

# JAXA LUNAR FARMING CONCEPT STUDY WORKING GROUP ACTIVITY

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**Tetsuhito Fuse**  
**Space Exploration Innovation Hub Center**  
**(TansaX)**



Technology Advancement Node for SpAce eXploration

# For sustainable moon exploration



**JAXA original technologies**

Transportation tech.

Unmanned Exploration tech.

Human Space Flight

**Private sector expertise**

Exploration

Production

Human Support

Construction

Habitation



**Efficient implementation by international cooperation**

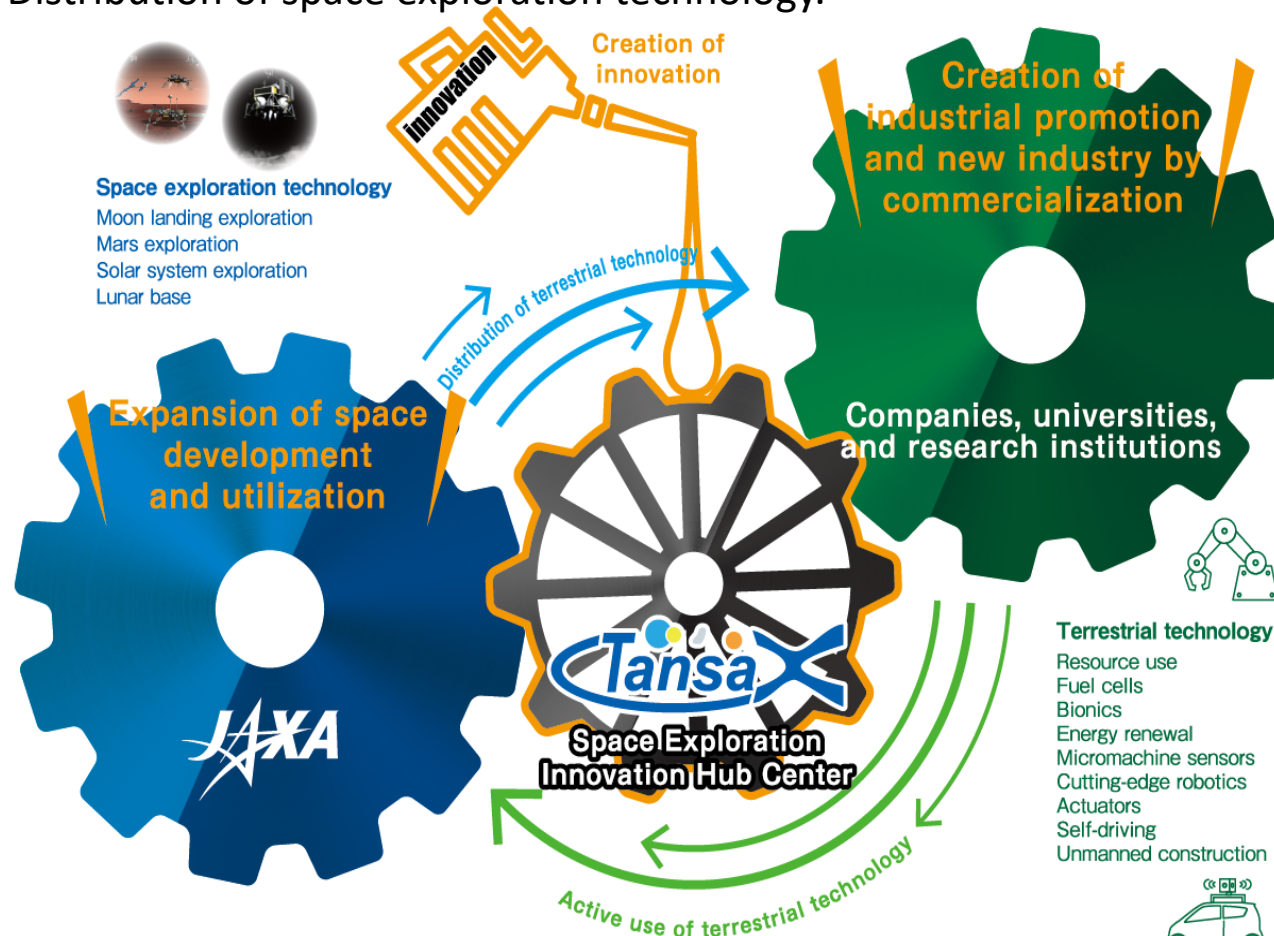
# Space Exploration Innovation Hub Center (TansaX)

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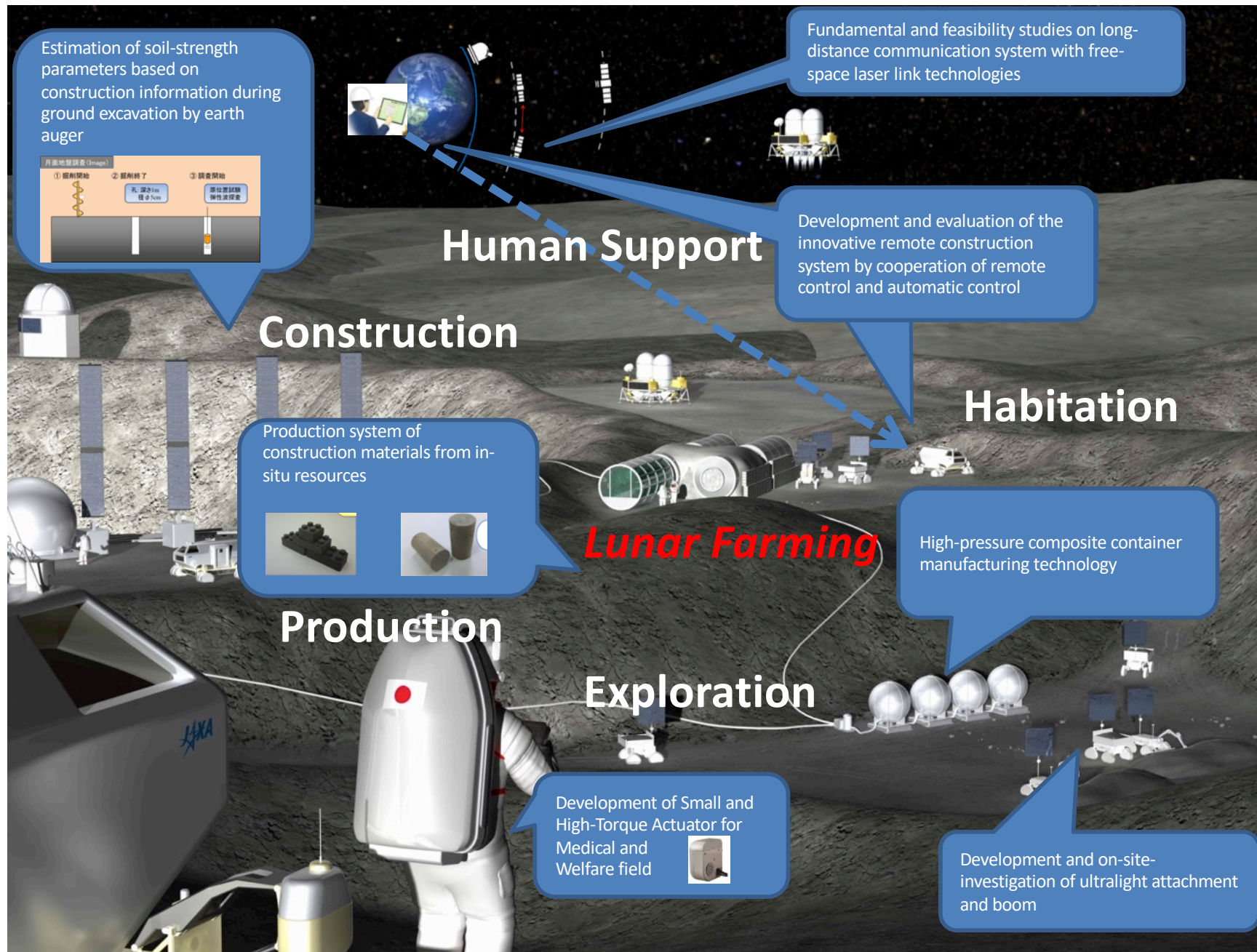
**We are**  
**R&D group for space and ground business**  
**using open innovation scheme**

# Open Innovation Explore Dual-utilization Technology to Terrestrial and Space

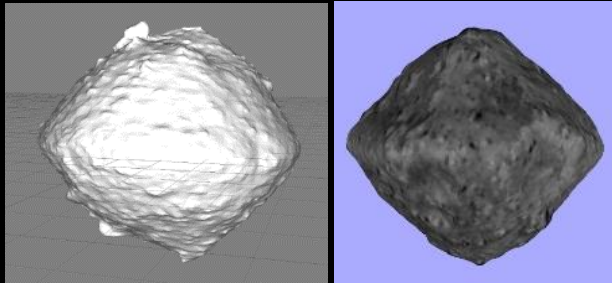
- **Space exploration technology**
  - Expansion of space development and utilization.
  - Active use of terrestrial technology.
- **Terrestrial technology**
  - Creation of industrial promotion and new industry by commercialization.
  - Distribution of space exploration technology.



# Our vision in Image



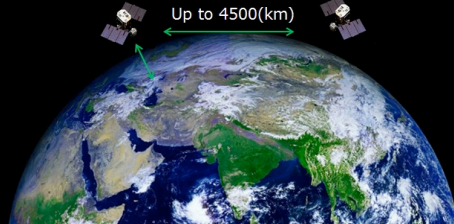
# Examples of Research Results



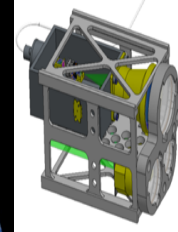
**vSLAM Technology for Hayabusa2 mission**

## Collaborative Research Project on "Small Optical Inter-Satellite Link"

- ✓ Latest Optical Disk Technologies from SONY
- ✓ Trusted Space Grade Engineering from JAXA



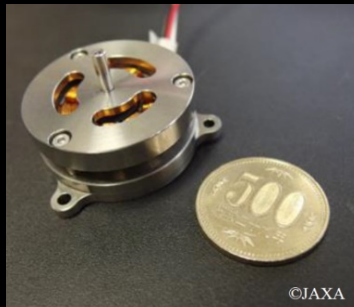
**Long-distance Communication System**



**Sustainable new housing system**



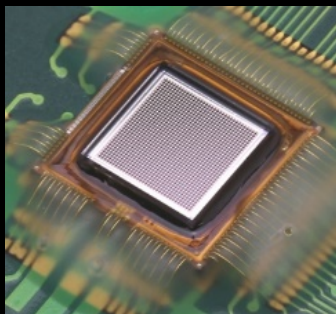
**Innovative remote construction system**



**The world's best- All-solid-state lithium-ion performing actuators secondary battery**



**Solid-state Marine Radar**



**2D Flash Lidar**



**Ultra-light Excavator**



**Next generation actiators**



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**Space Agriculture<sub>6</sub>**

# Lunar farming Concept Study and related R&D activities

# Lunar farming Concept Study as an In-situ resource utilization (ISRU) technology



- ◆ Cutting a pipe-line between outer space and the earth to promote pioneering is necessary.
- ◆ Our Goal is independent exploration, breakaway from supplied from the earth and controlled from the earth.
- ◆ In-Situ resource utilization is essential for sustainable exploration.



Apollo

Construct : NO  
Local Content : NO  
Recycle : NO

Astronauts stayed in lander. All necessary supplements are carried from the earth.



International Space Station

Construct : Astronaut  
Local Content : Electricity  
Recycle : A part of Air, Water  
Construction by module launch and connection with ground instruction.



Future Exploration

Construct : Unmanned, Automated  
Local Content :  $\cong$ 100%  
Recycle :  $\cong$ 100%  
Unmanned and automated construction. Fuel, Air, water, and **Food ISRU crucial**



# In-situ resource utilization (ISRU) technology

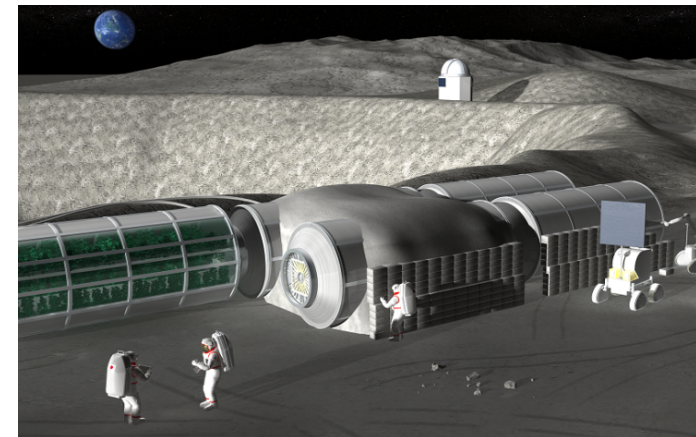
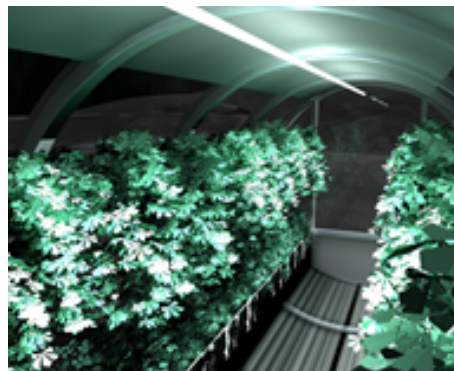
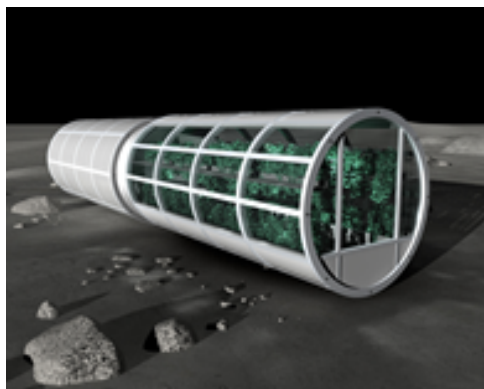
## → Concept Study for Lunar farming

### ◆ Concept

Aim for self-sufficiency of food production system in space, which is necessary to realize a long-term stay of human beings as an ISRU technology.

### ◆ Research Projects for realizing lunar farming with TansaX.

To establish a system for self-sufficiency of food for manned activities in space, searching for R&D themes which have common technical subjects with ground plant factories, And construct a system that can efficiently produce the necessary supplies compared to the transport cost from the earth.



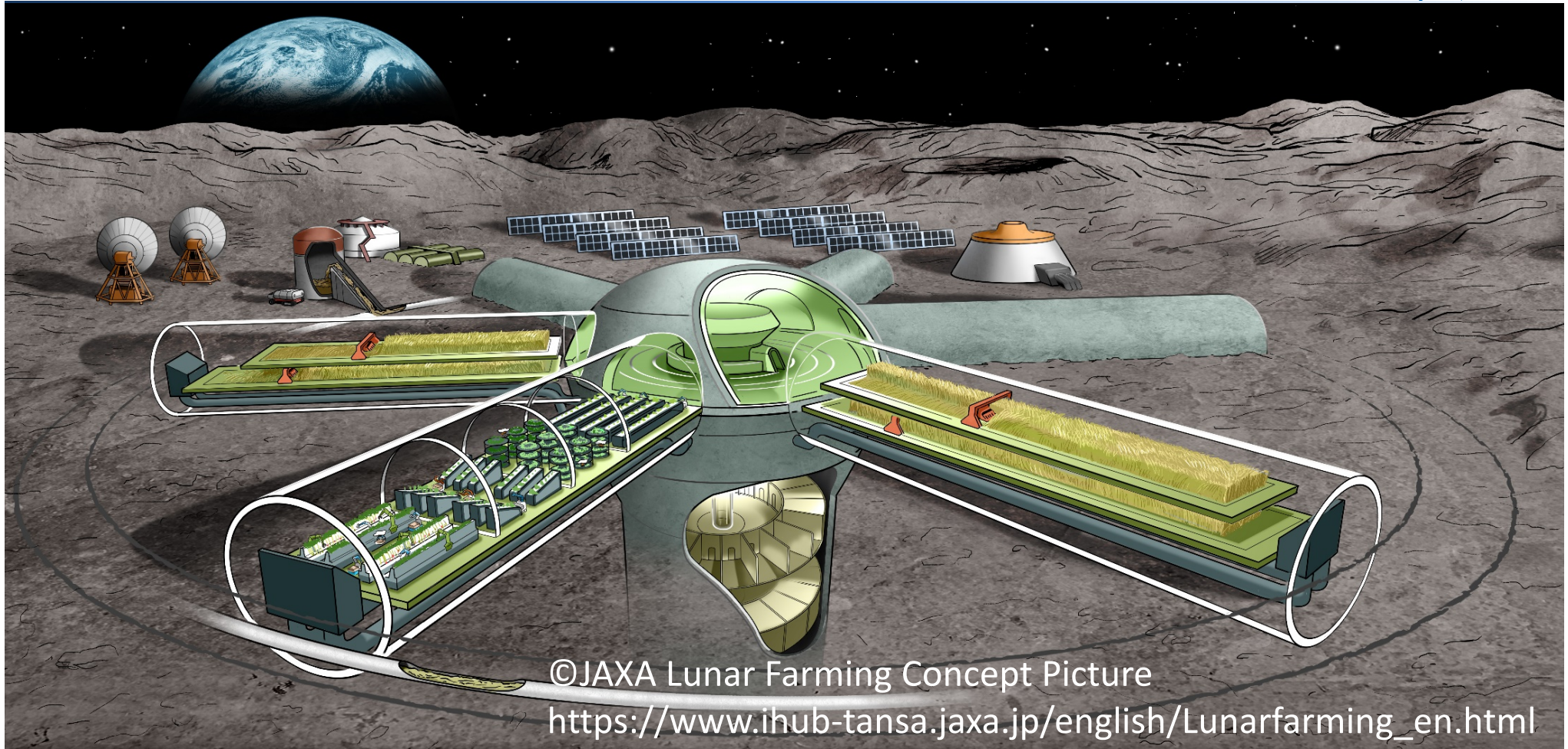
# Lunar farming WG members



	Sub-Group	Topic	member
1	Environmental control technology	<ul style="list-style-type: none"><li>• Cultivation environmental control</li><li>• LED, Air, Water control</li></ul>	Prof. Kitaya Prof. Watanabe
2	Unmanned and Automation technology	<ul style="list-style-type: none"><li>• Monitoring with sensors</li><li>• Robotics</li><li>• Seeding, Harvesting</li></ul>	Prof. Oba Prof. Kondo Prof. Ito Dr. Kashima
3	Recycle technology	<ul style="list-style-type: none"><li>• Soil improvement</li><li>• Regolith utilization</li><li>• Methane fermentation</li></ul>	Prof. Toyoda Dr. Endo Dr. Nakai Dr. Kojima
4	Overall System and Selection of crop species	<ul style="list-style-type: none"><li>• Overall System</li><li>• Nutrition</li></ul>	Prof. Goto Prof. Miyajima Prof. Shinohara Dr. Yano Prof. Kawai

## Our Concept

- Utilize state-of-the-art technologies at present and future technologies that will be required in the future, although feasibility is important.
- Assumed age is 2030s
- Based on the similar consideration of the past, not to follow the existing ideas in NASA and Europe, but to make it Japanese unique.
- Identify and actively incorporate technologies that will help solve the problems of plant factories on the ground business.
- Emphasize space-saving, energy-saving and resource-saving (water, O<sub>2</sub>, CO<sub>2</sub>), important for realization on the moon. This leads to energy saving technology on the ground.
- Before realization on the moon, should have attractive features on the ground like a compact multi-plant farming.



©JAXA Lunar Farming Concept Picture

[https://www.ihub-tansa.jaxa.jp/english/Lunarfarming\\_en.html](https://www.ihub-tansa.jaxa.jp/english/Lunarfarming_en.html)

## Key Concept

- Japan oriented
- Smart Agri
- In-situ resource utilization (ISRU) , Recycling
- High resource efficiency, No labor work

Category	Research theme	Partners
Cultivation	Research on a farm system free from pathogens and insects and capable of backing up in emergency	Takenaka Corporation, Kirin Company, Limited, Chiba University and Tokyo University of Science
Cultivation	The feasibility study of the cultivation system for high calorie plant in lunar farm	Chiyoda Corporation, Mebiol Inc.
Cultivation	A study on the plant cultivation system using hydroponics with artificial light for the production of eatable potatoes	Tamagawa University, Panasonic Corporation
Cultivation	Development of high-throughput plasma irradiation to seeds for crop yield improvement	Kyushu University, Kenix Co. Ltd
Cultivation	Development of indoor dry fog cultivation system with enhanced water use efficiency	Ikeuchi Co.,Ltd., Osaka Prefecture Univ

Category	Research theme	Partners
Recycle	Development of high-performance material made of engineered protein for use as a fertilizer for plant cultivation	Spiber Inc.
Recycle	Development of a small scale and efficient protein production platform utilizing edible microalga, Spirulina	Chitose Laboratory Corp., Tavelmout Corp., IHI Aerospace Co., Fujimori Kogyo Co.,LTD.
Recycle	Sustainable food/protein production by symbiotic recycling culture system combining algae and animal cells	Tokyo Women's Medical University, Integriculture Inc.
Recycle	Develop a recyclable new medium for plant factory with artificial light	National Agriculture and Food Research Organization, JSP Co., Ltd
Recycle	Development of compact quad-generation system for recycling plant residue based on the methane fermentation technology	Osaka Prefecture University with project members from Yanmar Energy System Co., Ltd

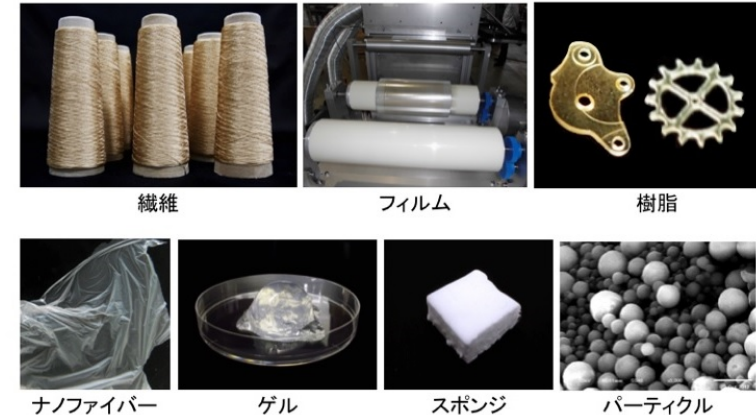
Category	Research theme	Partners
<b>Unmanned and Automation technology</b>	Development of LED multi-stage rotary cherry tomato cultivation system and automatic harvesting robot	GINZA FARM Co.,Ltd. with project members from Tokyo Institute of technology and Kyoto Univ..

## 1. 「Development of high-performance material made of engineered protein for use as a fertilizer for plant cultivation」

Spiber Inc.

### ■ Point

- Soil reducible plastic is important theme for the ground, too.



## 2. 「Research on a farm system free from pathogens and insects and capable of backing up in emergency」

Takenaka Corporation, Kirin Company, Limited, Chiba University and Tokyo University of Science

### ■ Point

- Bag-type culturing system. The creation and maintenance virus-free strains is also Necessary.



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3. 「The feasibility study of the cultivation system for high calorie plant in lunar farm」

Chiyoda Corporation, Mebiol Inc.

■ Point

- Promote the cultivation of “*Apios fortune* (Hodo)” as a highly nutritious crop.

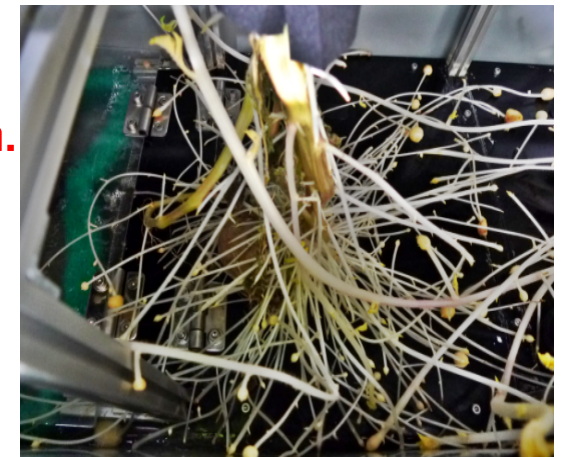


4. 「A study on the plant cultivation system using hydroponics with artificial light for the production of eatable potatoes」

Tamagawa University, Panasonic Corporation

■ Point

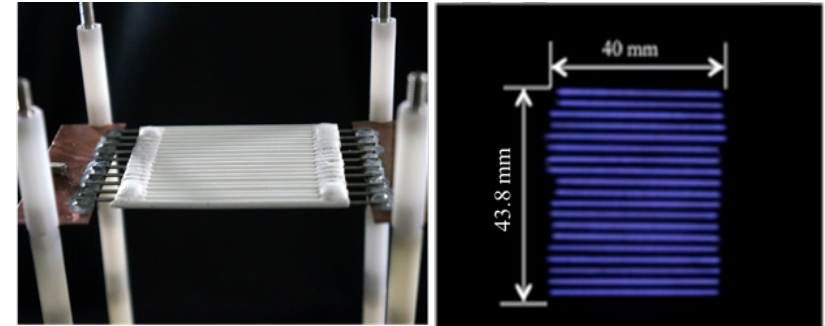
- Potatoes’ hydroponic culture system demonstration. Technology to cultivate potatoes, which can be staple foods in space and put it into practical use.



5. 「Development of high-throughput plasma irradiation to seeds for crop yield improvement」  
Kyushu University, Kenix Co. Ltd.

■ Point

- Plasma irradiation can make affection on producibility and efficiency.



State of plasma processing

6. 「Development of indoor dry fog cultivation system with enhanced water use efficiency」  
Ikeuchi Co.,Ltd., Osaka Prefecture Univ.

■ Point

- Development of indoor dry fog cultivation equipment with improved air tightness. Sprayed Nutrient Dry Fog Improve the water conservation by minimizing adhesion to other roots.



Ikeuchi Co.,Ltd HP

7. 「Development of a small scale and efficient protein production platform utilizing edible microalga, Spirulina」

Chitose Laboratory Corp., Tavelmout Corp., IHI Aerospace Co., Fujimori Kogyo Co.,LTD.

■ Point

- Spirulina is said to have the highest protein production efficiency on earth.



レースウェイシステム  
粉末スピルリナ  
図 3. ORP による生産風景とスピルリナ製品

Spirulina Culture Field

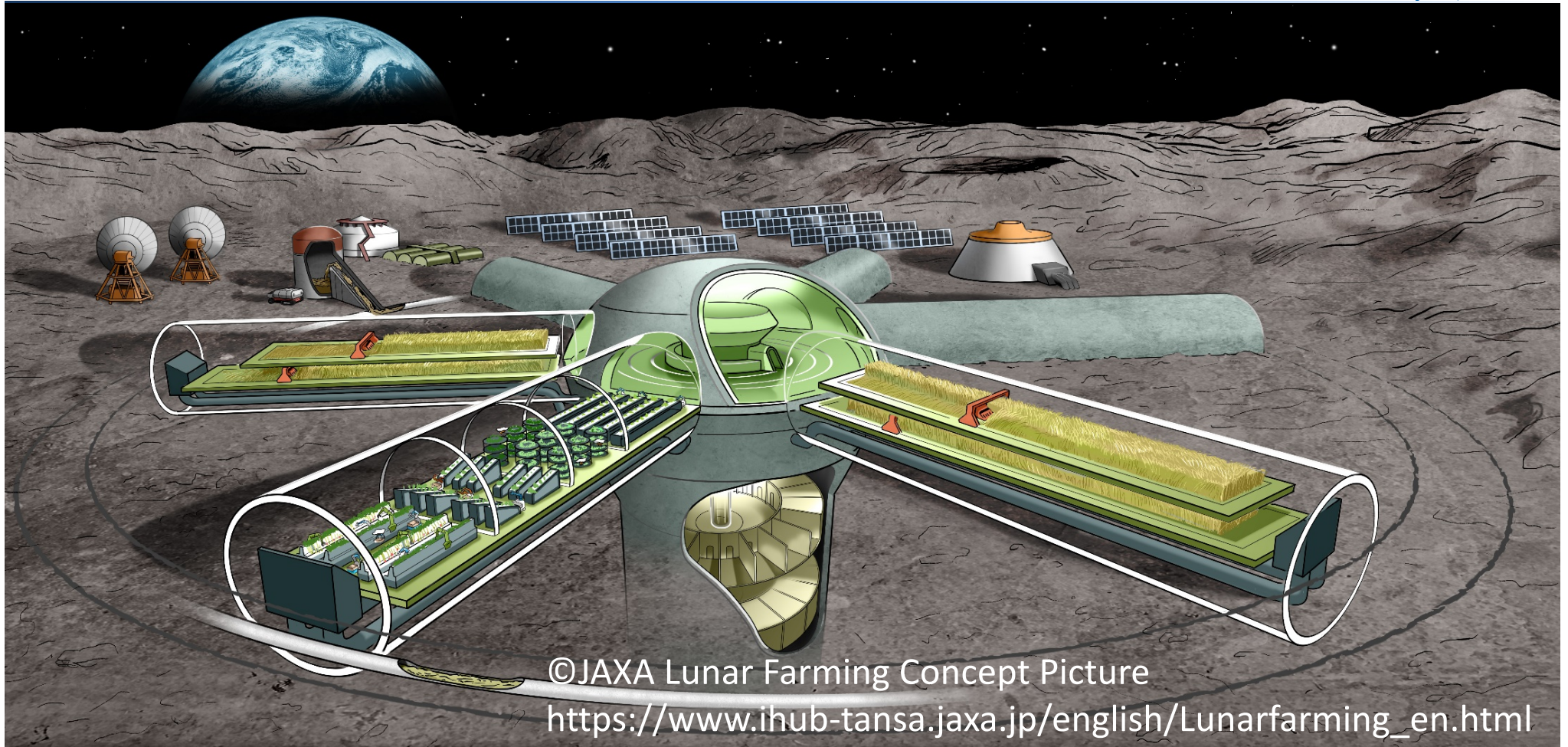
8. 「Sustainable food/protein production by symbiotic recycling culture system combining algae and animal cells」

Tokyo Women's Medical University, Integriculture Inc.

■ Point

- Co-culture of photosynthetic algae and protein source animal cells simultaneously.

9. Development of LED multi-stage rotary cherry tomato cultivation system and automatic harvesting robot」  
GINZA FARM Co.,Ltd. with project members from Tokyo Institute of technology and Kyoto Univ..
  
10. 「Develop a recyclable new medium for plant factory with artificial light」  
Kyushu Okinawa Agricultural Research Center, National Agriculture and Food Research Organization (KARC, NARO) with project members from JSP Co., Ltd
  
11. 「Development of compact quad-generation system for recycling plant residue based on the methane fermentation technology」  
Osaka Prefecture University with project members from Yanmar Energy System Co., Ltd..



**We are happy to share our activities and look forward to collaboration with international partners through elaboration for both space exploration and business to realize lunar farming.**