An overview of JAXA R&D in Regenerative life support system

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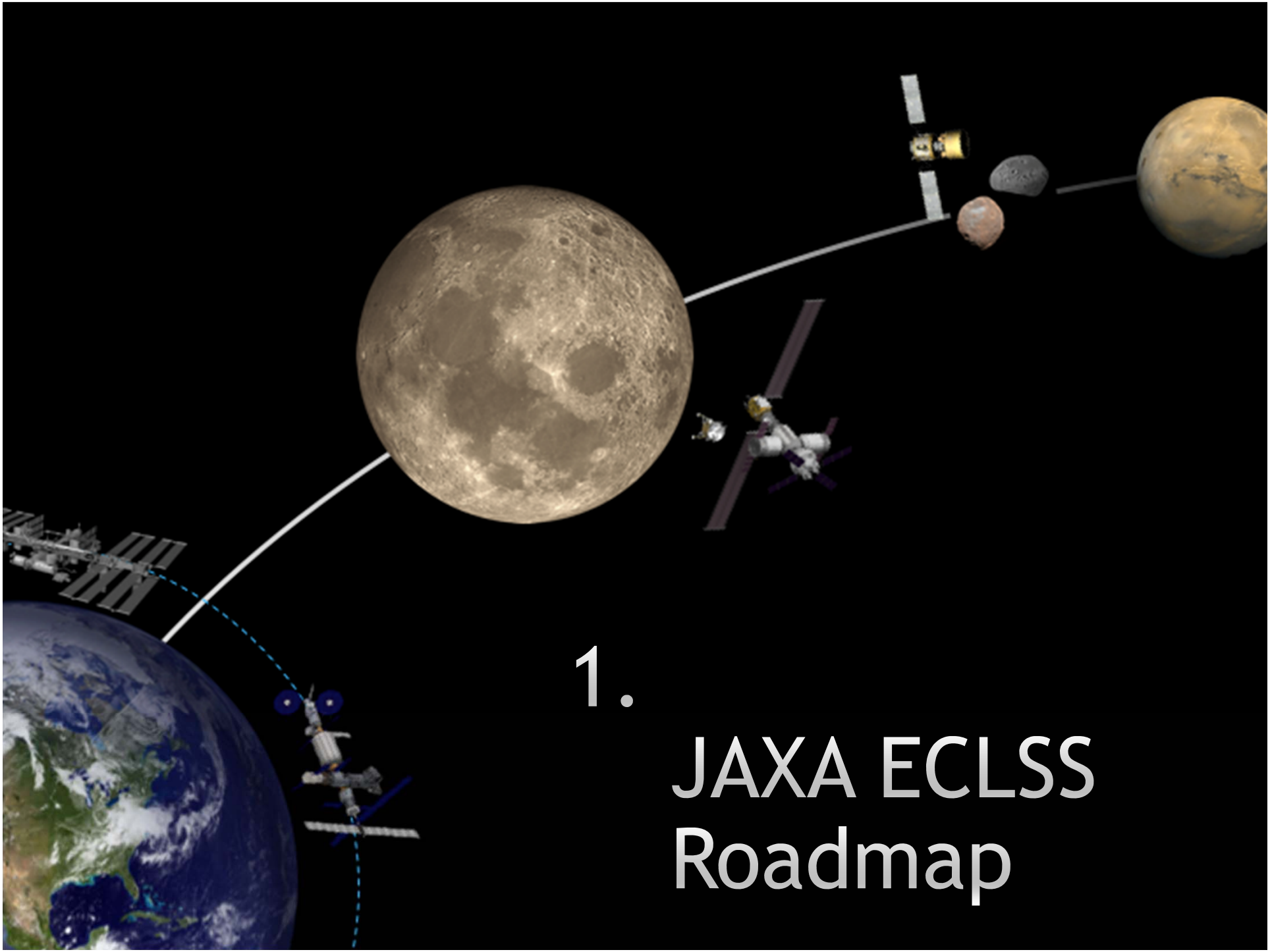
Outline

1. JAXA ECLSS Roadmap
2. Development Status of JAXA's ECLSS
3. Demonstration Platform in "Kibo" for Agro-space



1. JAXA ECLSS Roadmap

ISS

- *Psysicochemical ECLSS*
  - ✓ On orbit Demonstration (each process technology)
- *Biological Use*
  - ✓ On orbit Demonstration (plant hydroponics, Algae cultivation, etc.)

Plant cultivation in space

2018

Deep Space Gateway

- ✓ Partial Closed ECLSS

Post ISS platform

- ✓ Full Closed ECLSS
- ✓ Demonstration of food production and material circulation

Algae incubator

Water tillage

2024

Lunar Surface

- *Agro-space supported ECLSS*
  - ✓ Psysicochemical + Agrospace (plant cultivation using lunar soil, air revitalization, water purification, waste treatment)

Deep Space Transport

- ✓ ECLSS for transport vehicle (highly reliable, compact)

2028

Mars Surface

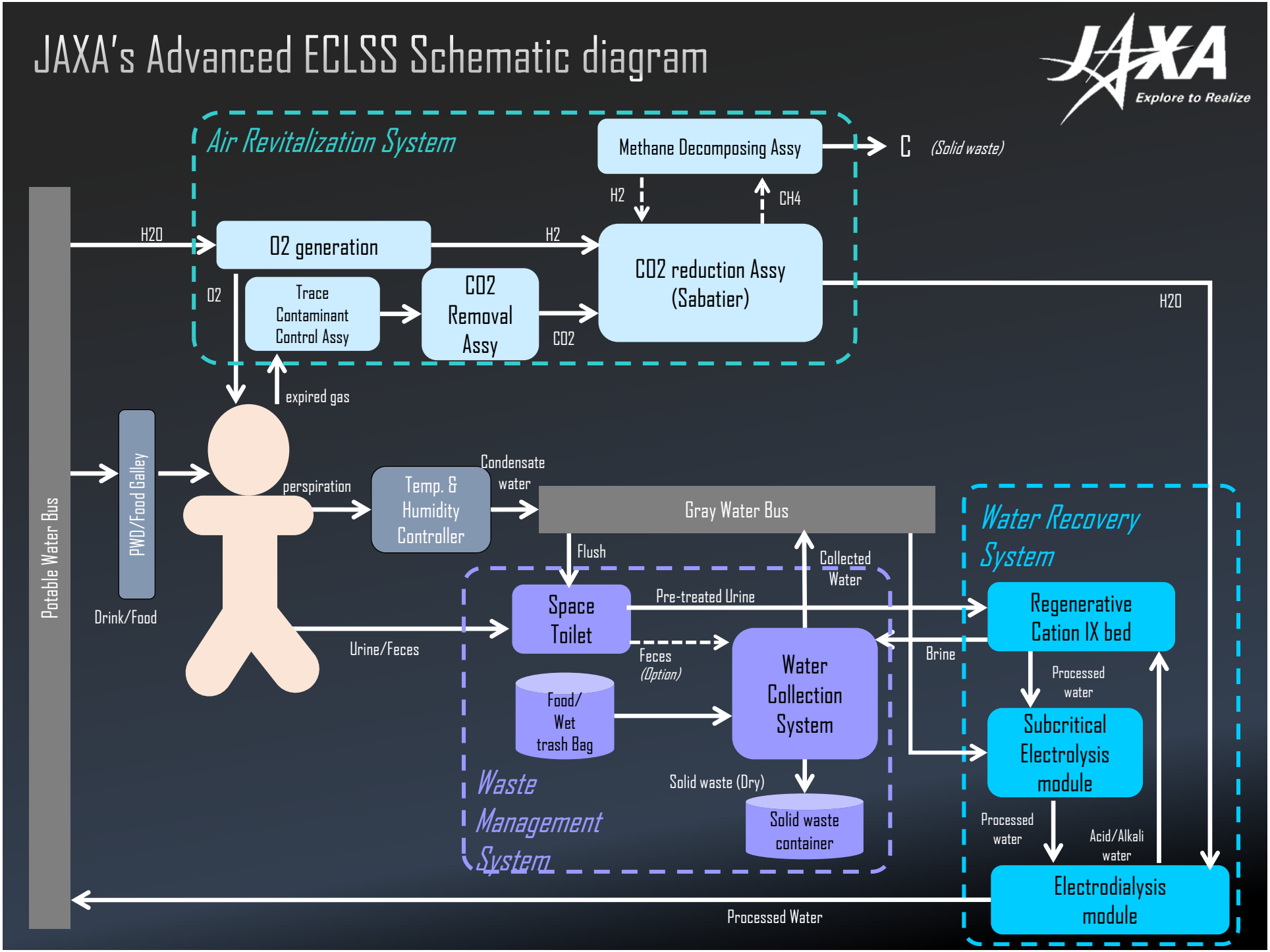
- ✓ ECLSS For Mars environment

Plant cultivation on lunar surface

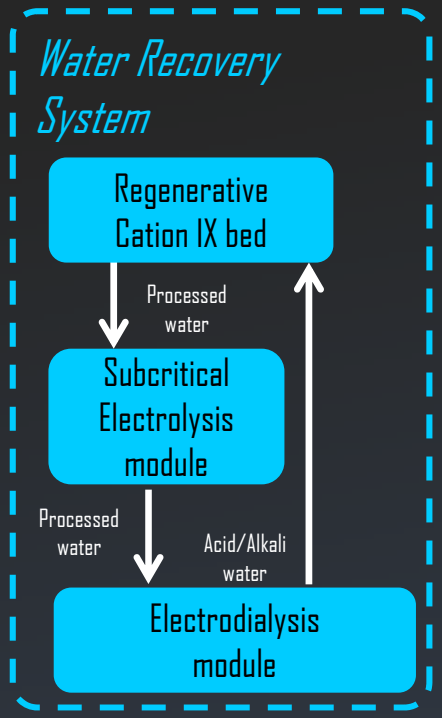
2030s~

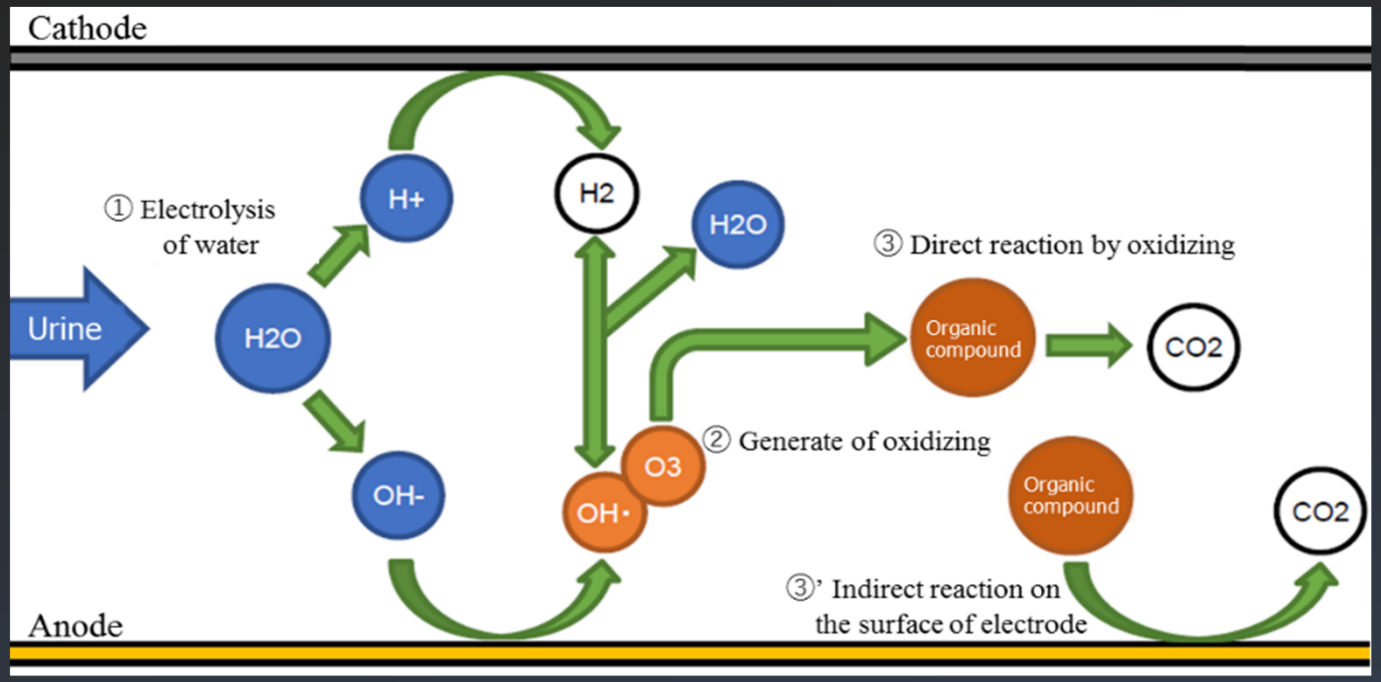
2. Development Status of JAXA's ECLSS

JAXA's Advanced ECLSS Schematic diagram

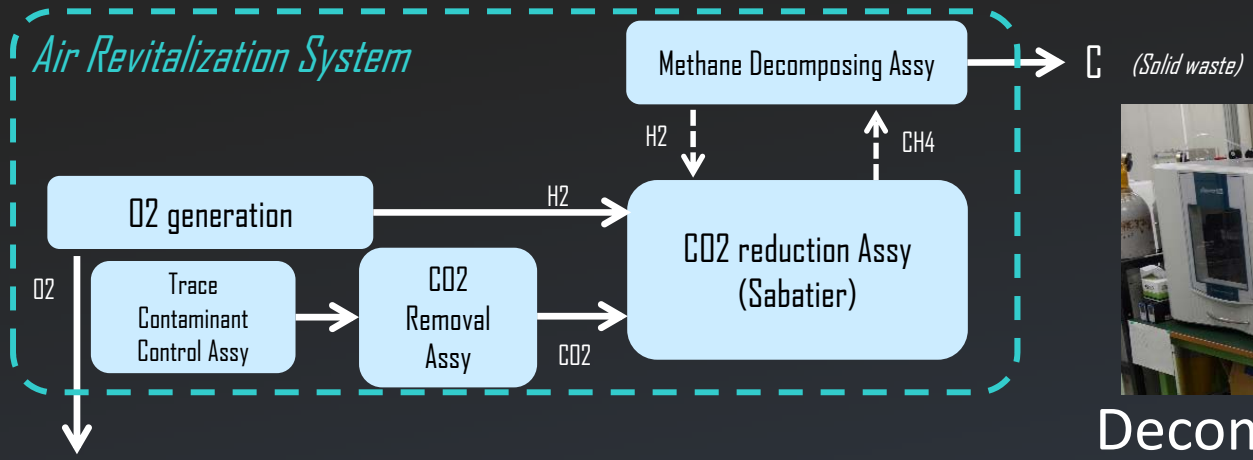


Water recovery system



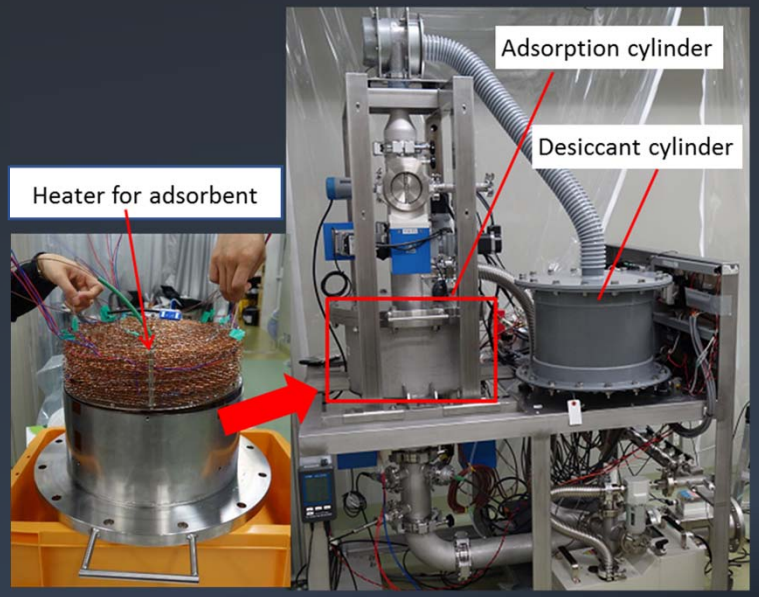


Air revitalization system

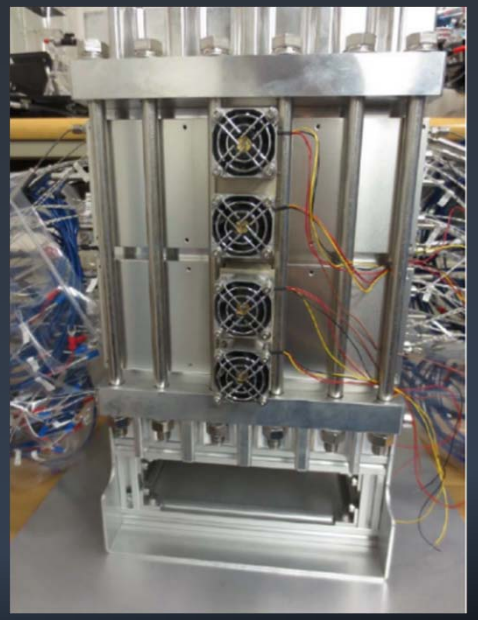


Decomposition by microwave

water electrolysis

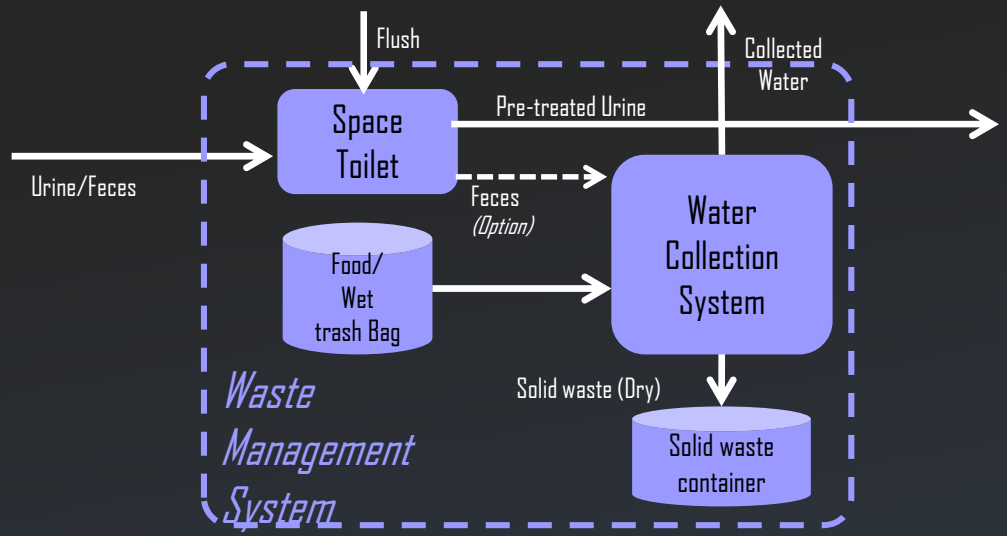


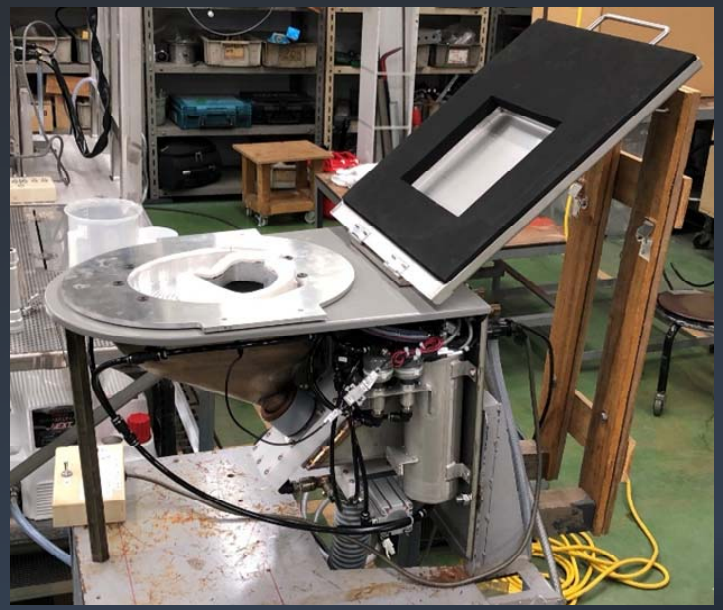
Adsorption & desorption



Reduction by catalysts

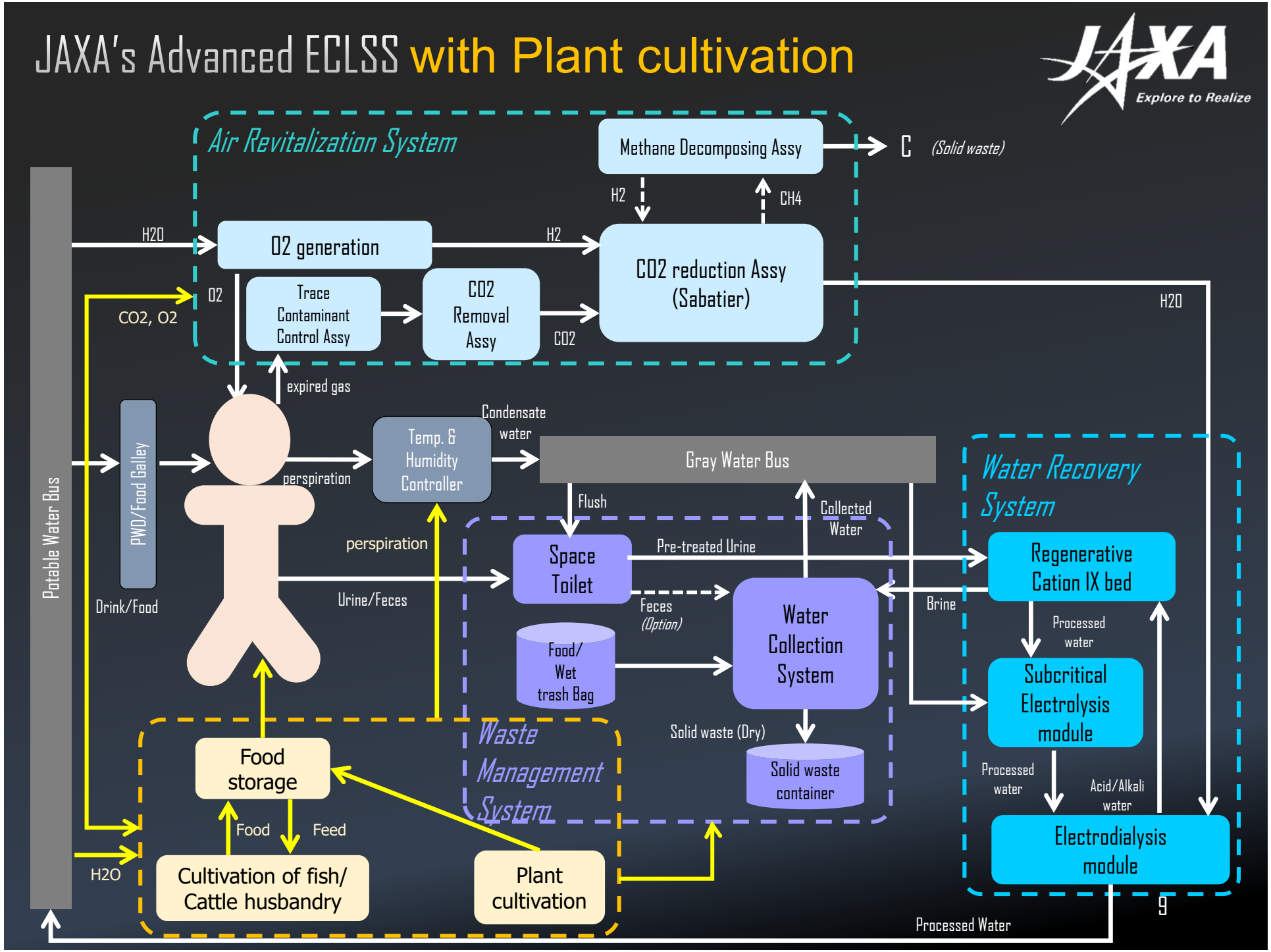
Waste management system



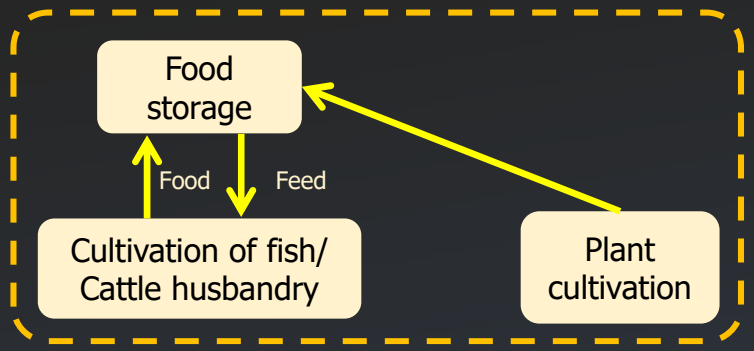


Vaccum toilet

Freeze-dry
(freeze&sublimation)

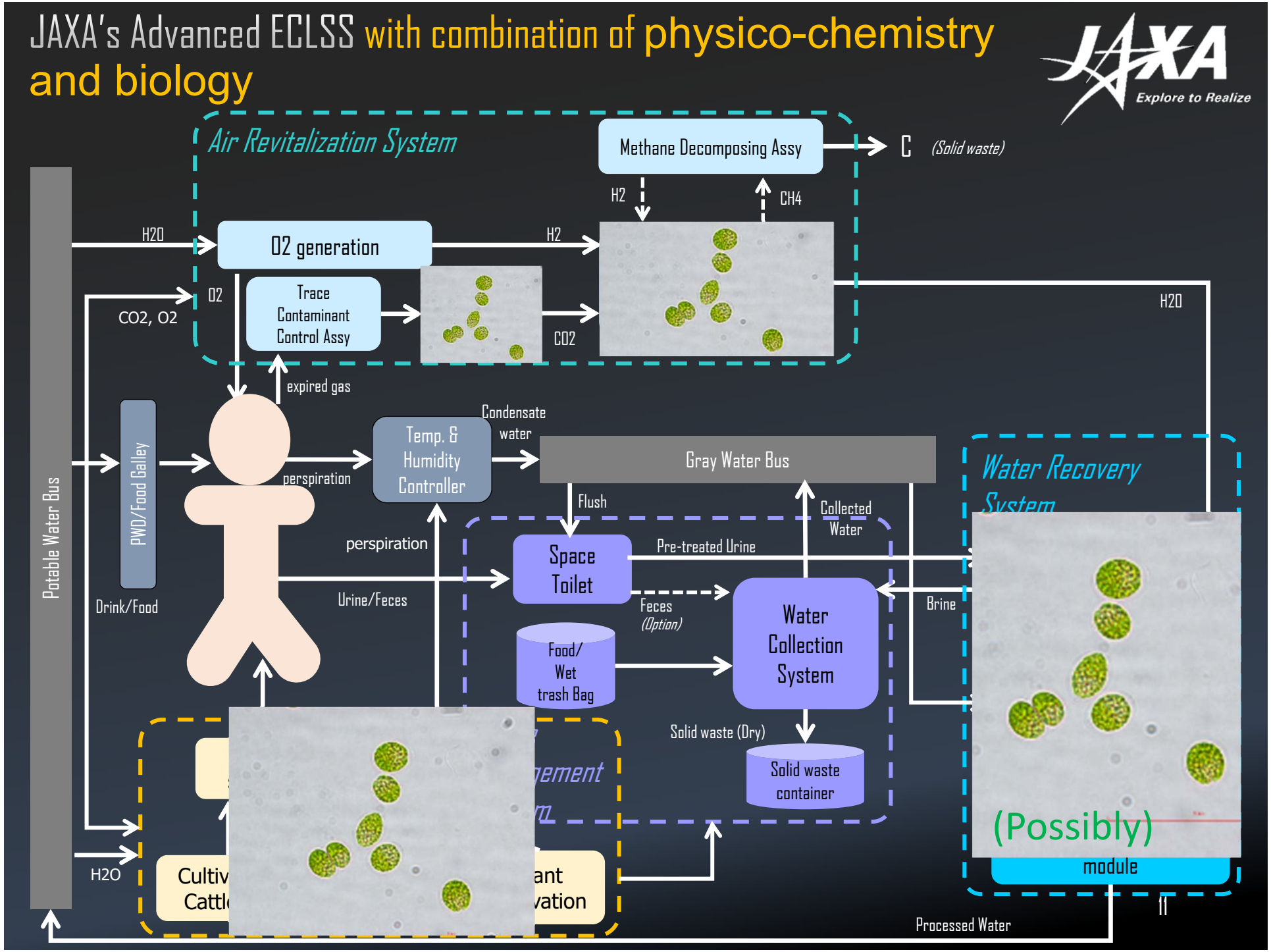

JAXA's Advanced ECLSS with Plant cultivation
JAXA
Explore to Realize
Air Revitalization System
Methane Decomposing Assy
C
(Solid waste)
H2
CH4
H2O
O2 generation
H2
CO2 reduction Assy
(Sabatier)
O2
Trace
Contaminant
Control Assy
CO2
Removal
Assy
CO2
H2O
CO2, O2
expired gas
Potable Water Bus
PWD/Food Galley
Drink/Food
perspiration
Temp. &
Humidity
Controller
Condensate
water
Gray Water Bus
Flush
perspiration
Urine/Feces
Space
Toilet
Pre-treated Urine
Collected
Water
Feces
(Option)
Water
Collection
System
Brine
Food/
Wet
trash Bag
Solid waste (Dry)
Solid waste
container
Waste
Management
System
Water Recovery
System
Regenerative
Cation IX bed
Processed
water
Subcritical
Electrolysis
module
Processed
water
Acid/Alkali
water
Electrodialysis
module
Food
storage
Food
Feed
H2O
Cultivation of fish/
Cattle husbandry
Plant
cultivation
Processed Water
9

JAXA's Advanced ECLSS with Plant cultivation

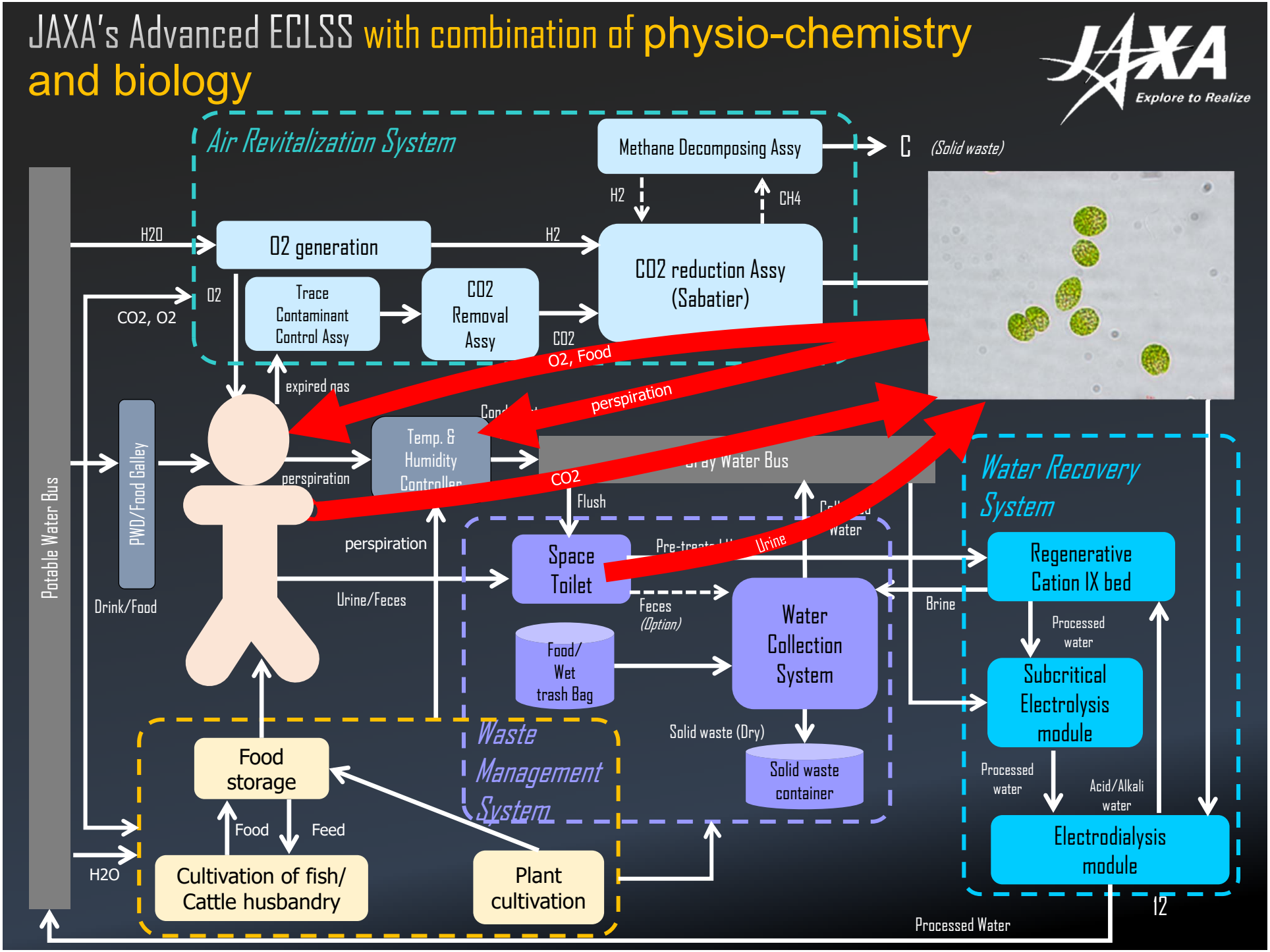


Strawberry, tomato, lettuce, potato
uG condition or lunar surface

JAXA's Advanced ECLSS with combination of physico-chemistry and biology



JAXA's Advanced ECLSS with combination of physio-chemistry and biology



Study Results about bioregenerative ECLSS using Chlamydomonas so far...

Preliminary experiments shows;

- Chlamydomonas may be able to propagate in urine medium. (without pretreatment of nitrification)
- Consumption of CO2 by Chlamydomonas in 500 mL incubator was confirmed at 3000 ppm CO2.
- Selecting specific light spectrum and using pulse light will optimize power efficiency.
- Chlamydomonas contains some carbohydrate and protein.

Summary

We have been developing physio-chemical ECLSS and trying to develop bioregenerative ECLSS for future ECLSS with combination of them.

The challenge before us is …

- Power
- Mass
- Controllability
- Stability

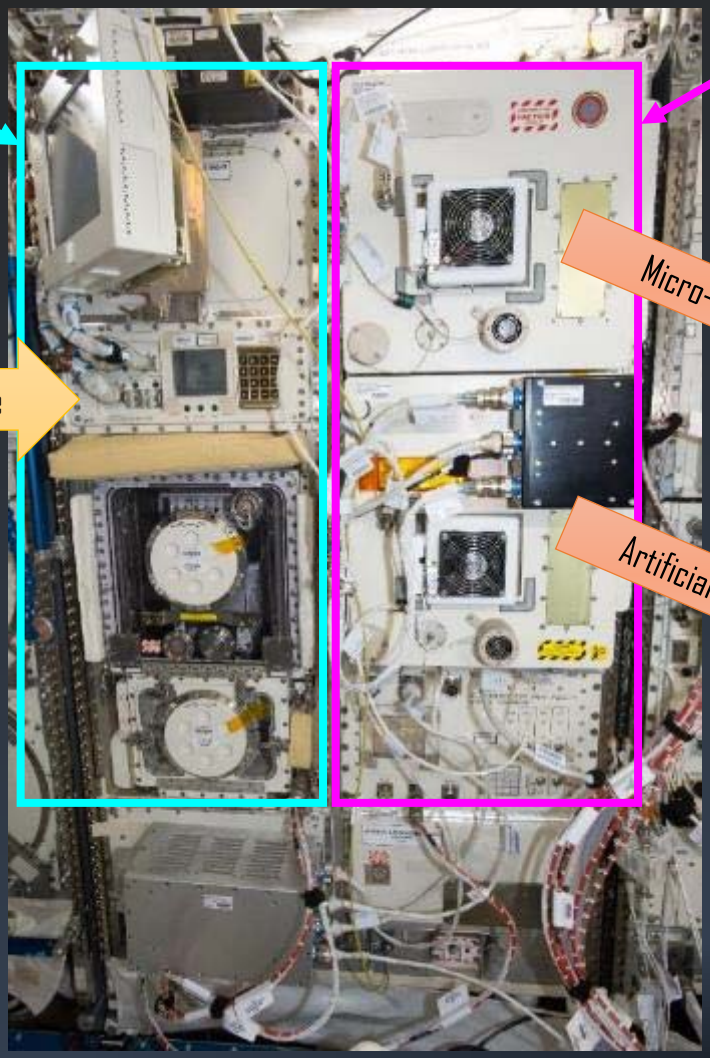
3. Demonstration Platform in “Kibo” for Agro-space

Cell Biology Experiment Facility - Left (CBEF-L)

Clean Bench

Cell Biology Experiment Facility (CBEF)

substitute

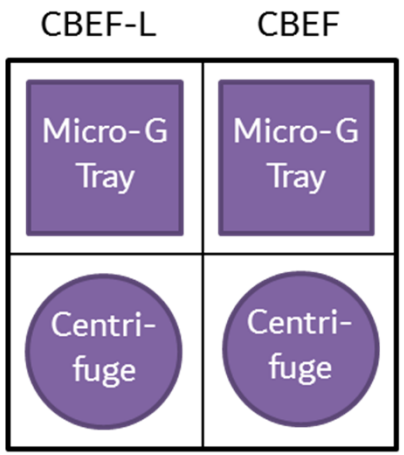
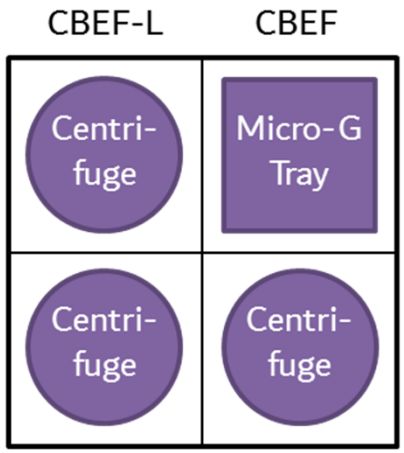
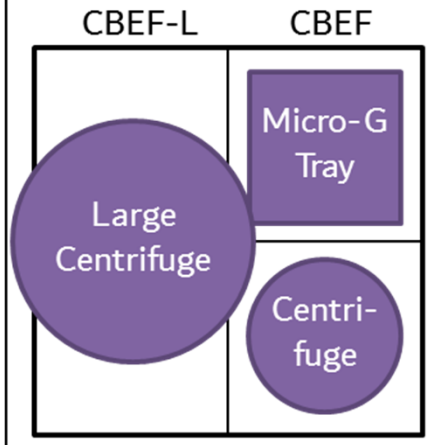


Micro-G

Artificial-G

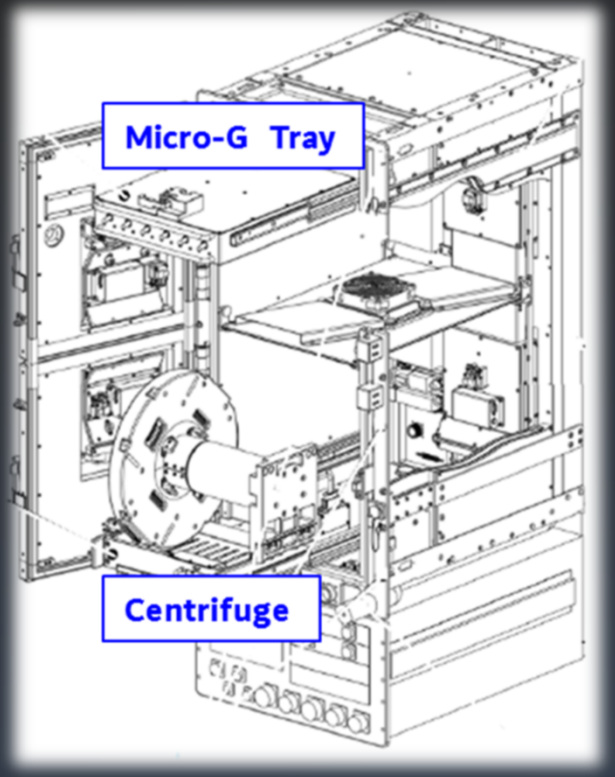
CBEF-L

CBEF-L Operation Configurations

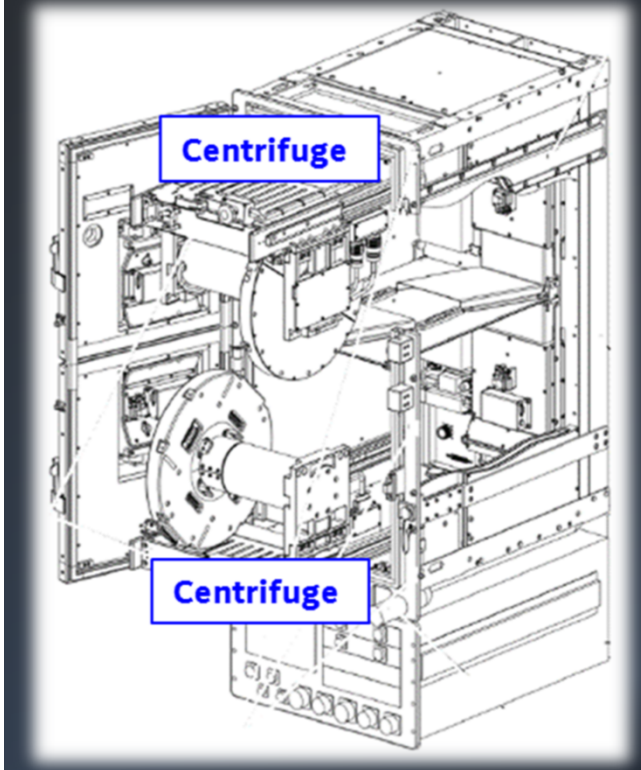
	Configuration 1	Configuration 2	Configuration 3
Incubator Configuration			
Experiment Opportunity	CBEF and CBEF-L have the same number of samples on micro-G trays and regular centrifuges. It doubles the sample number.	3 different artificial-G environments (0.1 - 2G) and 1 micro-G environment.	Artificial-G environment on the large centrifuge in CBEF-L, and micro-G environment on both the micro-G tray and the regular centrifuge without rotation in CBEF.

CBEF-L Operation Configurations

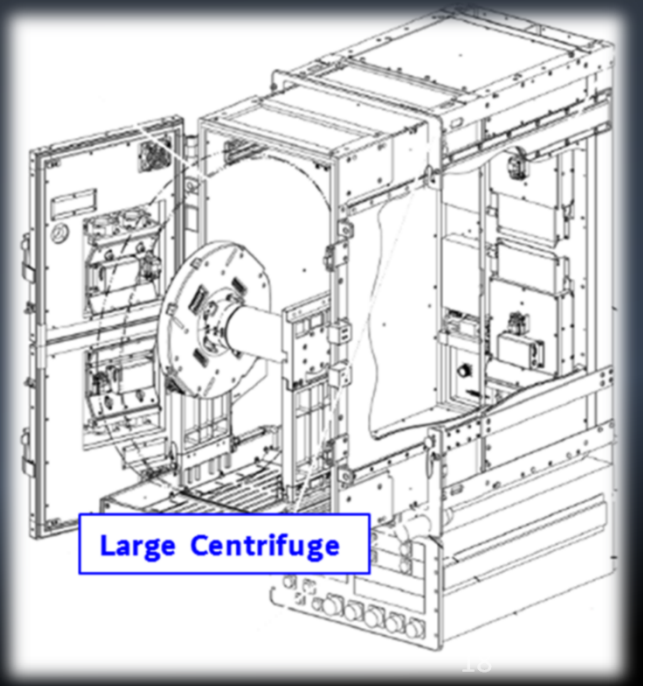
Configuration 1



Configuration 2

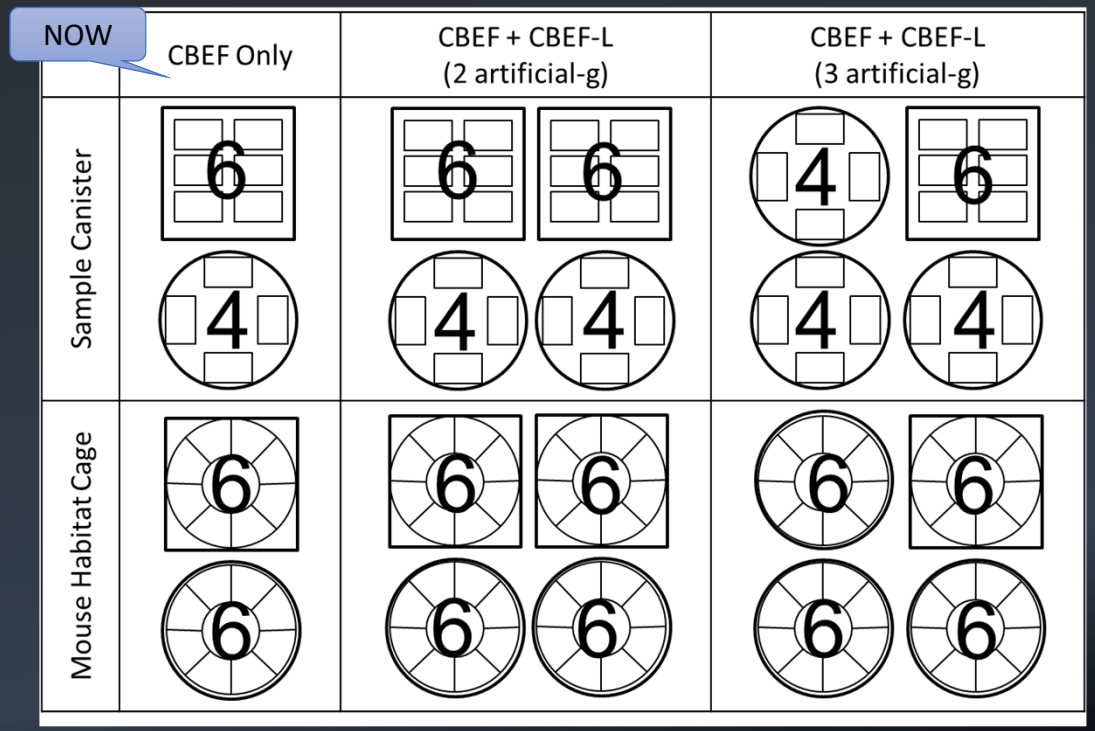


Configuration 3



CBEF-L Concept 1. Increasing Sample Number

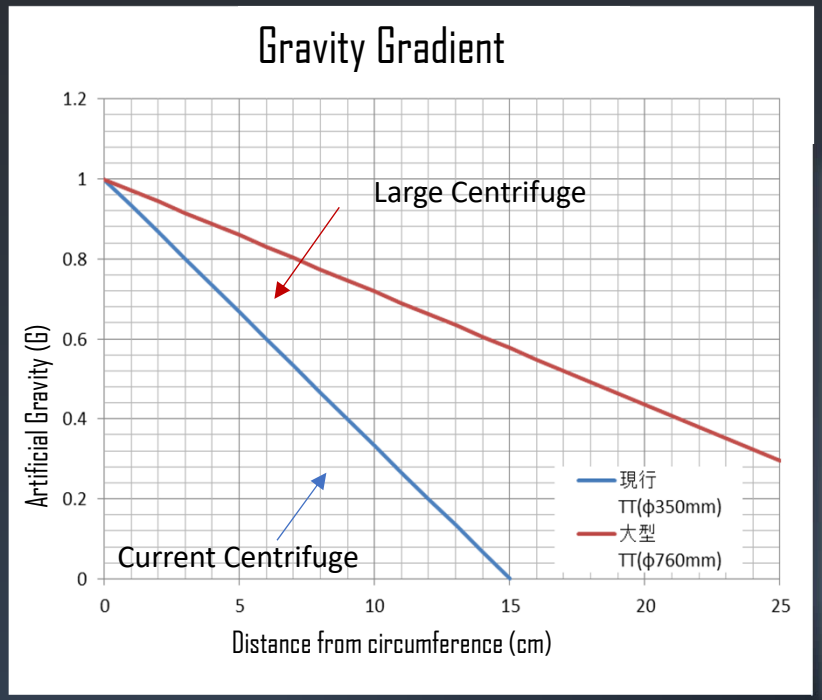
CBEF-L can accommodate the same number of sample canisters or mouse cages as the current CBEF having the same micro-g and artificial-g sections. Moreover, micro-g section of CBEF-L can be replaced with the second artificial-g section. The advantage of having two artificial-g sections is that it can create 4 different gravity levels (including micro-g) at the same time.

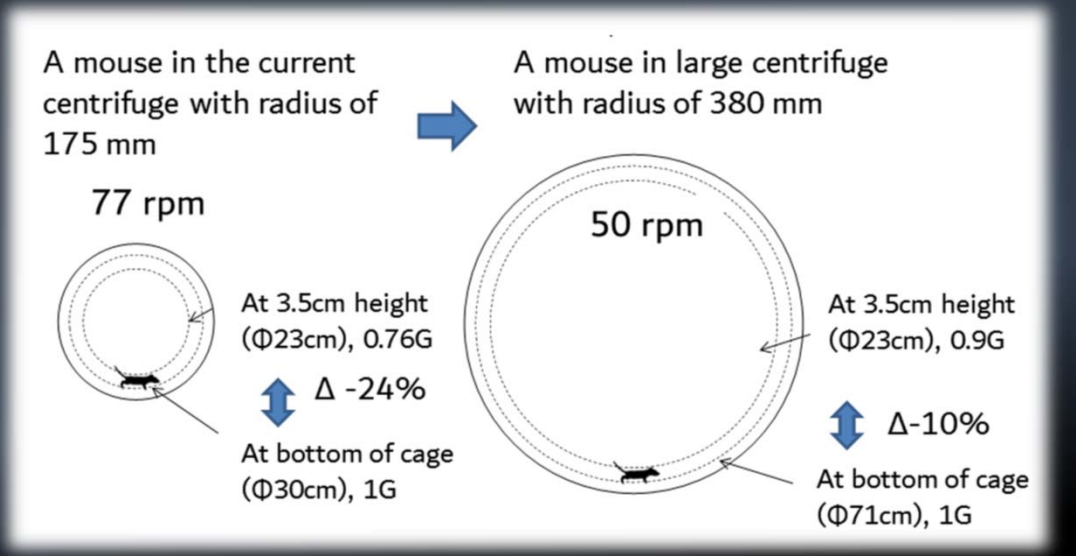


CBEF-L Concept 2. Mitigation of Gravity Gradient

In case of mice, the current centrifuge with R175 mm occurs 24% difference in gravity gradient between bottom (feet) and top (head) of a mouse. By increasing the size of centrifuge to R380 mm, the difference reduces to 10%.

- Current Centrifuge (Φ350mm/R175mm): 1G@bottom, 0.76G@top (Δ-24%)
- Large Centrifuge (Φ760mm/R380mm): 1G@bottom, 0.90G@top (Δ-10%)

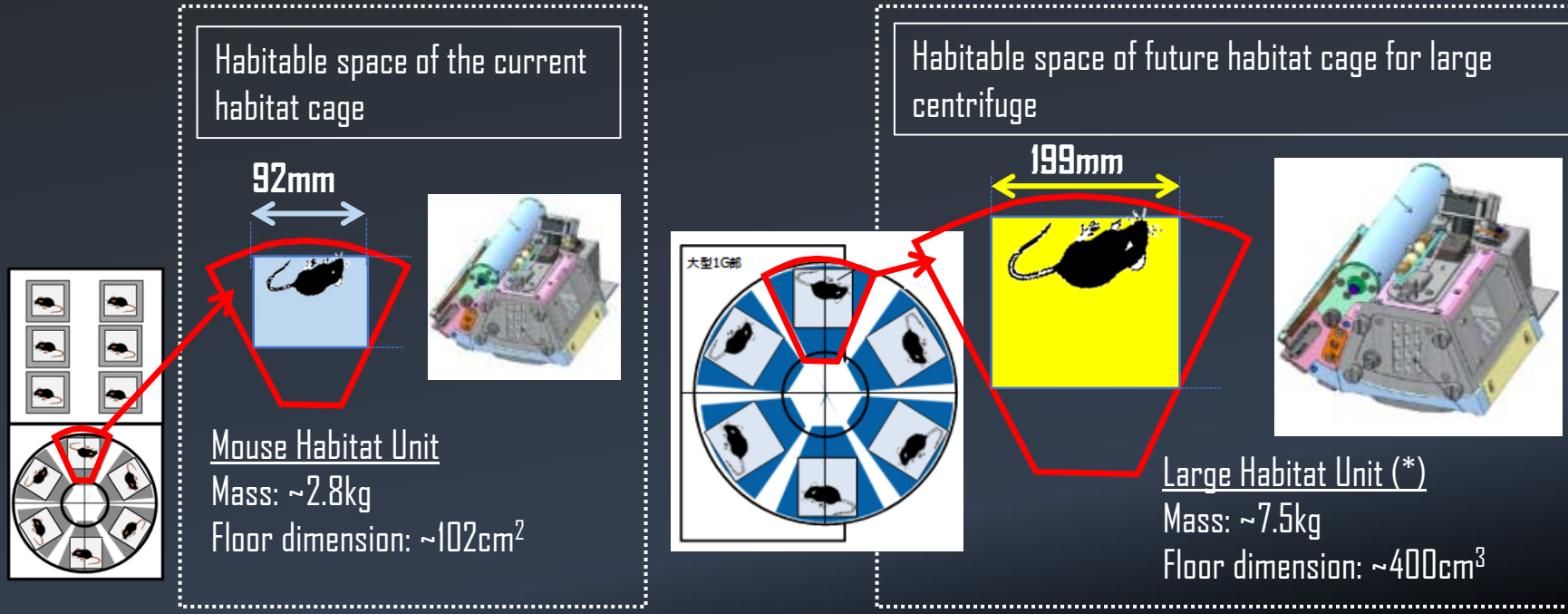




CBEF-L Concept 3. Increasing Installation Area

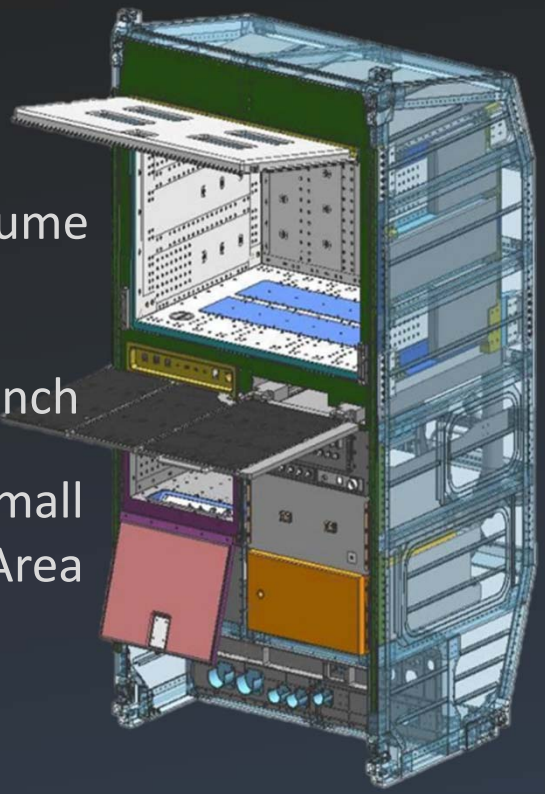
For example, habitat cage for a rat requires more than 387cm^2 of floor dimension. The enlarged centrifuge can house 6 habitat cages with floor dimension of approximately 400cm^2.

- Current Centrifuge (Φ350mm/R175mm): floor dimension ~102cm^2
- Large Centrifuge (Φ760mm/R380mm): floor dimension ~400cm^2



(*) Not exist yet. Assuming upscaled current cage.

Multi-purpose Small Payload Rack (MSPR)



MSPR

MSPR2

Resorce	MSPR	MSPR2
Gas	N2	N2, Ar, CO2
Water and cooling water	MTL (16~23°C)	
Other	Video	

Freezer-Refrigerator Of STirling cycle (FROST)

FROST

-35°C or +3°C

FROST2

-100 °C to +60°C

Summary

- CBEF-L can be used to test under the gravity condition of the moon and Mars.
- MSPR can be used to test using gases, water and video.
- FROST can be used to create the environment of constant temperature.