

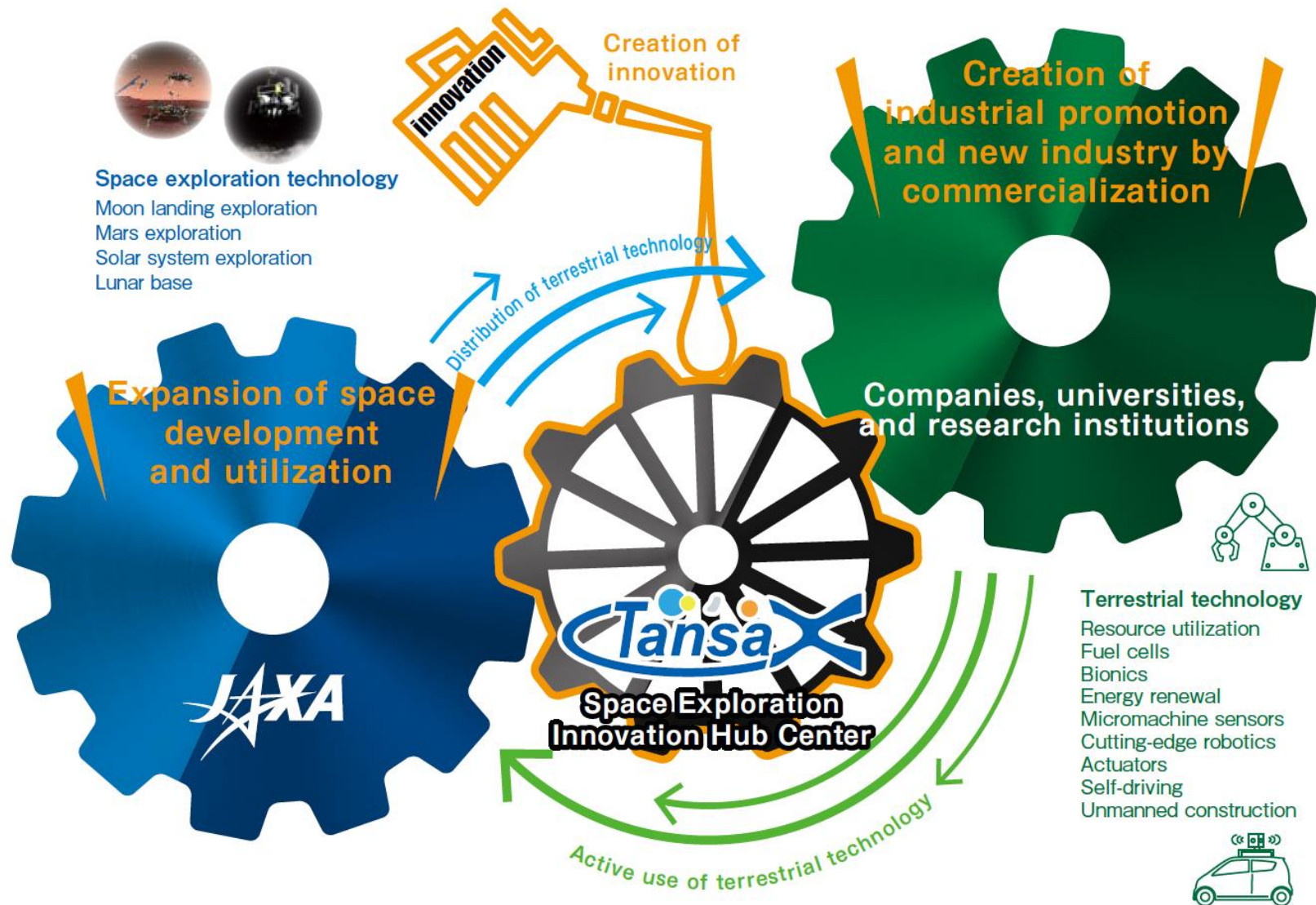
Remote Construction Experiment for Utilizing Water Resources on the Moon

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- ❑ Introduction; background and objectives
- ❑ Water resource utilization scenario on the Moon
- ❑ Demonstration experiment using construction machinery
- ❑ Summary and future works

Innovation from the union of space and terrestrial technologies



Innovation from the union of space and terrestrial technologies



Construction

- Remote unmanned construction
- Large and light-weight construction machinery

- Apply cutting-edge terrestrial technology into space exploration
- Enhance competitiveness of terrestrial industries

Production

- “Waterless” concrete
- Resource extraction from regolith, e.g., water and minerals

Exploration

- Wide-area exploration by insectoid robots
- Small but powerful motors
- Sensors that detect even small traces of water

Habitation

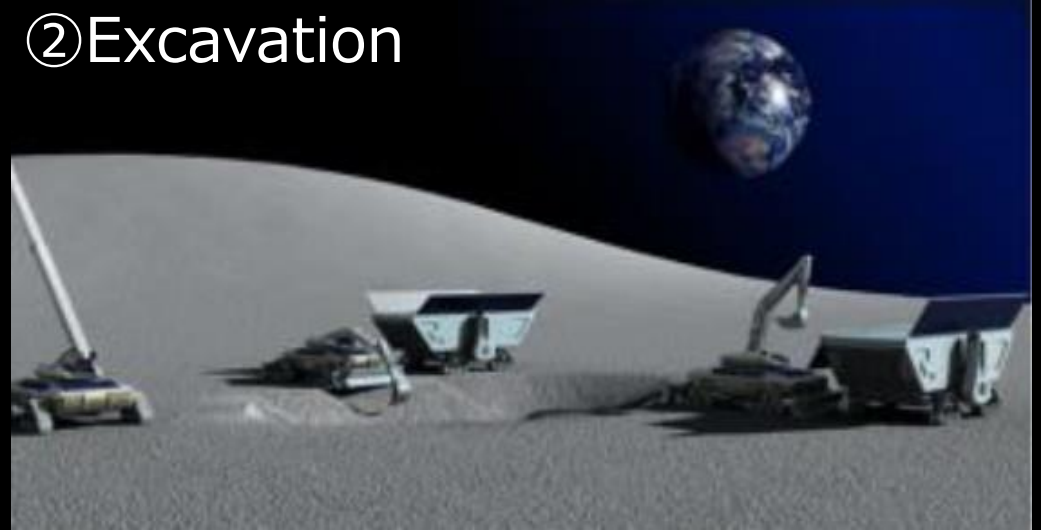
- Regenerative fuel cells
- Thermally insulated tanks
- Plant production
- Protection from radiation

Unmanned construction for manned lunar base

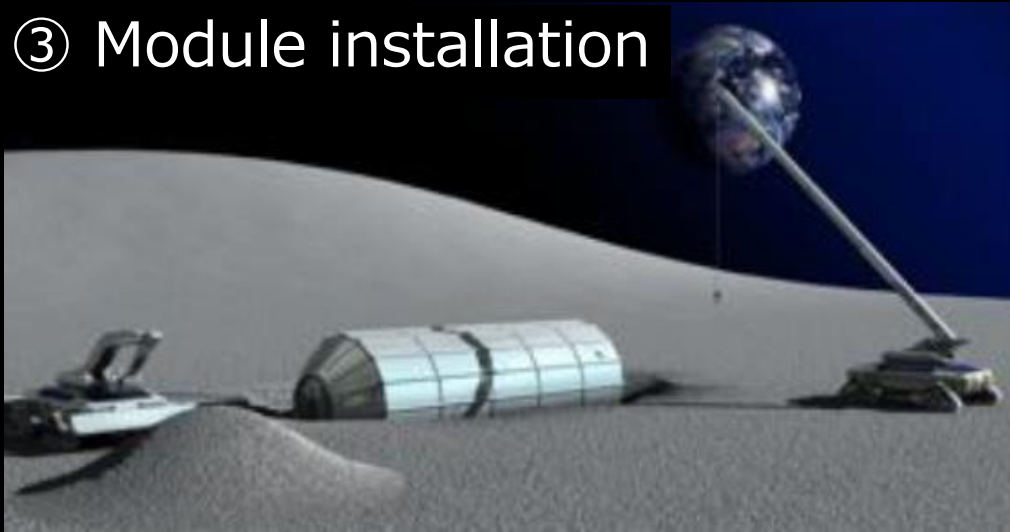
① Leveling



② Excavation



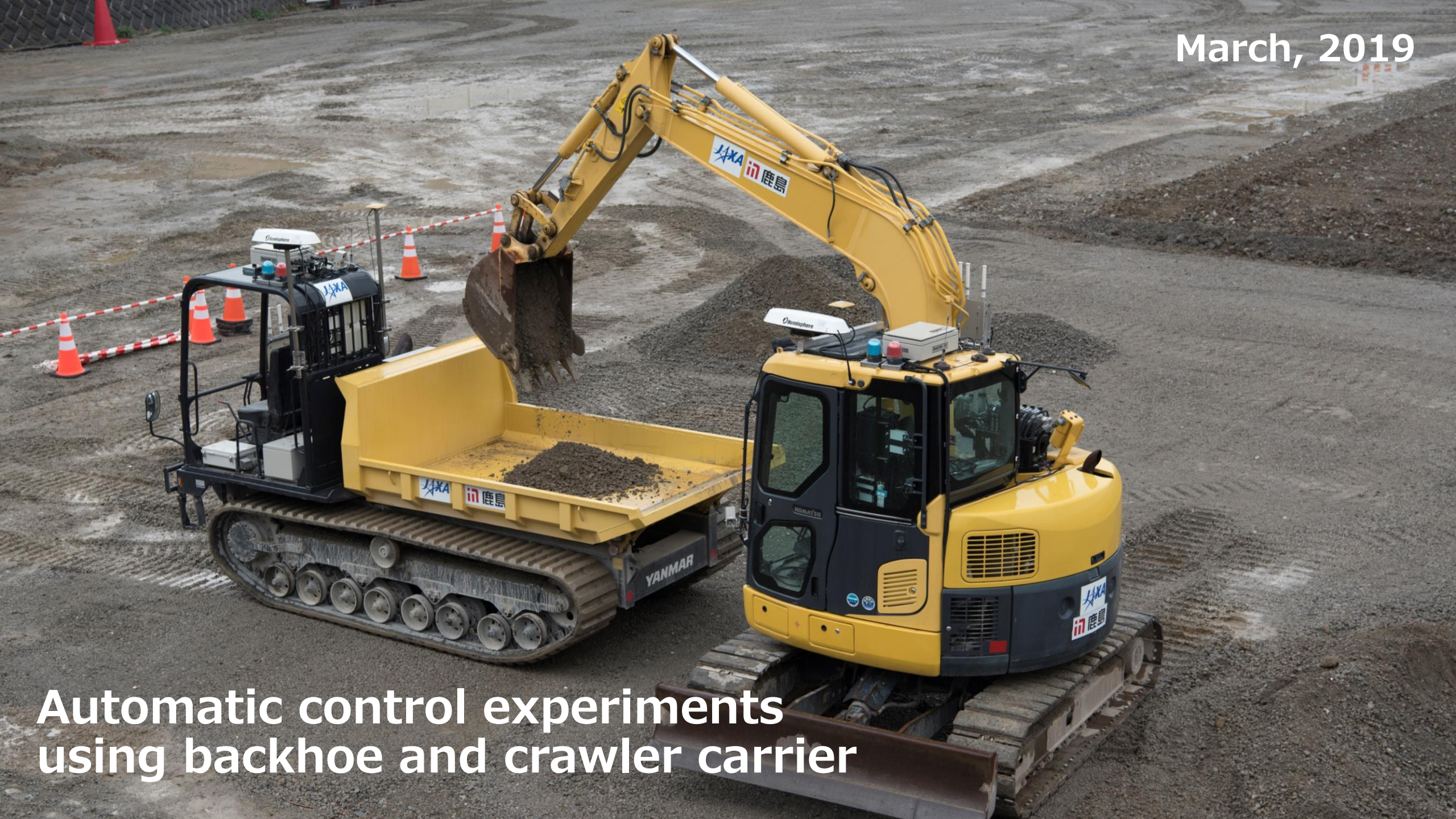
③ Module installation



④ Shielding



March, 2019

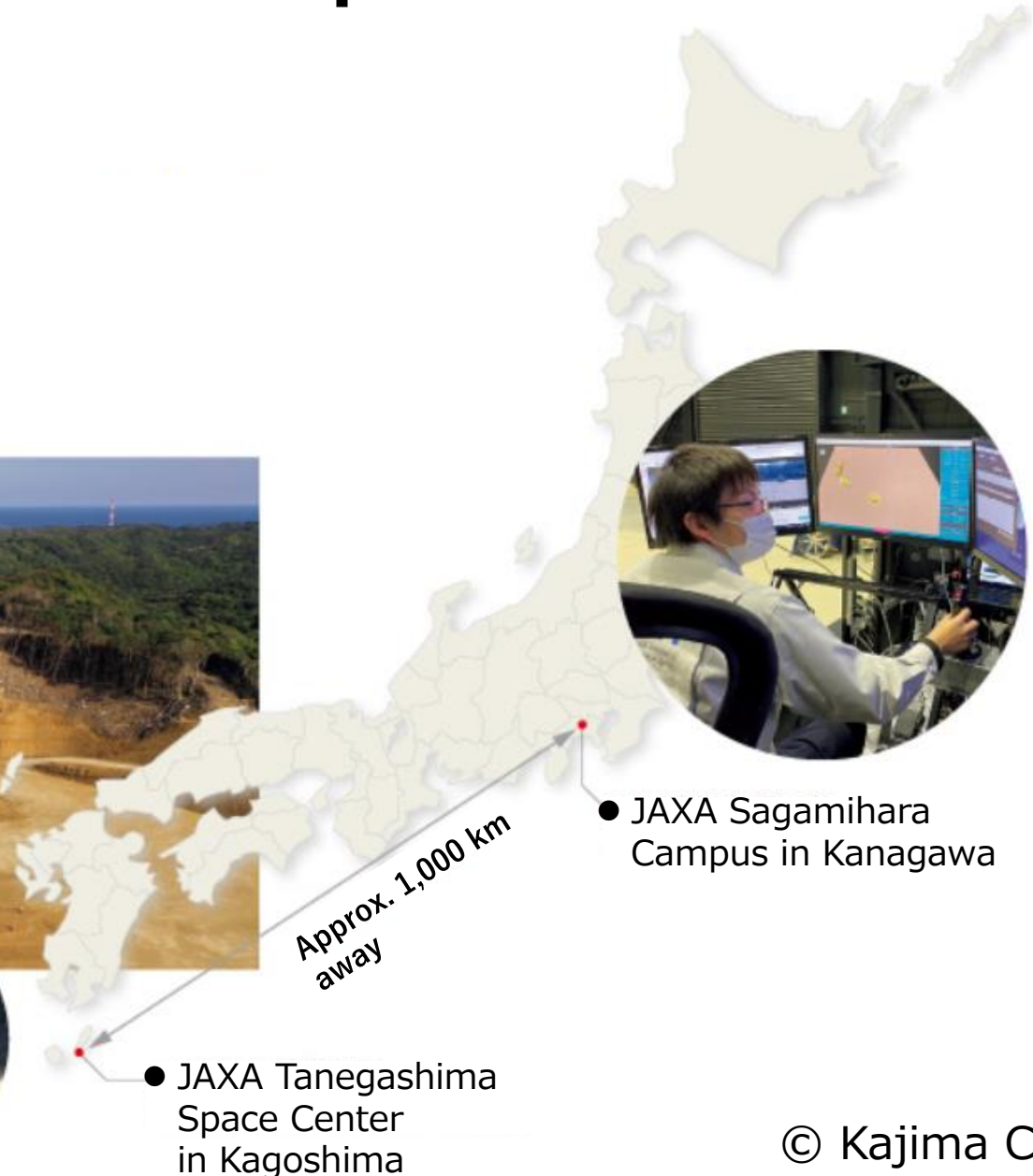
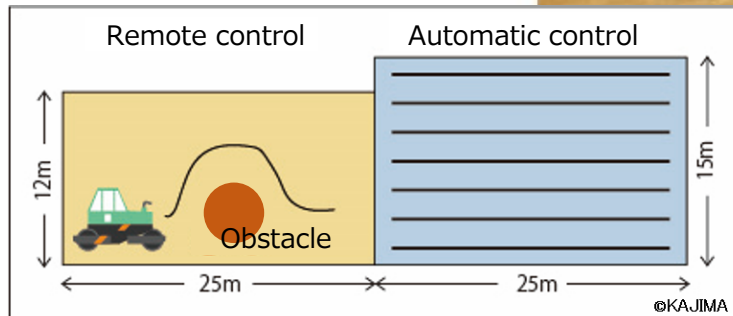


Automatic control experiments
using backhoe and crawler carrier

Remote and automatic control experiments using a vibration roller



March, 2021



● JAXA Sagami-hara Campus in Kanagawa

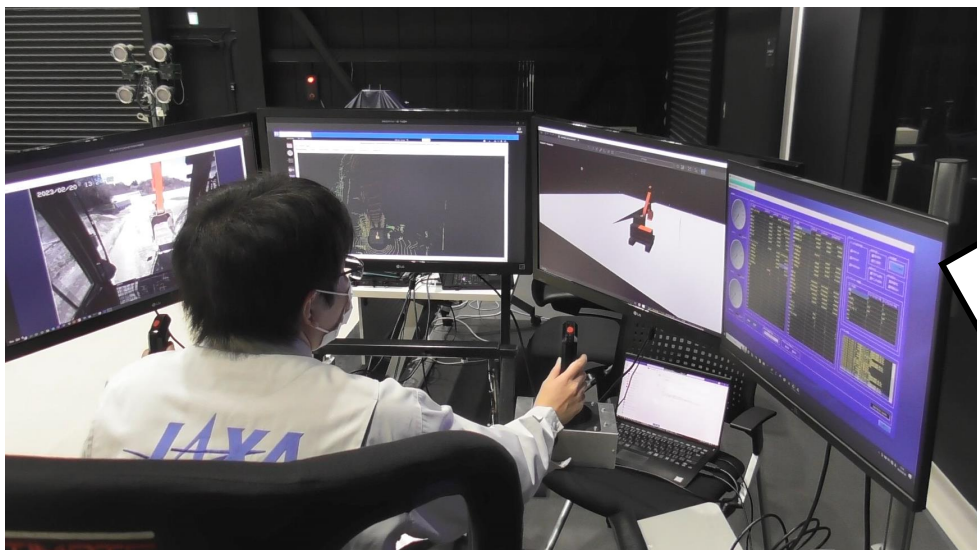
● JAXA Tanegashima Space Center in Kagoshima

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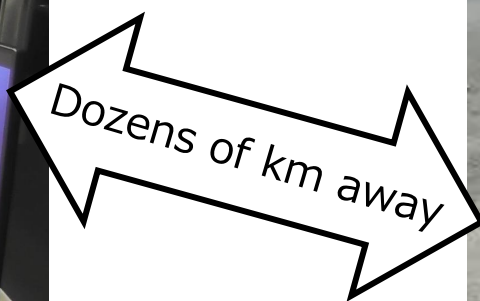
Objectives of research



- ❑ To confirm the effectiveness of a remote and automatic control system for construction machinery, we performed demonstration experiments for a water resource utilization scenario on the Moon.



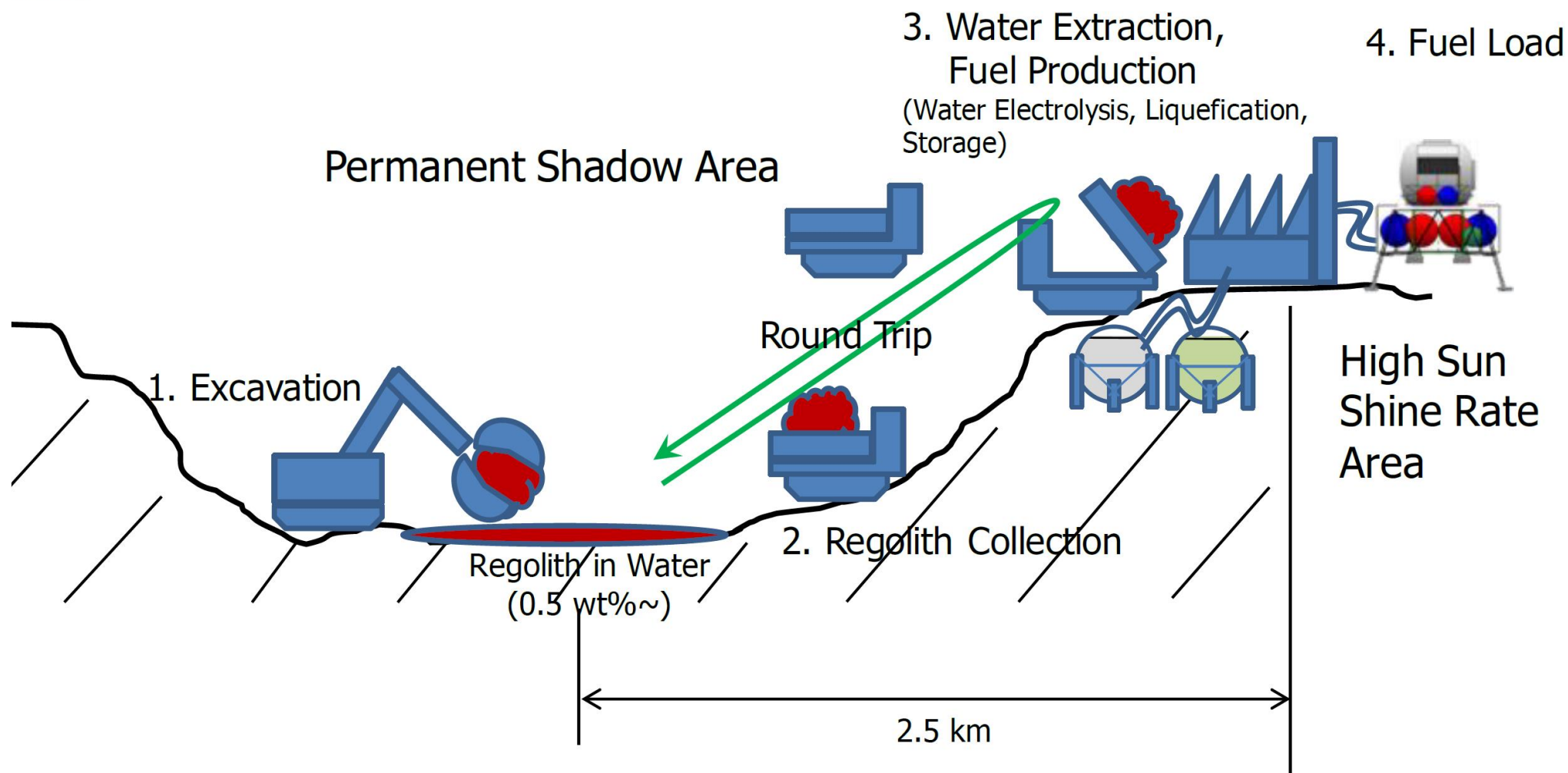
Operator @ JAXA Sagamihara Campus



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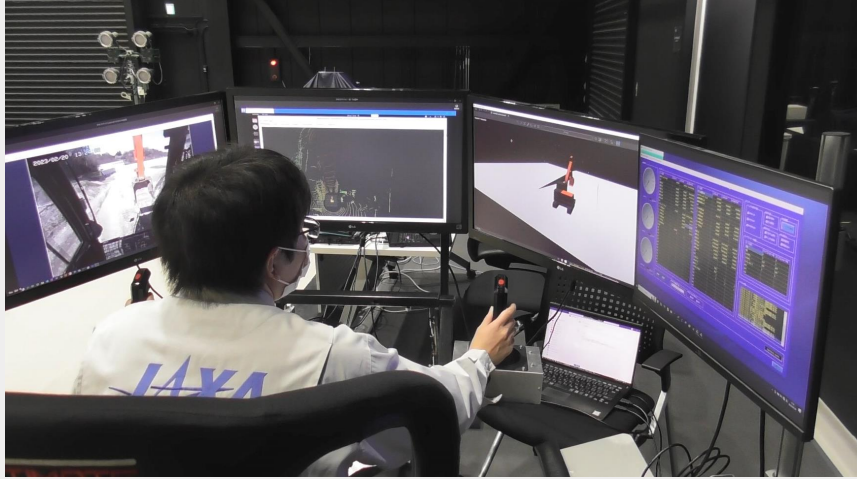
Construction machinery
@ Kajima Seisho Test and Practice Field

Water resource utilization scenario on the Moon



From "JAXA's International Space Exploration Scenario"

Demonstration experiment using construction machinery



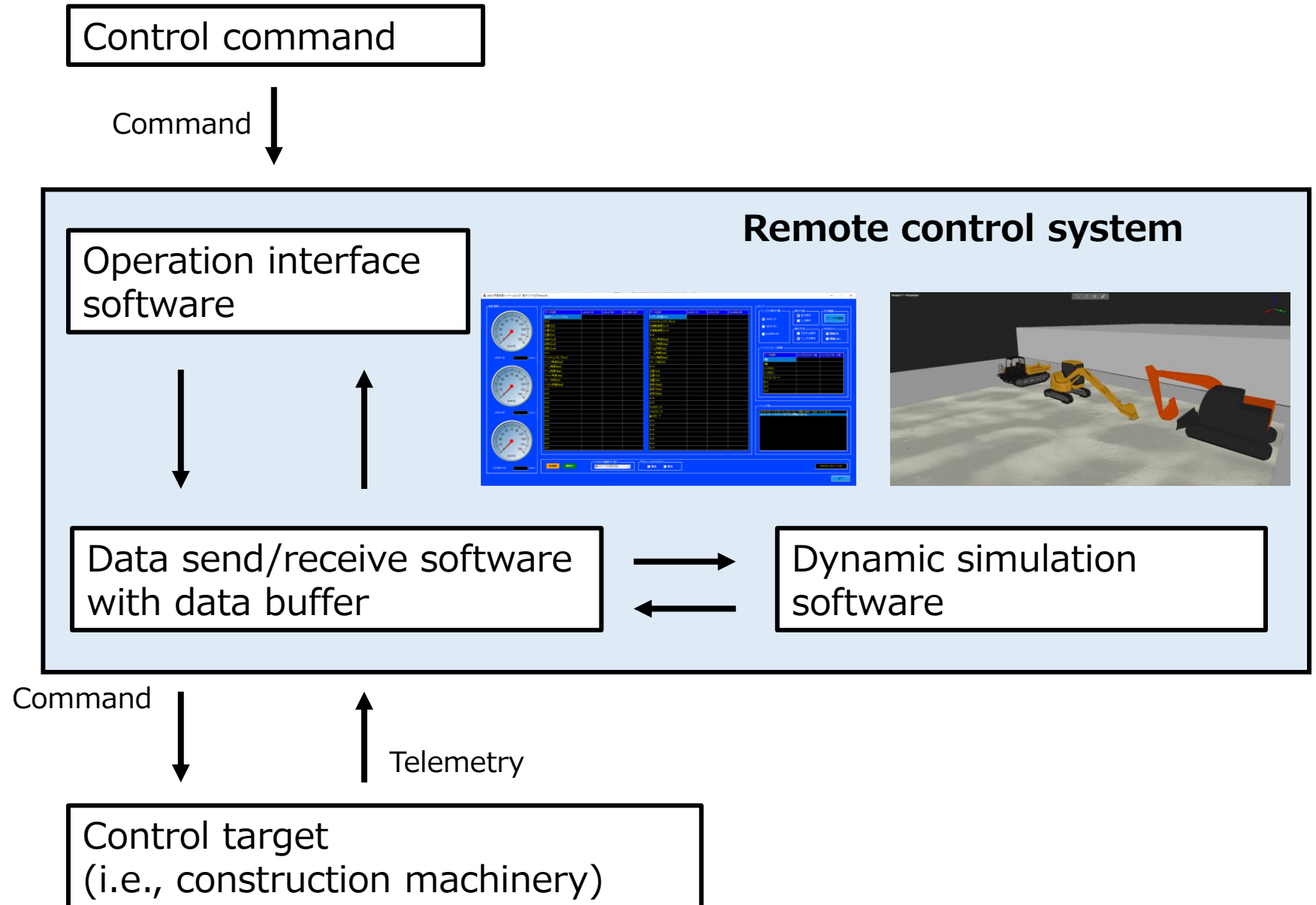
Operation console
@ JAXA Sagamihara Campus



Construction machinery
@ Kajima Seisho Test and Practice Field

Construction machineries are remotely controlled via commands developed at an operation console located dozens of km away from the machineries.

Remote control system architecture



Operation console

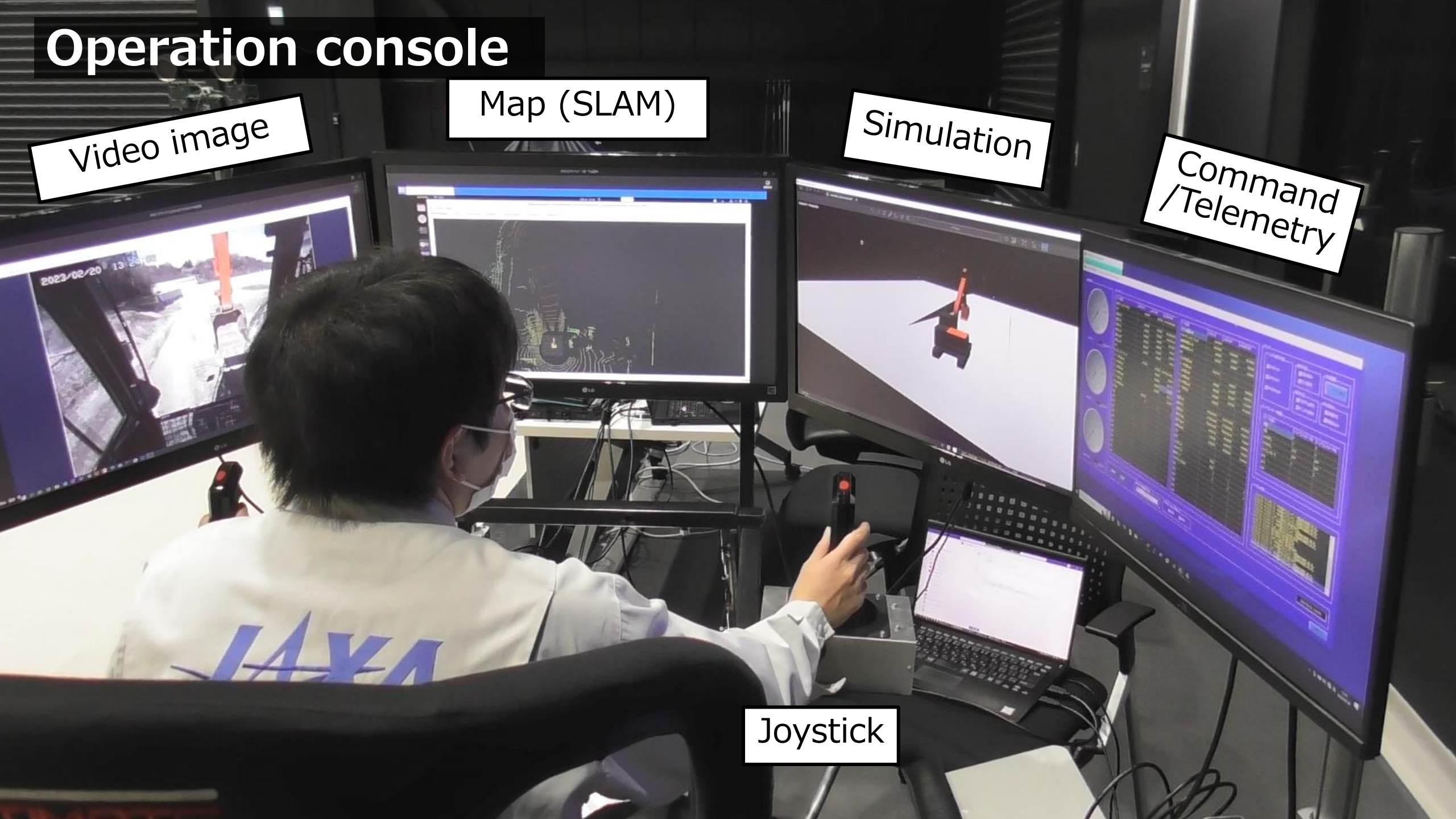
Map (SLAM)

Video image

Simulation

Command
/Telemetry

Joystick



Construction machinery

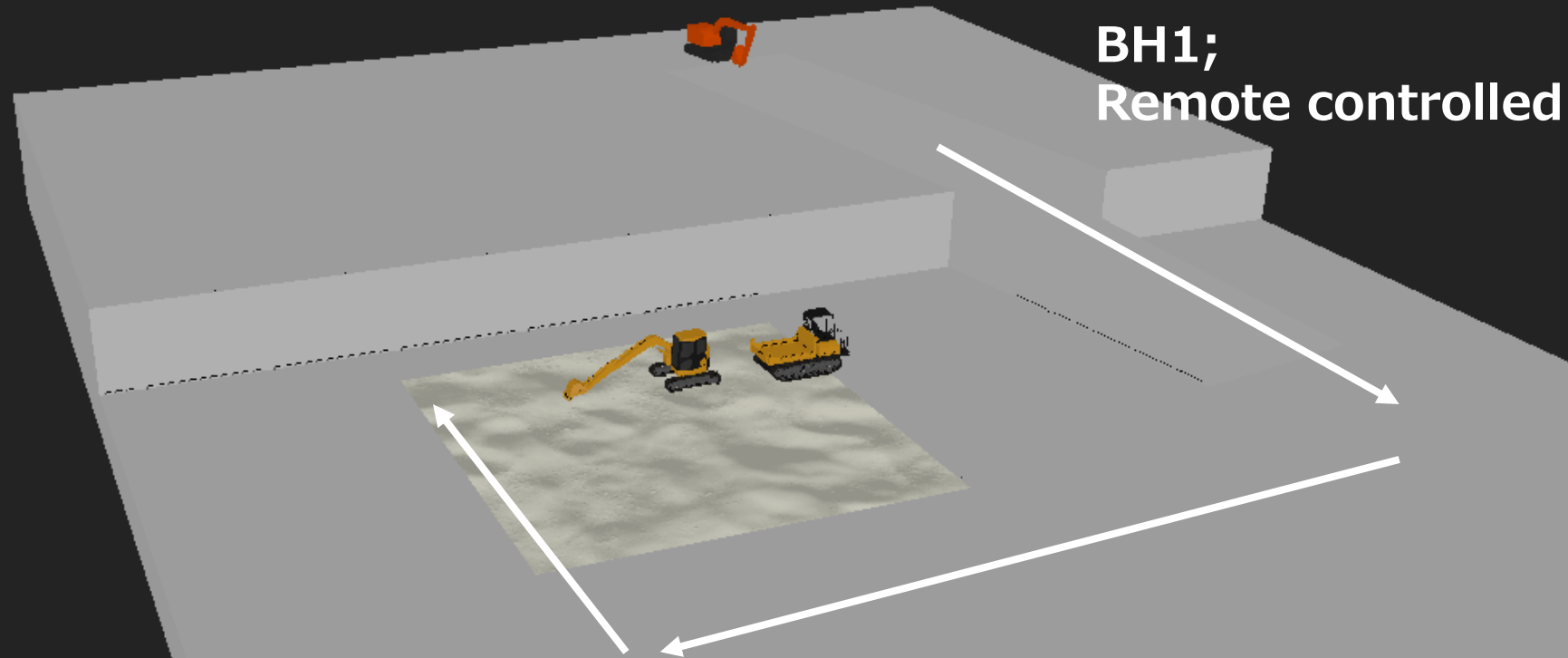
Hydraulic backhoes and crawler carrier modified for remote control via electronic signals

**Crawler carrier
(CC)**

**Backhoe 1
(BH1)**

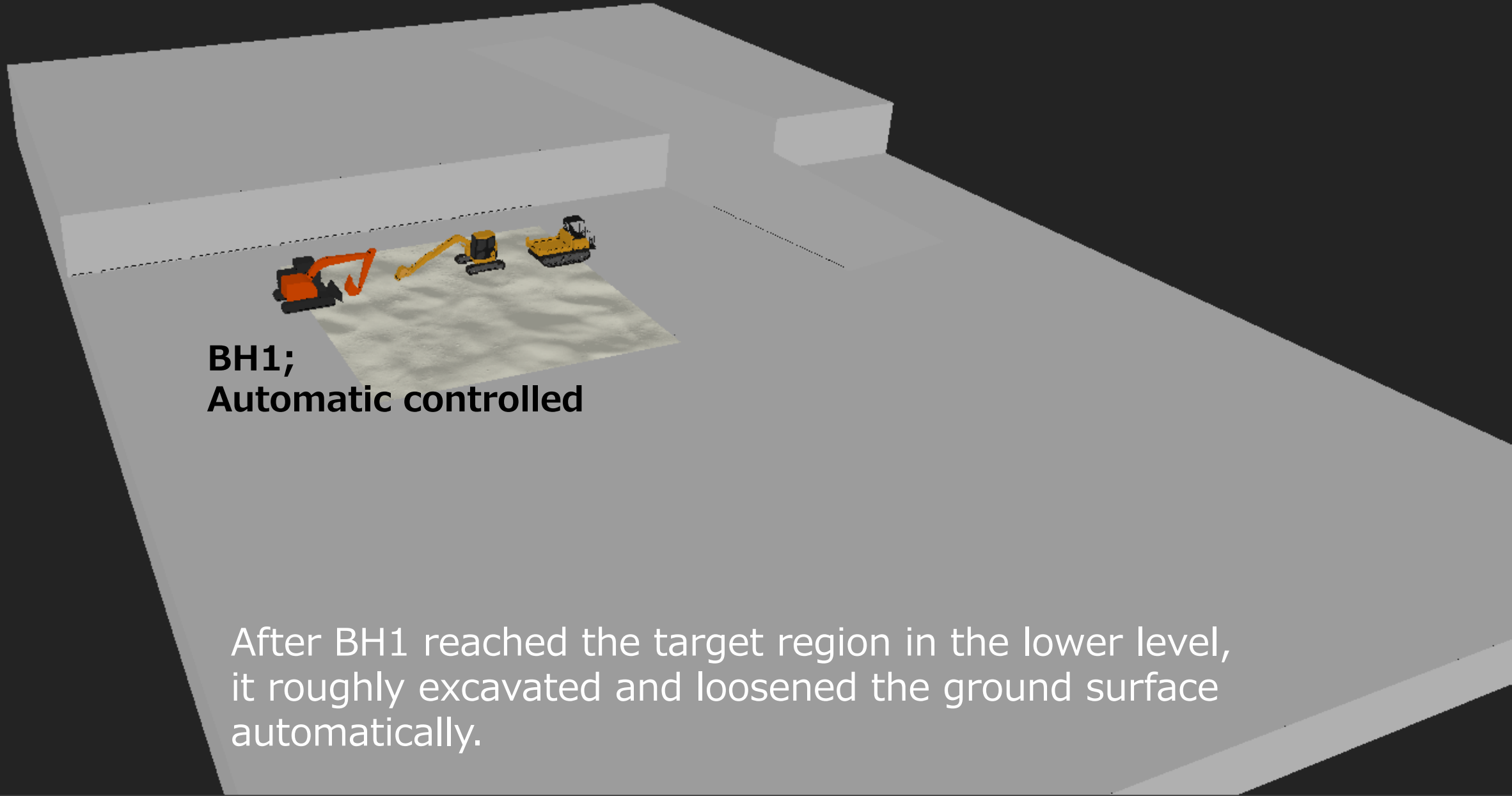
**Backhoe 2
(BH2)**

Overview of the experiment



BH1 is remotely controlled and moved from the upper to the lower level through a slope connecting the levels.

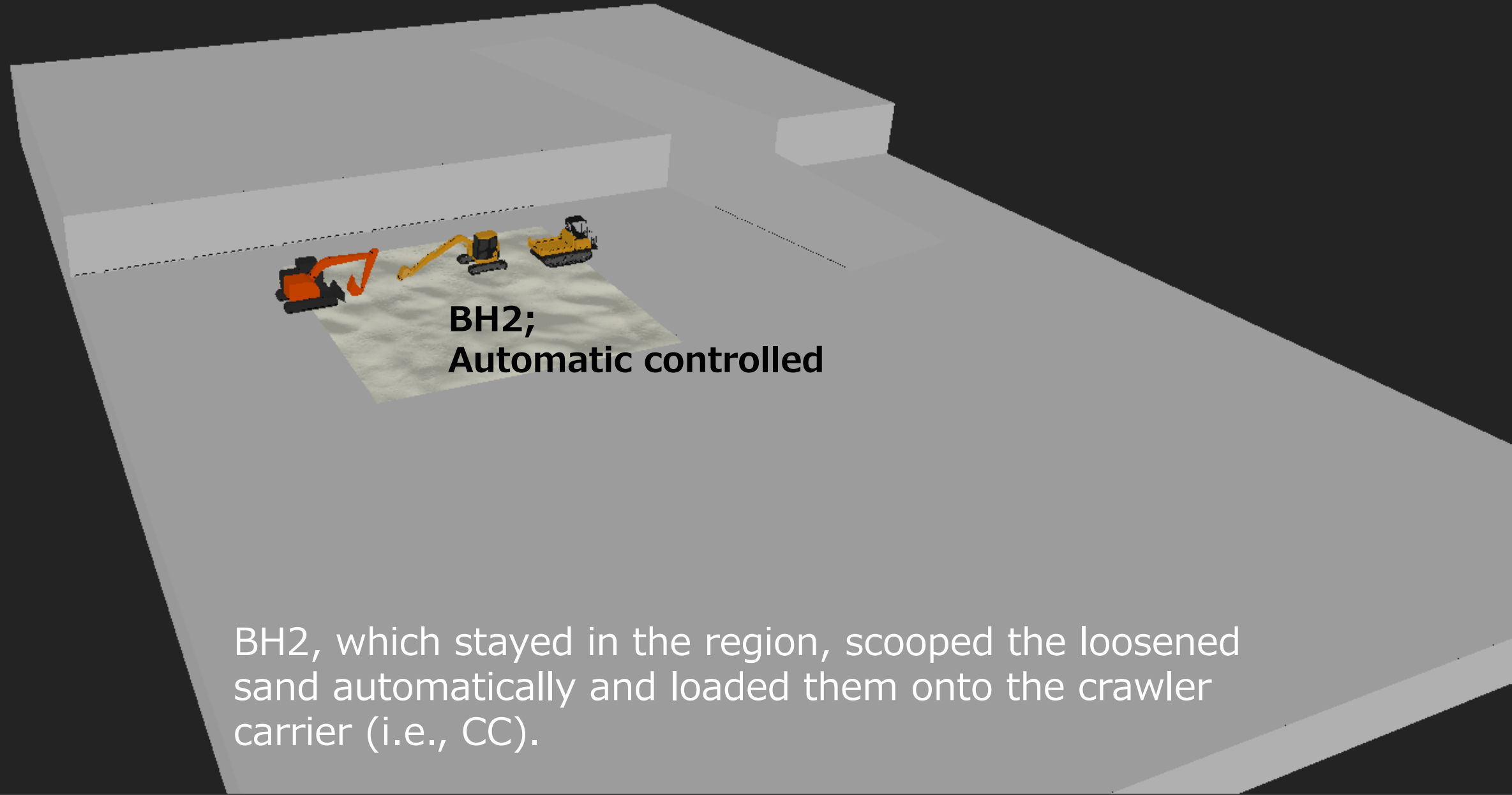
Overview of the experiment



**BH1;
Automatic controlled**

After BH1 reached the target region in the lower level, it roughly excavated and loosened the ground surface automatically.

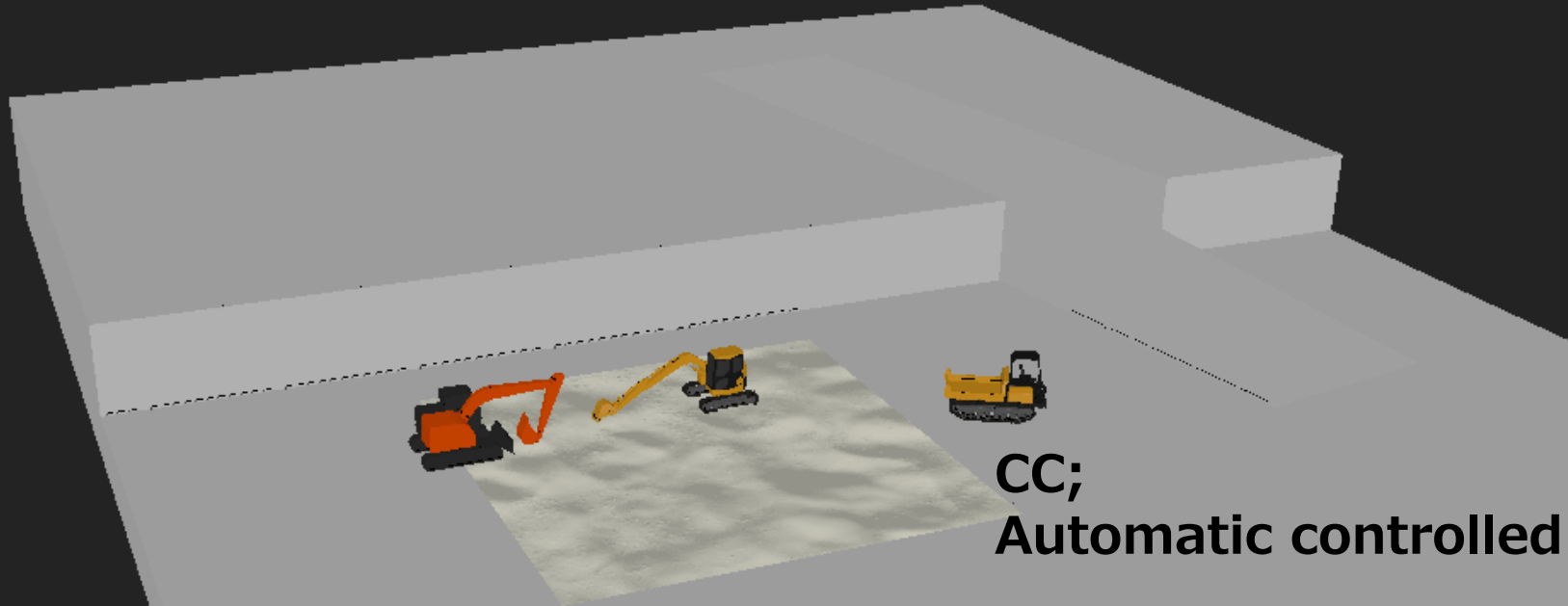
Overview of the experiment



**BH2;
Automatic controlled**

BH2, which stayed in the region, scooped the loosened sand automatically and loaded them onto the crawler carrier (i.e., CC).

Overview of the experiment



The CC transported this sand from the lower level to the upper level.

Overview of the experiment



**BH1, BH2, and CC;
Automatic controlled**

This construction sequences was repeated many times via automatic operation.

Summary

- ✓ We performed demonstration experiments for a water resource utilization scenario on the Moon and confirmed the effectiveness of a remote and automatic control system for construction machinery.
- ✓ The demonstration experiment also confirmed the feasibility of the water utilization scenario by effectively using remote and automatic control technology for the construction machinery.

Future work

- ✓ The effectiveness of the remote control system will be improved by real-time updating the machine/terrain model in the dynamic simulation based on the information obtained in experiments.