waves by analog circuits
- Fast processing and scanning
- Flexibility of the frequency and functions is poor
- Direction finding and beam forming via signal processing
- High applicability to SPS
- Authentication, security and other functions are available

The theories for the direction detection of the pilot signal

Direction Finding (DF) method Descriptions

- | Direction Finding (DF) method | Descriptions |
|--|--|
| Mono-pulse method
(phase/amplitude comparison): | <ul style="list-style-type: none">• will realize simplified DF,• will not have a few flexibilities compared to the software retrodirective. |

MUSIC, ESPRIT and other methods are being studied for more precision.



Recent technologies regarding the WPT

Phase-correction methods

- The phases of all antenna elements must be adjusted for precise beam forming.
- The phase errors ,caused by antenna deformation and temperature raises, must be compensated.



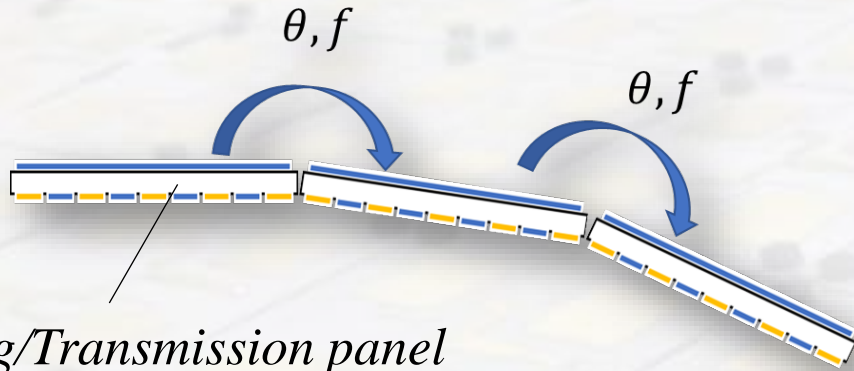
The phase correction method is required.

Phase-correction methods	Descriptions
Rotating Element Electric Field Vector (REV) method:	Measures the phases of each power elements, respectively, Requires tremendous processing time.
Parallel method:	Uses different frequency signals and works independently at each panels, Carries out the phase correction at the ground station.
Position and Angle Correction (PAC) method:	Detects the phase and angle of arrival of the pilot signal at each panels, Requires the timing synchronization.

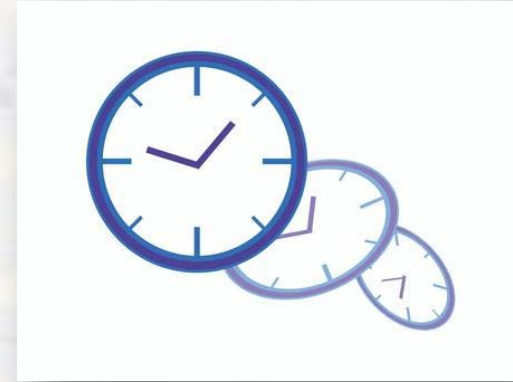


Unsolved issues for WPT technologies

We are focusing on **2 big issues** of the recent technologies as Software Retro and REV method.



Generating/Transmission panel



1. Synchronization of the phase and frequency

The reference signal must be shared among all equivalent modules, in modular structure system.

2. Long processing time to adjust the phases

The REV method, promising phase-correction method, requires too long processing time to scan the beam.



We consider solving these issues by: ① **Applying the latest technologies,**
② **Installing digital signal processing.**



Solution with the latest technologies

We will challenge: **Resolving the issues with the latest technologies.**

We will :

- Focus on the issue **sharing the reference signal** among Generation/Transmission panels,
- Investigate the MIMO, 5G ,Wireless LAN, GPS ,and other technologies,
- Apply **these latest technologies** for **the phase synchronization.**



Solution as a new method in JAXA/ISAS

For an example, we introduce a new method in ISAS/JAXA in Japan!

【Digital Retro-directive Method】

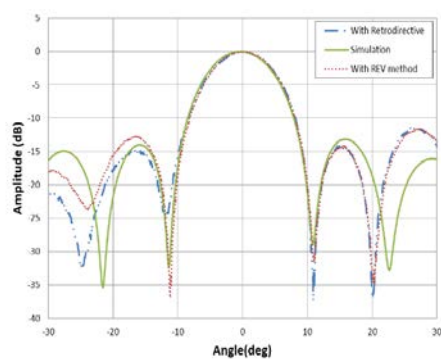
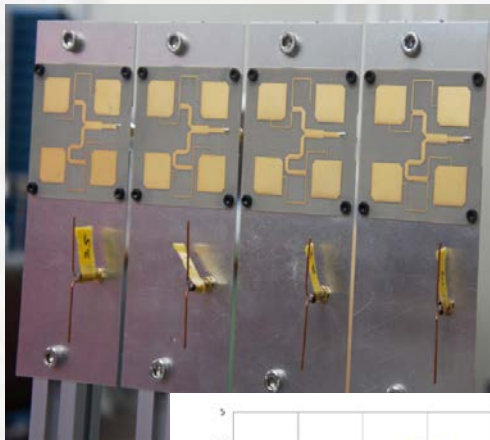
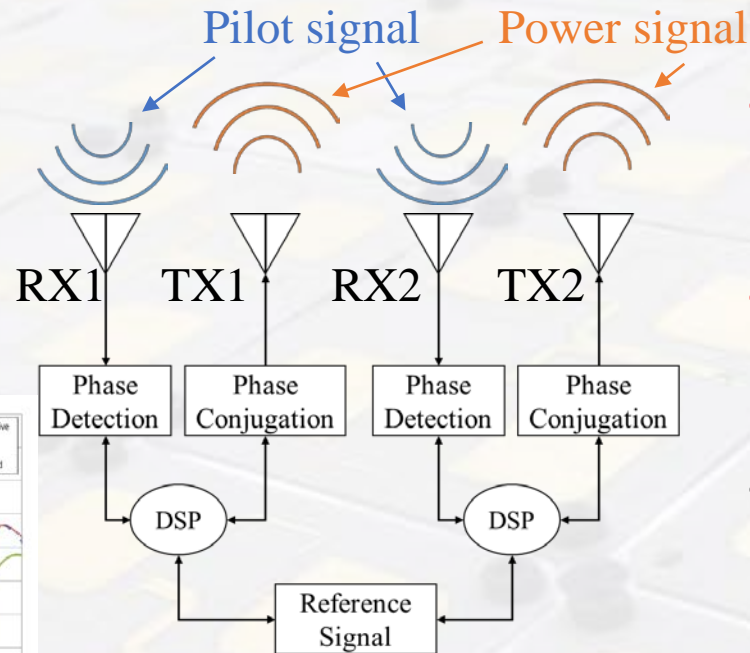


FIGURE 4.16: Comparison of Digital Retrodirective method with REV method.



- **Digital Signal Processing (DSP)** is used for:
Detecting phase and making Conjugate phase.
- **Synchronization** among panels is not required.
(Rx antenna and Tx antenna is same number)
- Digital retrodirective method correct errors with **short time** as compared to **REV method**.



We will demonstrate this method with a simplified model.



Our future process and goals

May

Feasibility study

- Summarize the traditional SPS
- Review the recent studies
- Clarify the unsolved issues

June

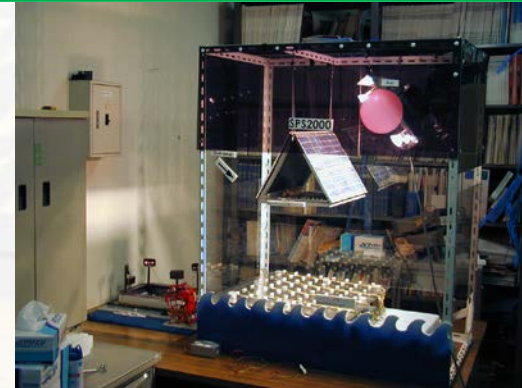
Investigation of the latest technologies.

- MIMO
- 5G
- Wireless LAN
- GPS technologies
- Challenge to apply the latest techs for WPT

Promotion of a new method in JAXA

- Development of experimental model
- Demonstrate a new method in ISAS/JAXA
- Verify a new method applied the latest technologies
- Promote the WPT system for a modular structure

July



August

Our project goals:

**Feasibility study and improvement,
Promotion of development for SPS**