JEM Internal Ball Camera (Int-Ball)

Feb 28, 2018

Japan Aerospace Exploration Agency

Objective of Project

- Currently, when working in the Japanese Experiment Module ("Kibo"), the crew (astronaut) often takes photos with existing wall-mounted cameras having many blind spots at low resolution. Sometimes the crew also uses handheld cameras to monitor conditions in detail (video and photos).

- The crew spends about 10% of their current working hours to prepare cameras and engage in photographing operations.

- To reduce the time required for shooting videos/photos, JAXA has developed the JEM Internal Ball Camera ("Int-Ball") that moves autonomously to the desired spatial position and shoots videos/photos of the subject, ultimately aiming to realize *zero photographing time by the crew*.

- The objective of this project is to contribute to maximizing the outcome of "Kibo" utilization experiments through productive use of the limited time in space by effectively conducting space experiments, which have become increasingly sophisticated and complicated, under cooperation between on the ground and in space.

- JAXA will strive to further improve next-generation Int-Ball performance, enhance its functions, and promote the automation and autonomy of intra- and extra-vehicular experiments, while seeking to acquire robotics technology available for future exploration missions.

Development status (as of February 2018)

- June 2016: Initiated the Int-Ball project.
- March 2017: Completed development and handover to SpaceX.
- June 4, 2017: Launched onboard the US Dragon spacecraft by the SpaceX Falcon 9 rocket.
- June 9, 2017: Unpacked at “Kibo” on the ISS, with initial checkout being started.
- Current: Finish initial checkout of the Phase1(next page).
  Next generation(next page) is under considering.

Verification process

Current phase

Phase 1

Flight verification

- Aiming to conduct on-orbit verification at the earliest opportunity by adopting existing drone technology
- Performance includes wireless shooting, hovering, and minimum movement.
- Assessing applicability to onboard flight data and practical operation, and reflecting the assessment in the next phase.

Phase 2

Autonomous control

- Manufacturing a drone capable of autonomous flight without maintenance, based on knowledge obtained in Phase #1.
- Aiming to realize *zero* photographing time by the crew.

Phase 3

Extended operations

- Enhancing functions to a range including the management of inventory and inspection of accident sites in an emergency instead of by the crew, and preliminary verification for replacement by extravehicular activity (EVA).

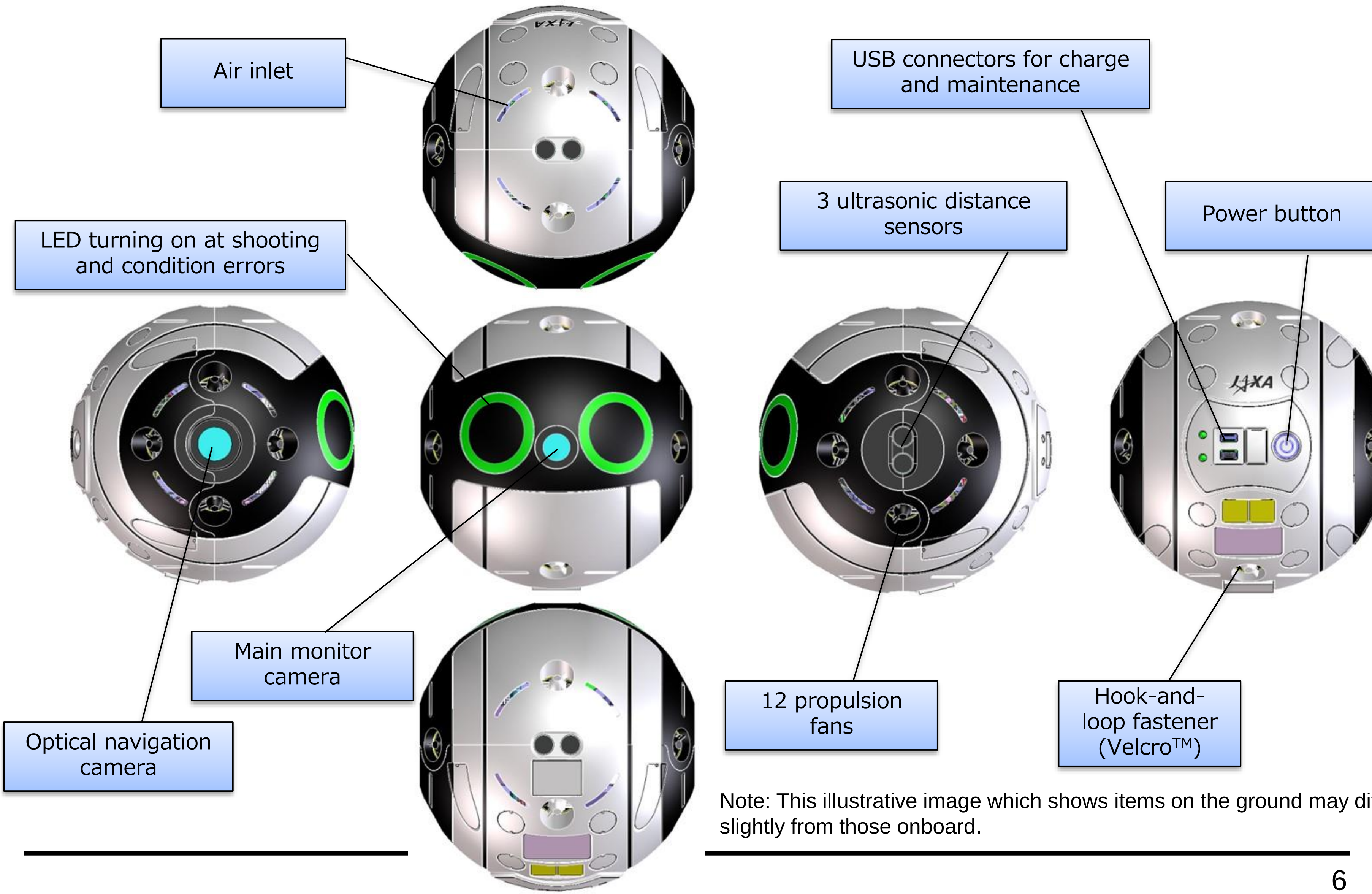
Next Generation

The Int-Ball specifications

Principal specifications

Item	Specification	Item	Specification
Photographing	Photo / Video (no audio)	Position control	Micro fans (Axial flow type)
Communication	Wireless transmission (Wireless LAN)	Attitude control	Reaction wheels / Micro fans
Resolution	HD, 720 pixels: 1280 x 720 pixels FHD, 1080 pixels: 1920 x 1080 pixels	Self-localization	Image recognition using 3D marker
Frame rate	10 - 30 fps	Dimension	150 mm in diameter
Bit rate	16 kbps – 40 Mbps	Weight	1 kg (not including cables and 3D marker)
Image stability	Bandwidth: Pan: 1 Hz or less Tilt and Roll: 0.3 Hz or less Attitude stability: ±1 deg/s or less	Battery Life	Approx. 2 hours (Rechargeable via USB connector)

Int-Ball external appearance



Note: This illustrative image which shows items on the ground may differ slightly from those onboard.

Sensor direction and field of view

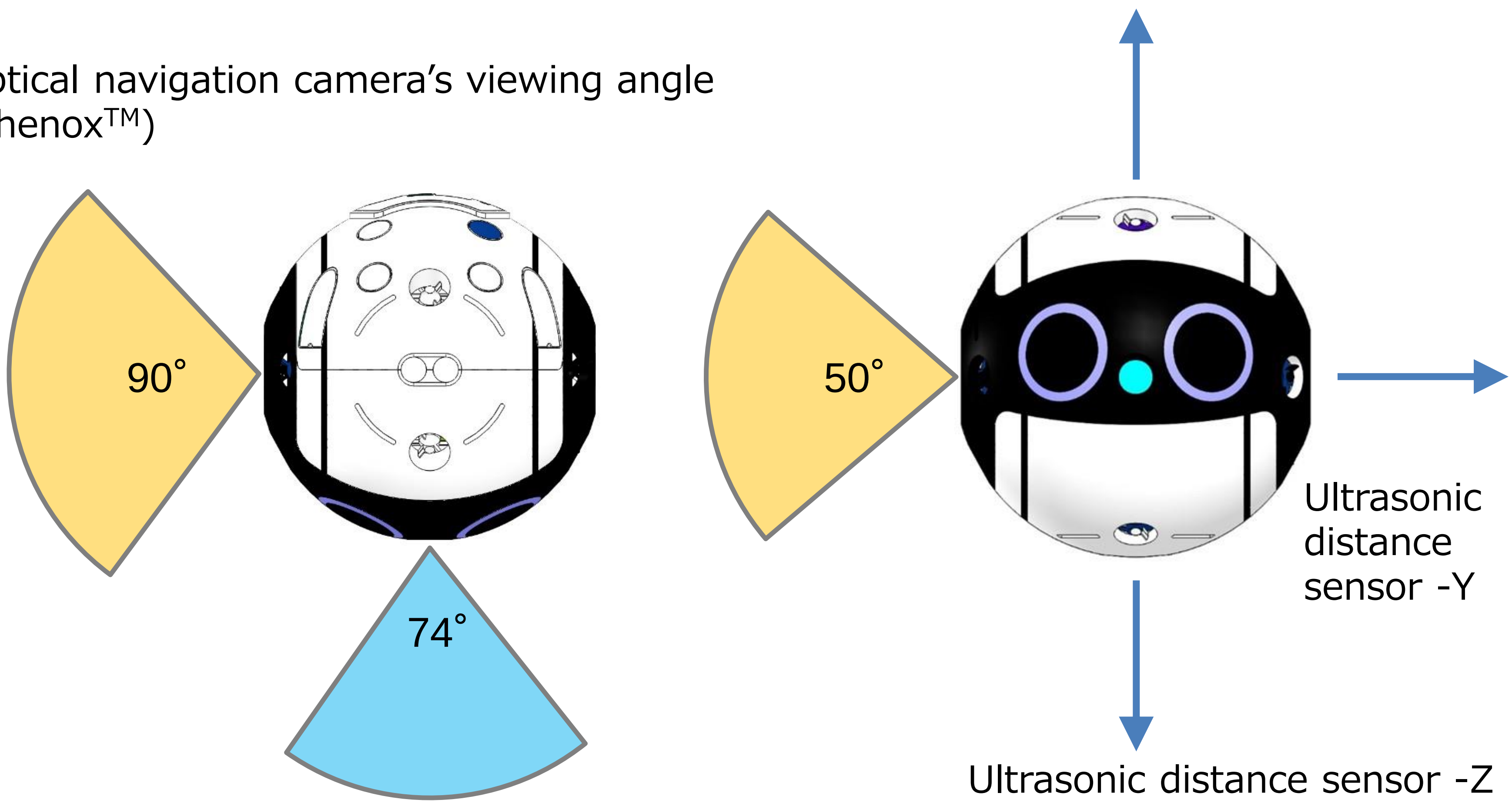
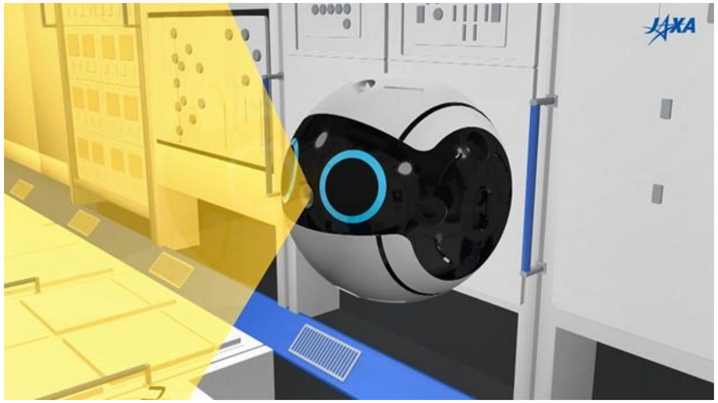
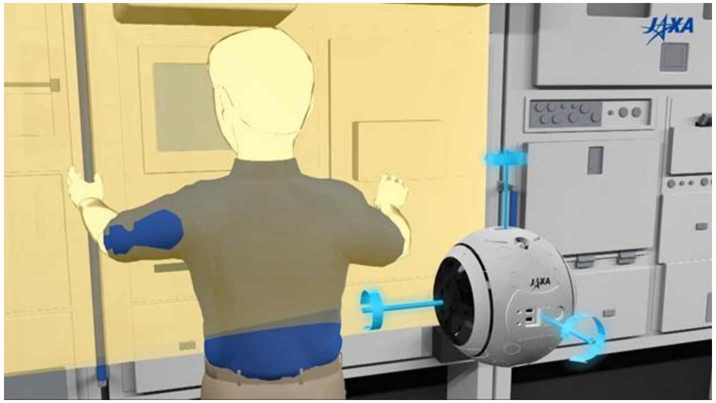


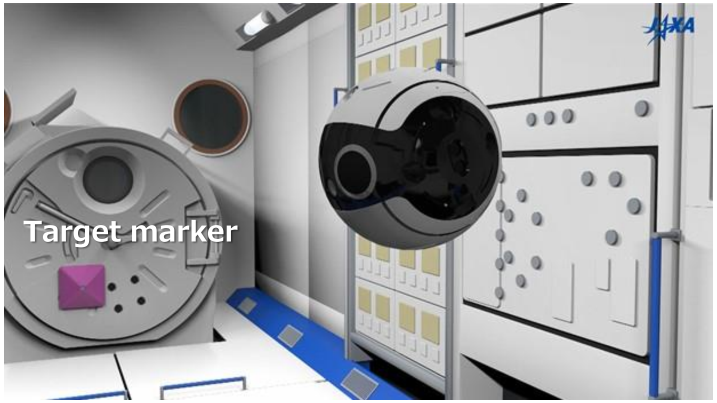
Image of Int-Ball being operated inside “Kibo”



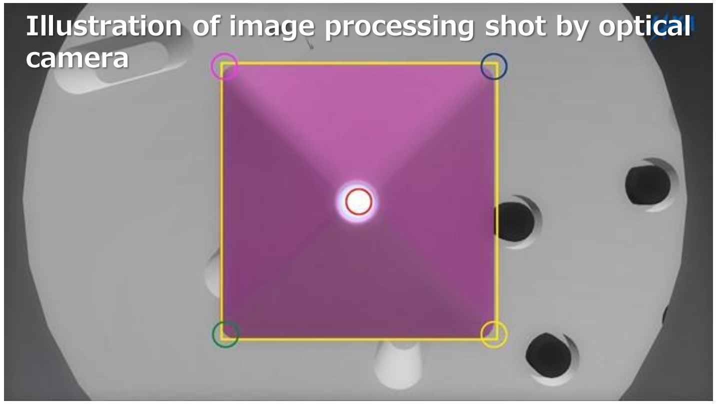
- Image being shot by the main monitor camera
- Real-time transmission to the ground control center



- Image-target tracking by wheels
- Image stabilization by wheels

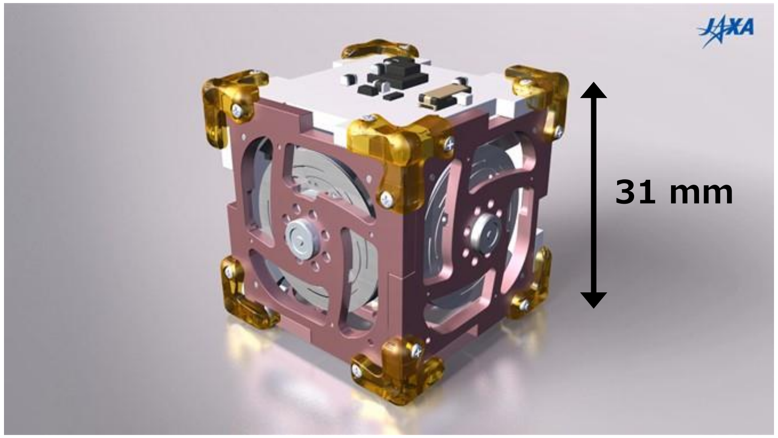


- Spatial movement and holding by micro fans
- Autonomous movement under desired commands from the ground control center

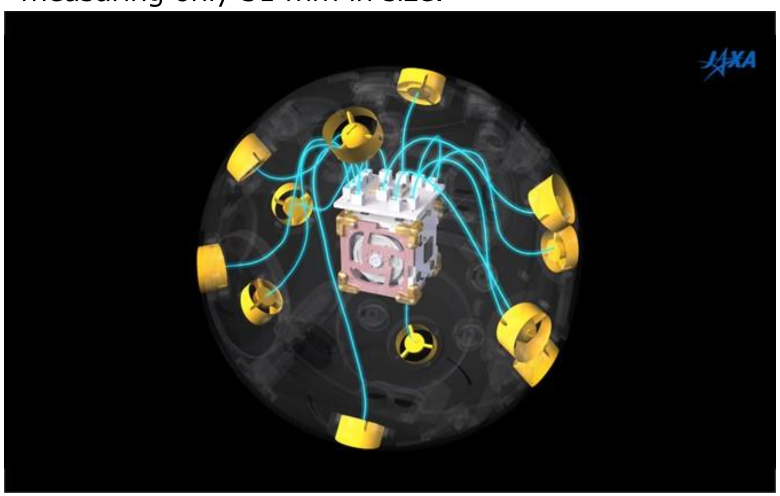


- Local navigation using 3D marker and camera

(Supplementary) Miniaturized Attitude Control Sensors and Actuators in an All-in-one Module



The guidance control computer, inertia sensors, and 3-axis reaction wheels are integrated into a cube measuring only 31 mm in size.



In the Int-Ball application, the module is equipped with an extension board connected to 12 micro fans, and enables its position / attitude control.

Weight:*1 88 g
Size:*1 31 mm
Power:*2 2 W（5V for input)

Principal specifications

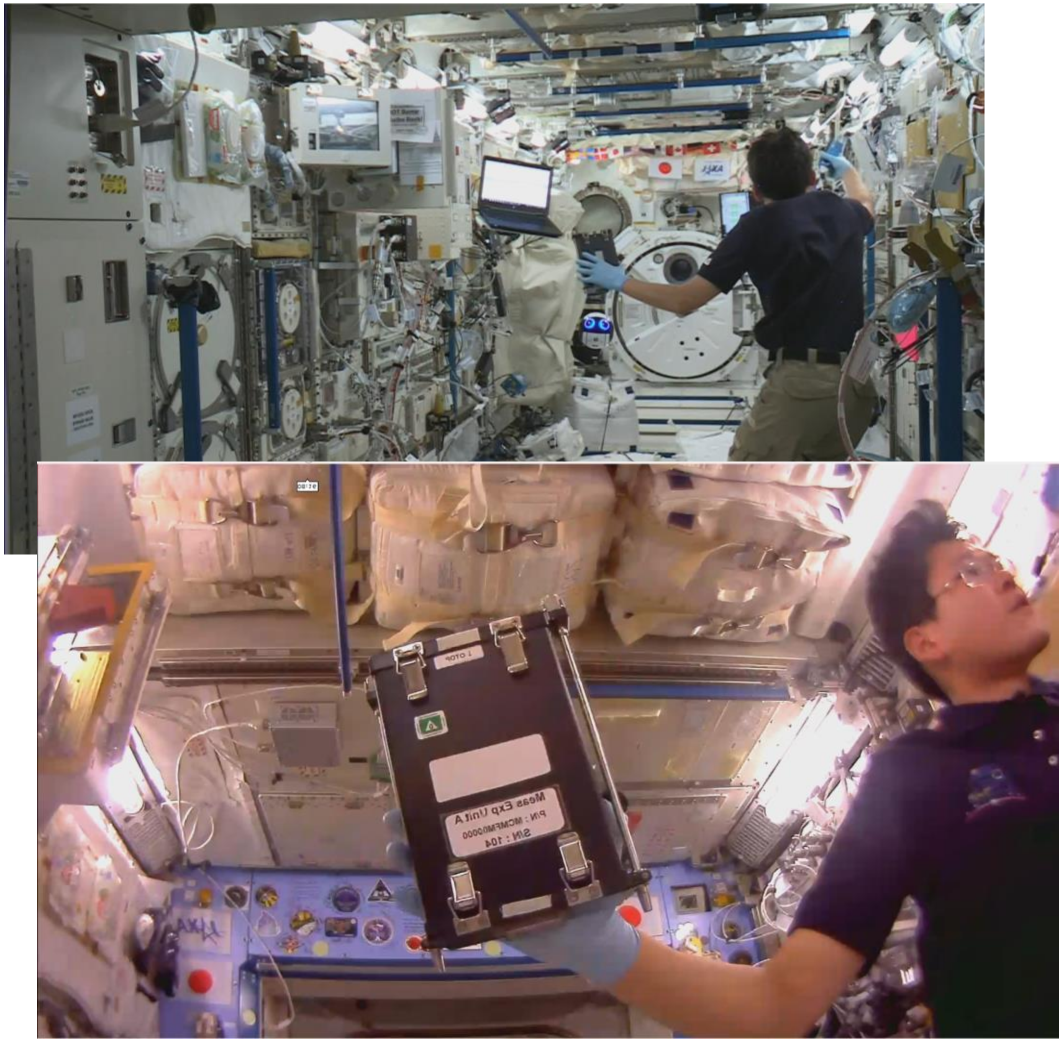
System on chip	1 unit (PSoC®)
CPU	32-bit ARM Cortex-M3
Reaction wheel	3 units
Moment of inertia	1,030 gmm^2
Maximum speed	16,000 rpm
Torque scale factor	1.96 mNm/A
Maximum current	0.122 A
Inertial sensor	6 units
Gyroscope range	±250 deg/s (Variable)
Gyroscope noise	0.008 deg/s/√Hz
Gyroscope bandwidth	< 250 Hz (Variable)
Acceleration range	±2 g (Variable)
Acceleration noise	250 μg/√Hz
Acceleration bandwidth	< 218 Hz (Variable)
Micro fan	12 units w/ ext. board *1
Thrust per unit	~1 mN (measured value)

(Magnet brake function is not included)

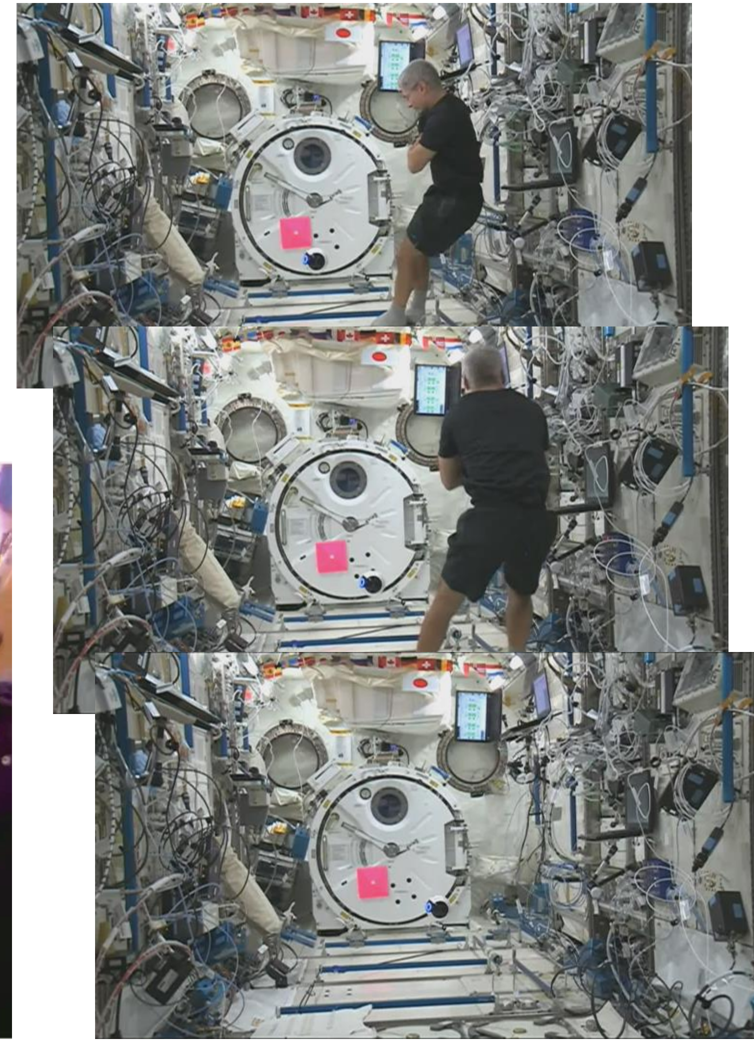
*1: Excludes the weight and size of the extension board.
*2: Under the condition that one wheel generates maximum torque with 4 micro fans running

Checkout Summary

Work with Astronauts Dr. Norishige Kanai



Move Aft to Fwd



Astrobee Collaboration

We are under considering collaboration of Astrobee and Int-Ball.
Competitors use Astrobee and Int-Ball to complete missions.
Now, we are sharing some ideas. For example,

- Time Trial Race “Read the Asian words”
- “Red light Green light” (“Daruma-san stumbled.” in Japanese)
- KIBO quiz champion ship
- Time Trial Race “Space Flyer Relay”

Next Generation(under assessment)