Delegates from　Embassy of Switzerland in Japan

May 28, 2018

Current status and perspectives for smart agriculture in Japan

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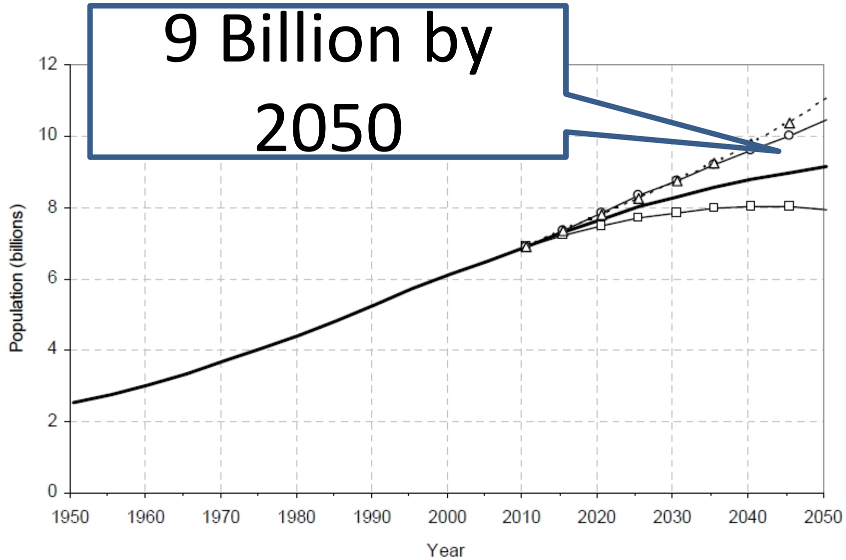
Cross-Ministerial Strategic Innovation Promotion Program(SIP), Cabinet office, Japan government

Topics

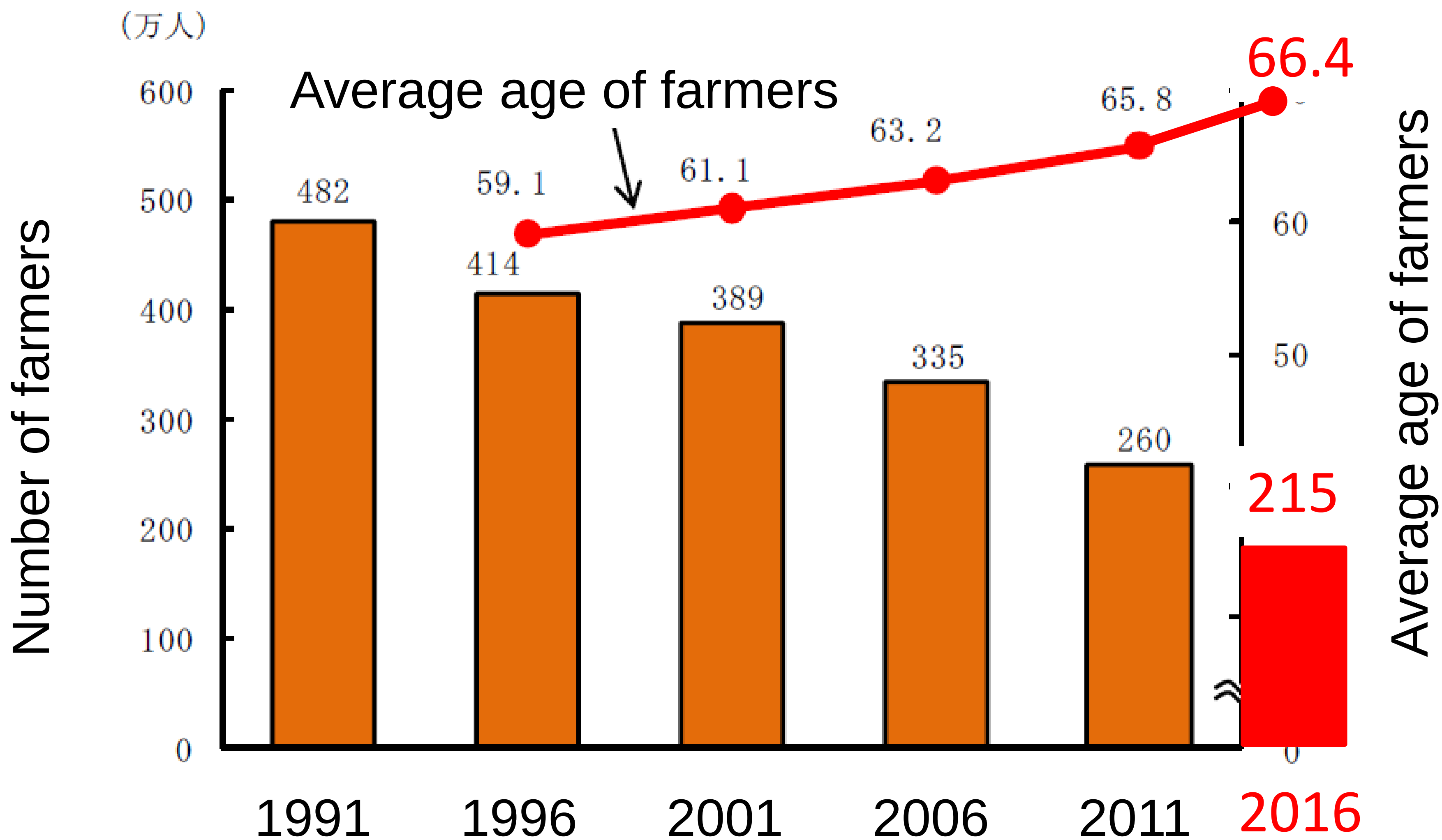
- World and Japan food problems
- Cross-Ministerial Strategic Innovation Promotion Program (SIP)
- Ag-robot developments in Vehicle Robotics Laboratory (VeBots）
- Quasi-zenith satellite system (QZSS) application to smart agriculture

World food problems

- Population growth ↑
- Protein consumption ↑
- Global warming ↑
- Energy crops ↑
- Food prices ↑
- Land & soil quality ↓
- Available land & water ↓
- % Rural population ↓



Labor shortage of agriculture in Japan



(2010 Japanese Census of Agriculture)

Topics

- World and Japan food problems
- Cross-Ministerial Strategic Innovation Promotion Program(SIP) “Technologies for Creating Next-Generation Agriculture, Forestry and Fisheries”
- Ag-robot developments in Vehicle Robotics Laboratory
- Quasi-zenith satellite system (QZSS) application to smart agriculture

Headquarter for Science and Technology to foster innovation
- Council for Science, Technology and Innovation (CSTI) -

- ***Promoting effective measures across ministries to create innovation beyond the borders of disciplines, ministries and sectors***

Three Arrows of Reinforcement of the HQ

<u>Improvement of the process for policy-making</u>
<u>"S&T Budgeting Strategy Committee" and "Action Plans for S&T Priority Measures"</u>

- *Prioritized area: "Energy", "Next-generation infrastructures", "Local resources", "Health & Medical"*
- *Budget for FY2014: ¥335bil*

SIP <u>(Cross-Ministerial Strategic Innovation Promotion Program)</u>

- *Budget for FY2017: ¥50bil*

*Of this amount, 35 percent(¥17.5 billion) was allocated to medical fields

<u>ImPACT (Impulsing PAradigm Change through disruptive Technologies)</u>

- *Budget for FY2014-2018: ¥55bil*

11 Themes of SIP

Priority policy issues	Themes	Objective
Energy	Innovative Combustion Technology	Improving fuel efficiency of automobile engines
	Next-Generation Power Electronics	Integrating new semiconductor materials into highly efficient power electronics system
	Structural Materials for Innovation (SM⁴I)	Developing ultra-strong and –light materials such as magnesium-, titanium-alloys and carbon fibers
	Energy Carriers	Promoting R&D to contribute to the efficient and cost-effective technologies for utilizing hydrogen
	Next-Generation Technology for Ocean Resources Exploration	Establishing technologies for efficiently exploring submarine hydrothermal polymetallic ore
Next-generation infrastructures	Automated Driving System	Developing new transportation system including technologies for avoidance accidents and alleviating congestion
	Infrastructure Maintenance, Renovation and Management	Developing low-cost operation & maintenance system and long life materials for infrastructures
	Enhancement of Societal Resiliency against Natural Disasters	Developing technologies for observation, forecast and prediction of natural disasters
	Cyber-Security for Critical Infrastructures	Development of technologies that monitor, analyze, and defend control and communication system as well as confirm integrity and authenticity of system components to protect critical infrastructures against cyber threats.
Local resources	**Technologies for Creating Next-Generation Agriculture, Forestry and Fisheries**	**Realizing evolutionary high-yield and high-profit models by utilization of advanced IT etc**
	Innovative Design/Manufacturing Technologies	Establishing new styles of innovations arising from regions using new technologies such as Additive Manufacturing

1. Summary of the project plan

Current situation of agriculture, forestry and fisheries in Japan

- **Decrease of core persons mainly engaged in farming**
  (1.75 million, 15% decrease in 5 yrs)
- **Aging of core persons mainly engaged in farming**
  (65 yrs-old or older accounts for 65%)
- **Rapid increase of large-scale farm**
  (100ha or larger increased by 30% in 5 yrs)

Chance for agricultural structure reform

- **Rapid progress of technologies** related to smart agriculture and breeding
- **Expansion of food market** such as health function
  (Market size of agriculture- or food-related industries: about 100 trillion yen)

Science and technology innovation aimed by SIP (2 goals)

1. **To develop a highly productive and labor-saving smart agriculture model** by innovative technologies such as **robotics, IT, and NBT** **<Smart agriculture>**
2. To add high value to agricultural and forest products by focusing on **functionality** of foods and developing **new materials from unutilized resources** **<Enhancing value>**

Future vision of agriculture, forestry and fisheries in Japan

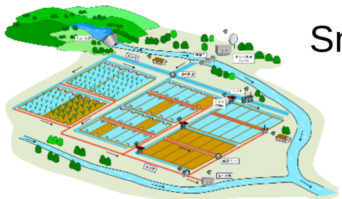
- **Strong production agriculture competitive with foreign countries**
- **Market expansion of agri-food industry and regional development by enhancing the value of products**

SIP

Goal 1: Development of smart agriculture models

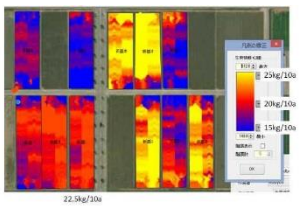
Develop an ultra-laborsaving and highly productive smart agriculture model using innovative technologies such as robotics, ICT, and NBT

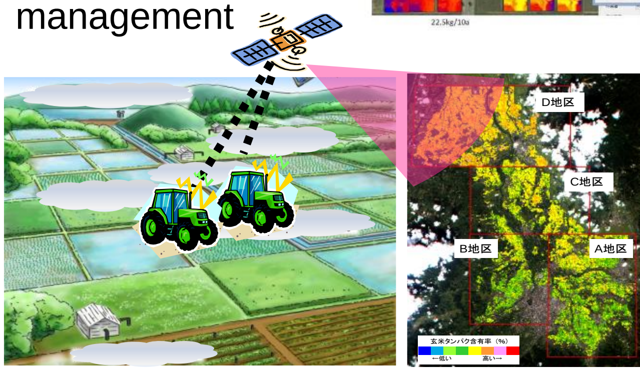
1-1) Paddy rice farming



Labor-saving water management

Smart fertilization system



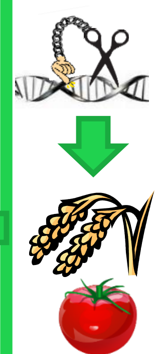


Multi-robot tractors

Remote sensing

Reduce rice production cost **by 40%** by **improving cultivation techniques by automation and intelligentization**.

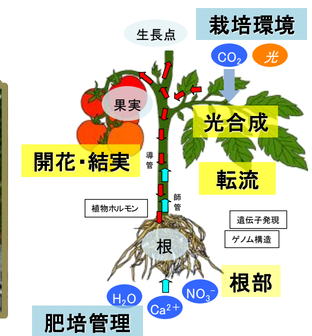
Japanese genome-editing techniques



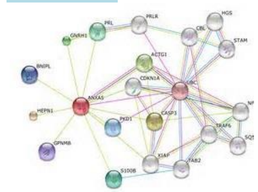
Epoch-making varieties

Develop competitive **Japan-made genome-editing techniques** which produce **high-yield and high-quality** varieties.

1-2) Greenhouse horticulture



Technologies for disease and pest prevention



Utilization of omics data

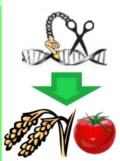
Establish an **optimum cultivation condition of tomato that can balance high-yield and high-quality** using omics data.
Reduce disease and pest damage substantially using new pesticide-free technologies.

SIP

Goal 2: Enhancing the value of agricultural and forestry products

Promote enhancing values of agricultural and forest products. For example, development of high-quality or **functional healthy foods** and **new materials from unutilized resources**

Japanese genome-editing techniques

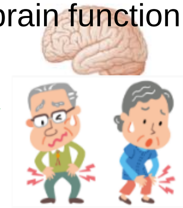


Epoch-making varieties

2-1) Development of functional health foods

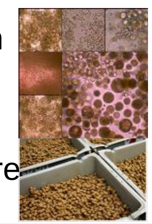
Functional healthy foods

Improvement of brain function



Cultivation of DHA-rich algae

Aquaculture feed

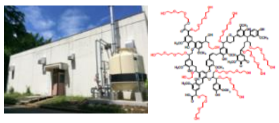


DHA-rich seafood

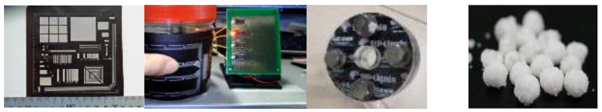
Obtain evidences about new functions of foods such as better cognition and locomotion and **commercialize more than 15 foods** by cooperating with food companies and agricultural cooperatives.

2-2) Creation of new local industry by developing new materials

Take out forest residues



Modified lignin production plant



Electronic substrate

IC tag (tags for merchandise management)

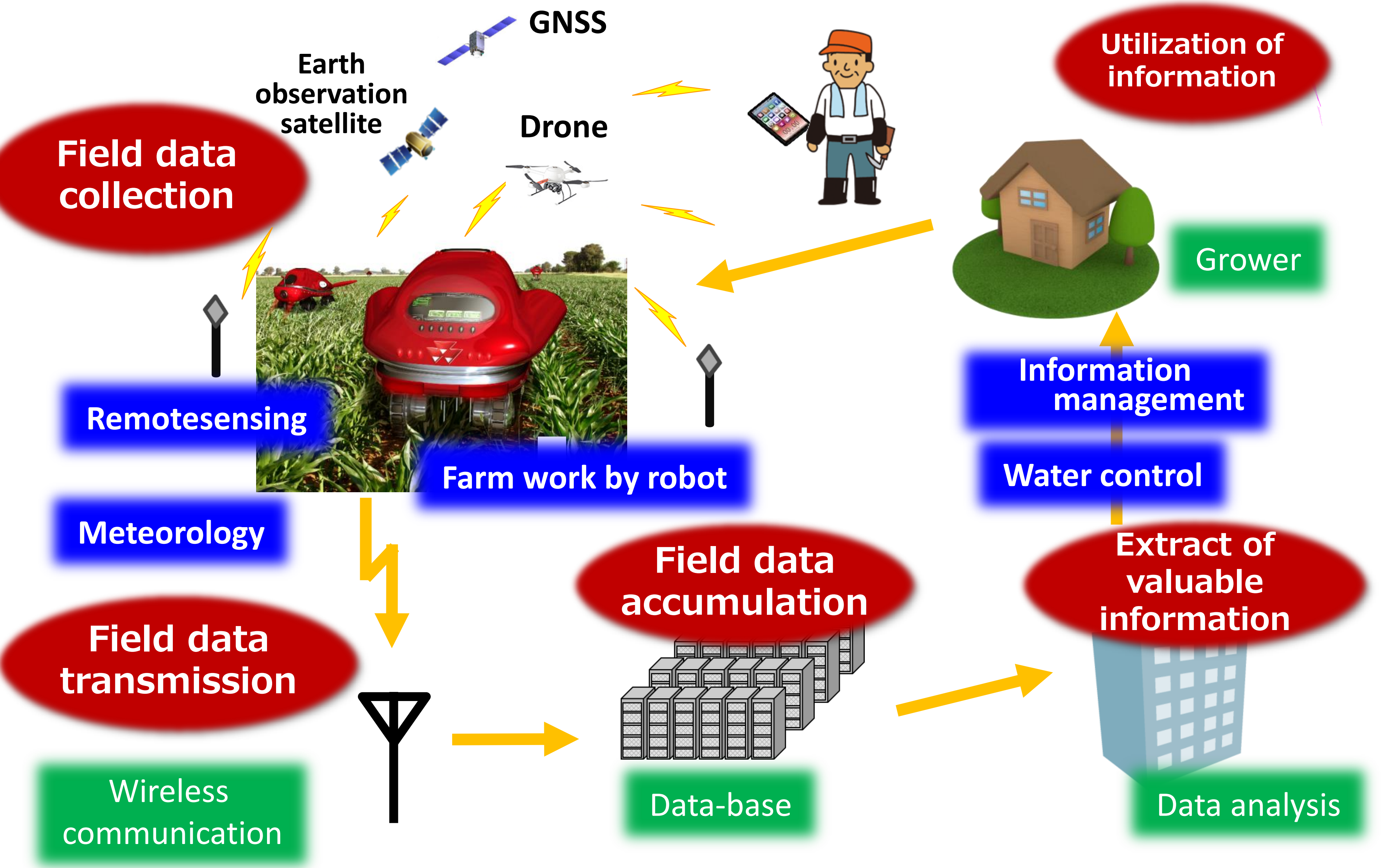
Heat-resistant gasket

Slow-release fertilizer

Extract modified lignin from forest residues safely at lower cost, and develop a comprehensive processing technology to obtain high value-added industrial applications, then create a new market.

SIP

Overall goal of smart farming system



GOAL: Smart farming system realize "Society 5.0" in agricultural sector

Topics

- World and Japan food problems
- Cross-Ministerial Strategic Innovation Promotion Program(SIP)
- Ag-robot developments in Vehicle Robotics Laboratory (VeBots）
- Quasi-zenith satellite system (QZSS) application to smart agriculture

Introduction

Ministry of Agriculture, Forestry and Fisheries

April, 2016

Vehicle Robotics Laboratory

Research Faculty of Agriculture
Hokkaido University

ICT & Robotics for Agriculture

Vehicle Robotics Laboratory (VeBots)

- Unmanned Ground **Vehicle**
- Unmanned Surface **Vehicle**
- Unmanned Aerial **Vehicle**
- Satellite **Vehicle**

北海道大学

VeBots
Laboratory of Vehicle Robotics
HOKKAIDO UNIVERSITY, SAPPORO, JAPAN

Timeline of launching Agri-robots in Japan

Decrease of core persons mainly engaged in farming
(1.75 million, 15% decrease in 5 yrs)

Aging of core persons mainly engaged in farming
(65 yrs-old or older accounts for 65%)

Serious labor shortage

Prime Mister Shinzo Abe directed to get robots working in Japanese agriculture by 2020 in "Public-private dialogue towards future" held in March 4.2016.

- Auto steering
- Robot tractor associating with human-drive tractor
- Robot tractor under human observation
- Robot system by remote observation
- Multi-robot

Now

2018

By 2020

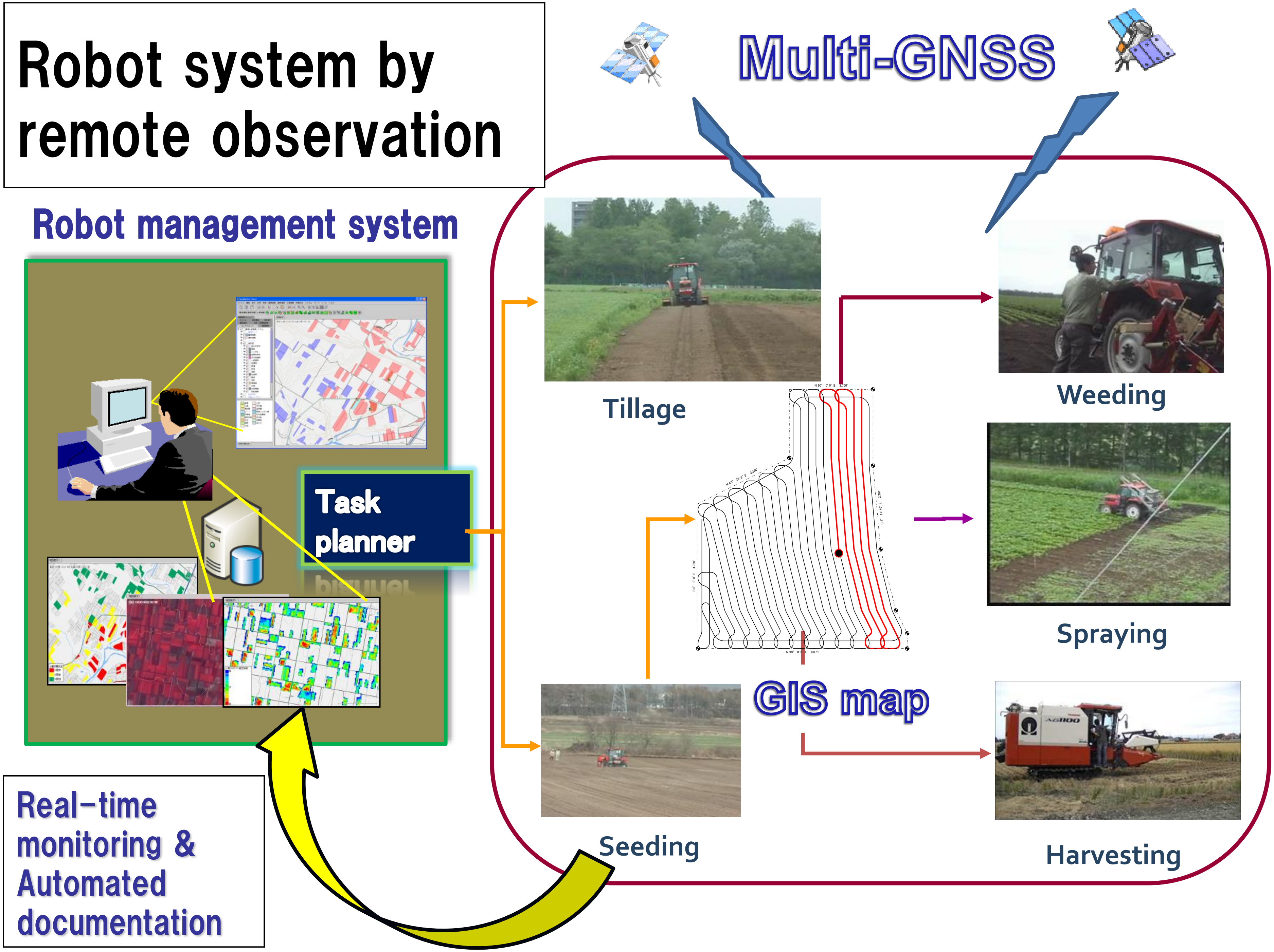
The Ministry of Agriculture, Forestry and Fisheries, Japan

Safe security guidelines of robotic agricultural machinery

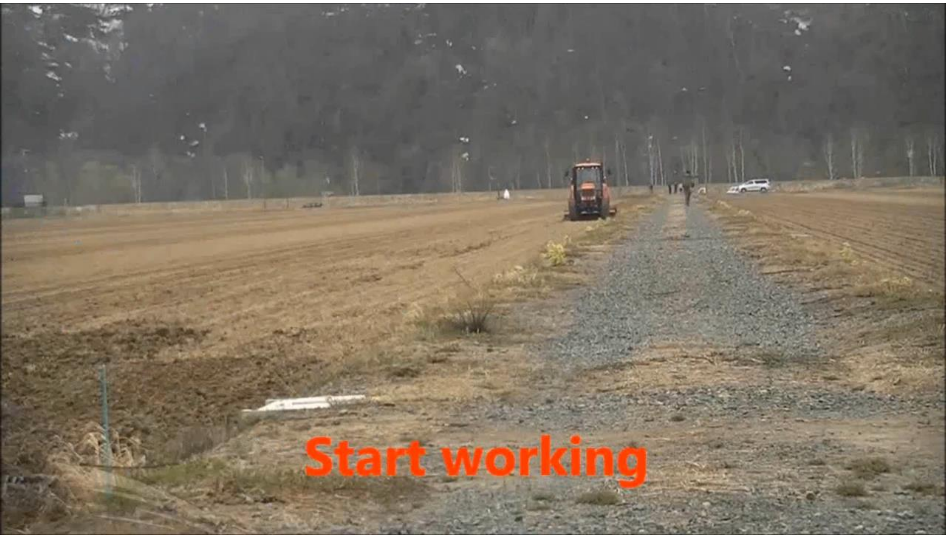
The purpose of the guideline is to ensure safe operation of an autonomous agricultural vehicle incorporating with a robot technology.
The guideline also indicates a basic concept of the safety security including the enforcement of the risk assessment and the role of the person concerned.

Effective date: March,2017

Robot system by remote observation



Agri. robot demonstrations-1



Tillage

Puddling

Soil preparation

Planting

Agri. robot demonstrations

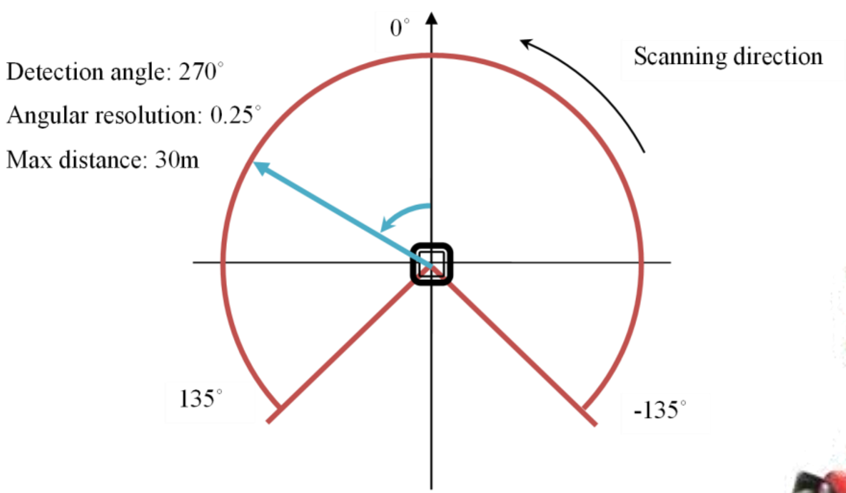
Tillage

Transfer from barn to field

Chemical application

Harvesting

Safety sensors; laser scanners



Demonstration of safety sensor

Timeline of launching Agri-robots into Japan agriculture

Auto steering

Robot tractor associating with human-drive tractor

Robot tractor under human observation

- Robot system by remote observation
- Multi-robot

2018

By 2020

GOAL: Create new type of agricultural meccanization using robots, and put the technology on global markets such as US, EU and Australia.

Current trend for mechanisation to get bigger

Advantages

- Current system very effective
- Reduced labour cost/ha
- High work rates/hour
- Good for large farms & fields
- Economies of scale

Disadvantages

- High cost of operator
- High capital expense
- Reduced flexibility
- Subsoil compaction?
- Cannot be used on wet soil

Soil compaction !

Professor Simon Blackmore, Harper Adams University, UK

Current system: Compaction

- Up to 90% of the energy going in to cultivation is there to repair the damage caused by large machines
- Up to 96% of the field area compacted by tyres in “random traffic” systems
- If we do not damage the soil in the first place, we do not need to repair it
- Move towards light machines

Climate change !

Cooperative work by two robot tractors

Tillage

Puddling

Cooperative work by two robot tractors with human

Daytime

Night

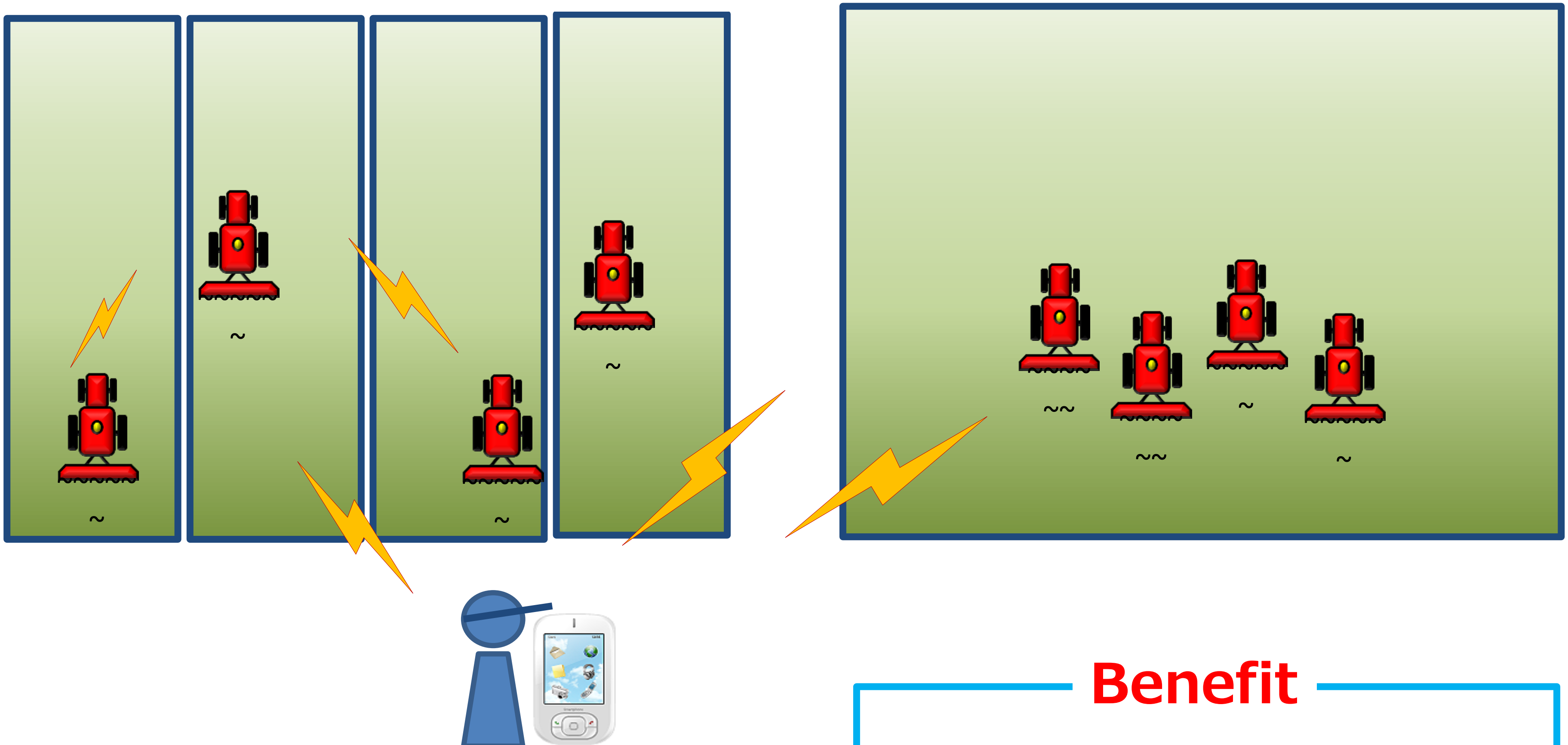
Observation is human's job

(This system is enable aged people, women, non-skilled people to operate perfectly)

Multi-robot tractor

Multiple small farm lands

Large farm land

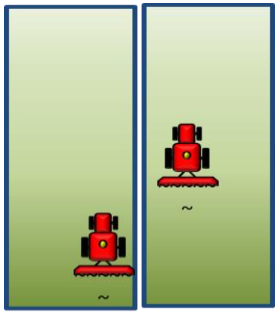


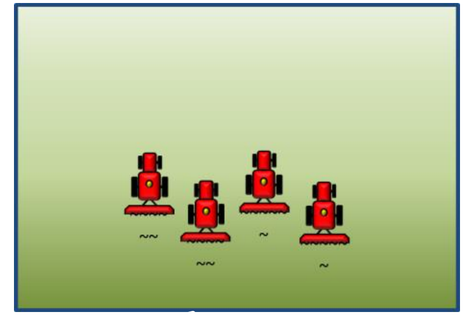
Small size machines are good for both safety and soil compaction

Benefit

Farmers borrow a small robot tractor each other, and make a flexible and efficient work.

Multi-robot tractor (continued)





Multiple small lands | **Large land**

Multi robot system can be used from small farm land to large farm land.

FOUR multi-robot tractor demonstration

Introduction of multi-robot by Prime Minister

Remarks By Prime Minister Abe at 14th Annual Meeting of the STS Forum
(October 1, 2017**,** Kyoto, Japan)

Multi-robot combine harvester

Robot combine harvester for four rows（67PS and 70PS)
M2M commutation is installed for safety.

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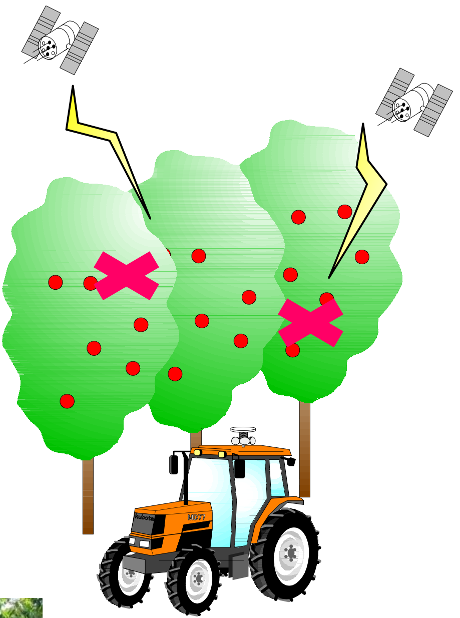
- Quasi-zenith satellite system (QZSS) application to smart agriculture

QZSS utilization for enhancing precise positioning

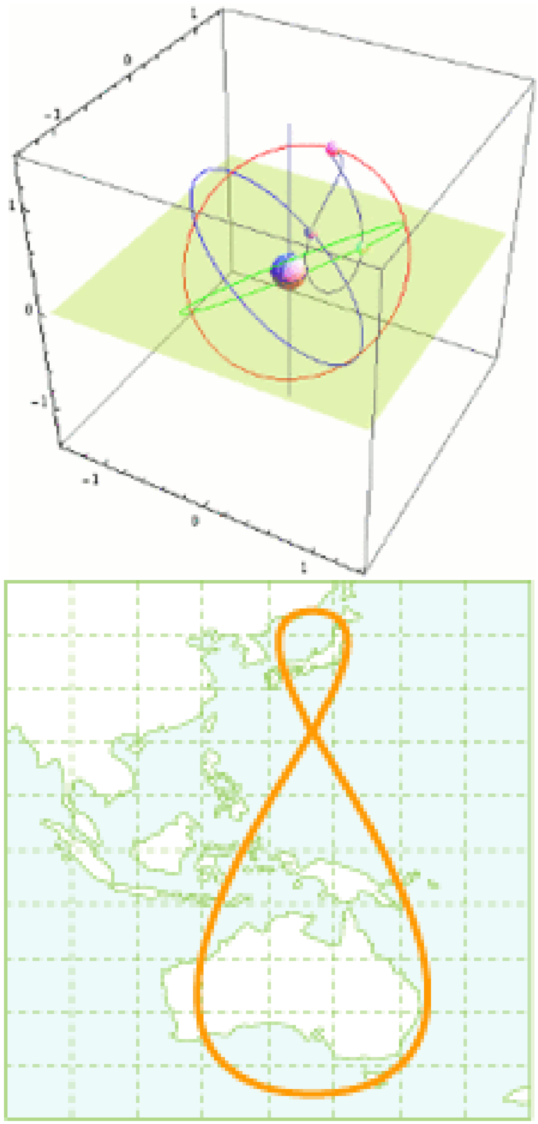
Current GNSS cannot be used in any time and any places

- Low reliability due to limited number of SVs

- Acquisition of correction signal for RTK-GPS has problems



QZSS for enhancing precise positioning



Quasi-zenith satellite orbit

QZSS enhances GPS services in the following ways:

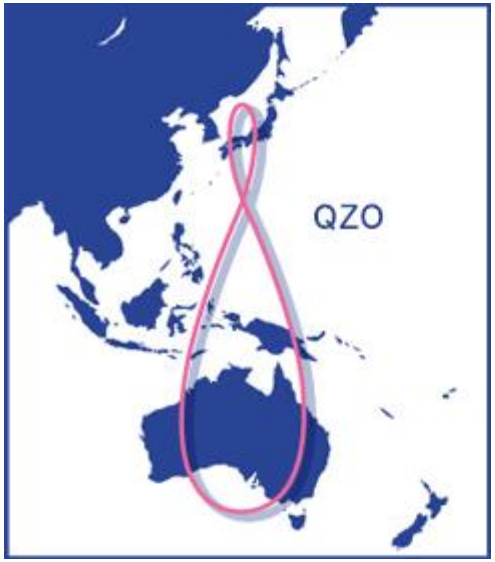
- Availability enhancement (improving the availability of GPS signals)
- Performance enhancement (increasing the accuracy and reliability of GPS signals).

Rice harvesting by robot combine harvester using QZSS (Sep. 12-13, 2013)

”Michibiki” Quasi-zenith satellite system (QZSS)

Current GNSS cannot be used in any time and any places

- Low reliability due to limited number of SVs.
- Acquisition of correction signal for RTK-GPS has problems.



Main area where QZSS is available

- QZSS (Michibiki) will be started in Nov. 2018 to develop a satellite positioning service that can be used in a stable way in all locations at all times. This system is compatible with GPS satellites and can be utilized with them in an integrated fashion. In this way, the satellite positioning service environment will be advanced dramatically.
- QZSS can be used even in the Asia-Oceania regions with longitudes close to Japan, so its usage will be expanded to other countries in these regions as well.

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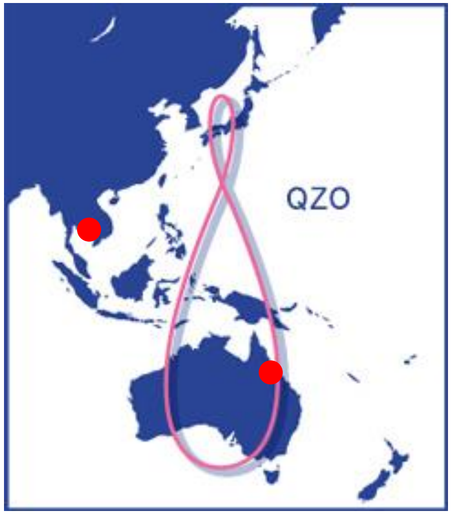
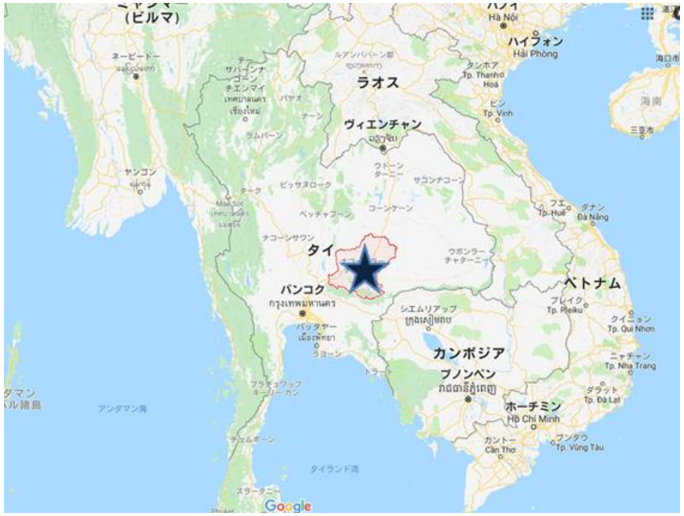
Demonstrations of "Michibiki"

- Cassava farm in Thailand
- Homebush cane farm in Australia



- 90% sugar from QLD
- 2nd largest export crop



Nakhon Ratchasima Province

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Cassava Planting Experiments

Demonstration of a robot tractor in Mackay

ABC News, 12 Dec. 2016

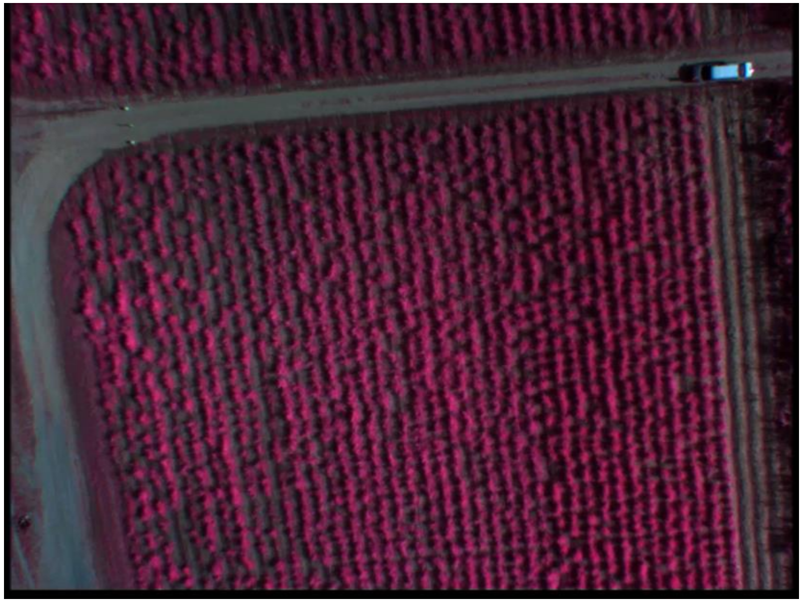
Remote sensing of sugarcane using a drone

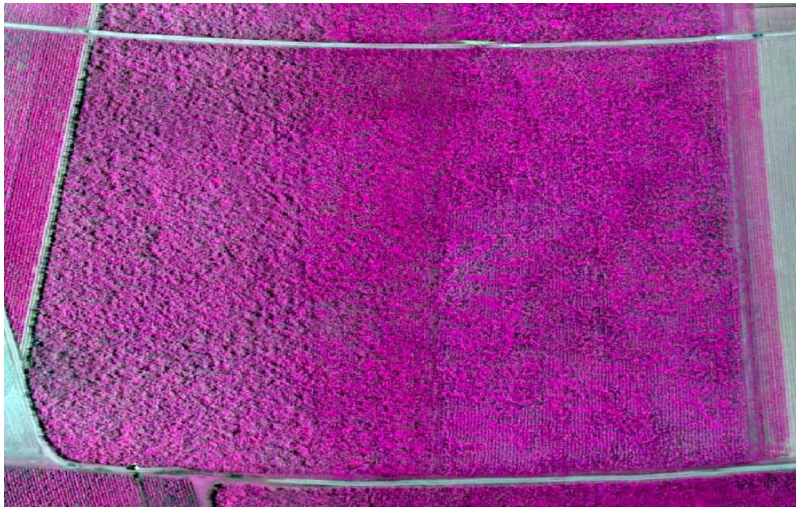
Feasibility study for acquiring NDVI and crop height

R-G-NIR camera

GPS rover

LIDAR



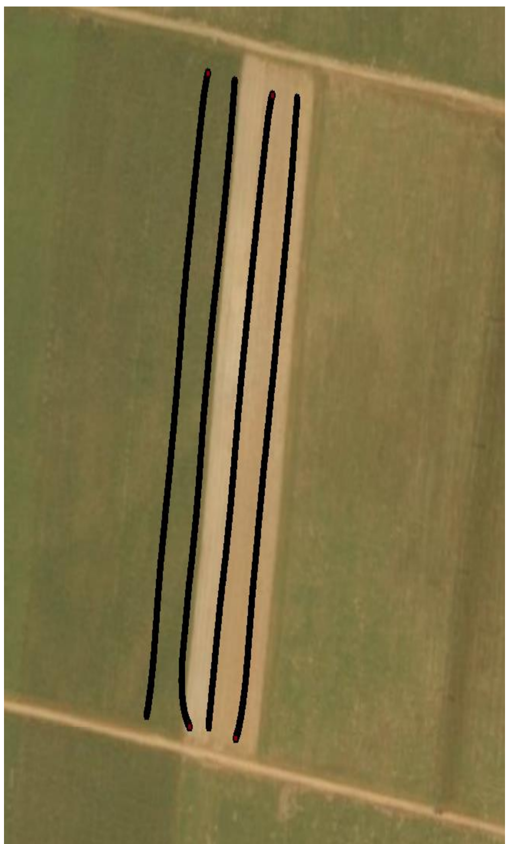


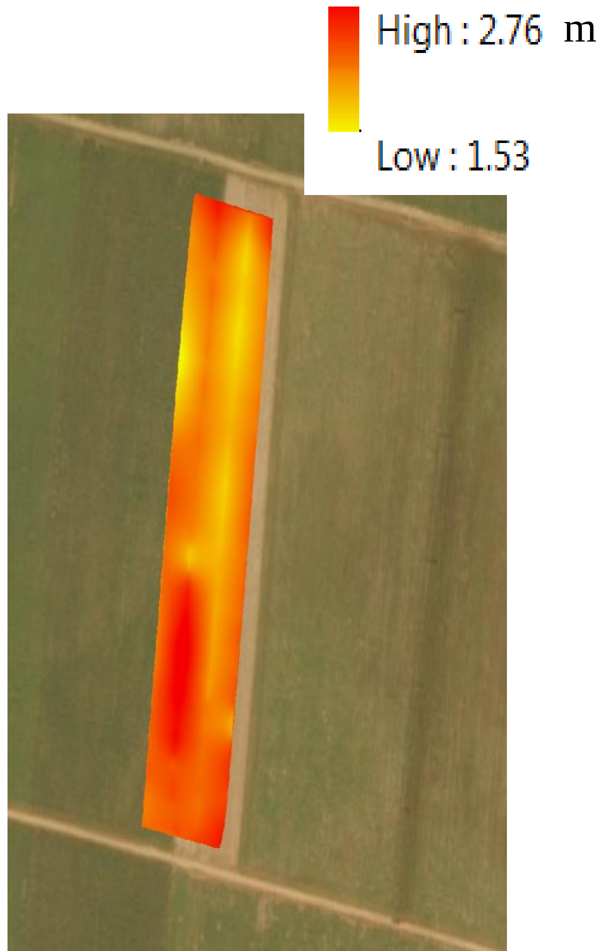
Flight altitude：100 m
Flight speed: 5 m/s
Ground resolution:
4.5 cm;
Area of test field:
550m * 300m

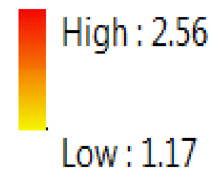
Sugarcane height map

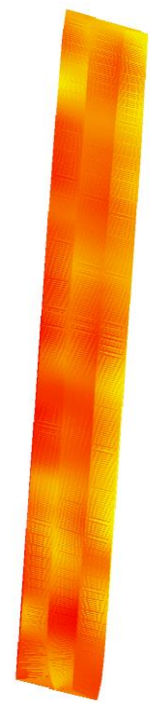
Generating height map from lidar data by using natural neighborhood interpolation method, to integrate with 2D NDVI map for mapping biomass's spatial variation.

Flight speed: 5 m/s
Lidar Output：5 Hz









To extract NDVI value and multiply with corresponding height data.

Video clip of measuring sugarcane hight

Flight altitude: 30 m   Flight speed: 5 m/s

Harvesting robot for heavy crops

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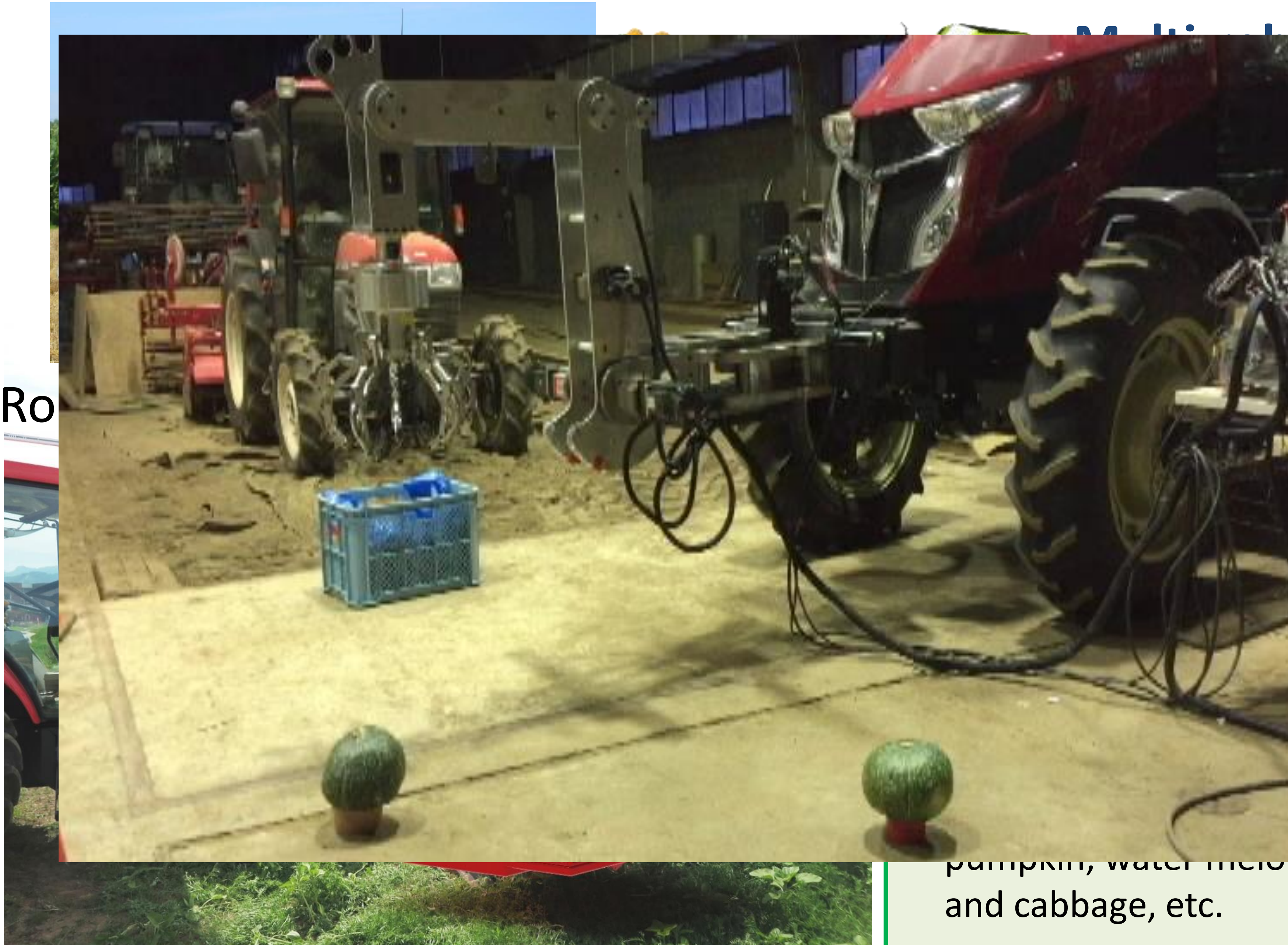

is

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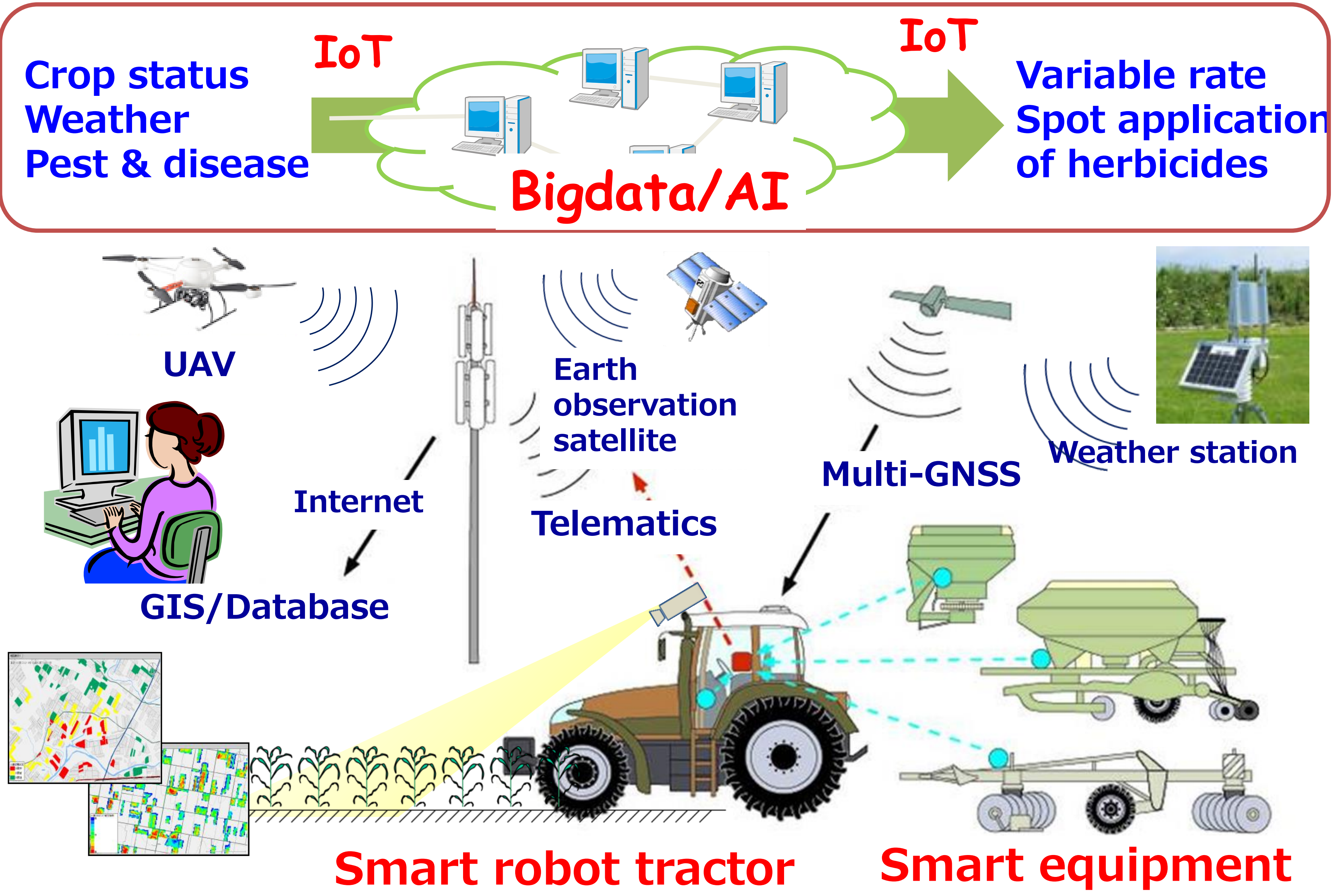
e.

pumpkin, water melon
and cabbage, etc.

Smart farm robot



Summary

- ✓ Many countries including Japan are interested in robot agriculture to solve current problems of production agriculture.
- ✓ Performed ICT agriculture demonstration using QZSS and robot technologies in Australia and Thailand.
- ✓ Smart agriculture is important for next generation's production agriculture

Thank you for listening!!!

VeBots
Laboratory of Vehicle Robotics
HOKKAIDO UNIVERSITY, SAPPORO, JAPAN