

National Aeronautics and
Space Administration



Space Tech Expo USA

Optimizing Mission Agility with Autonomous Systems:
The Benefits and Challenges of Implementing Artificial Intelligence

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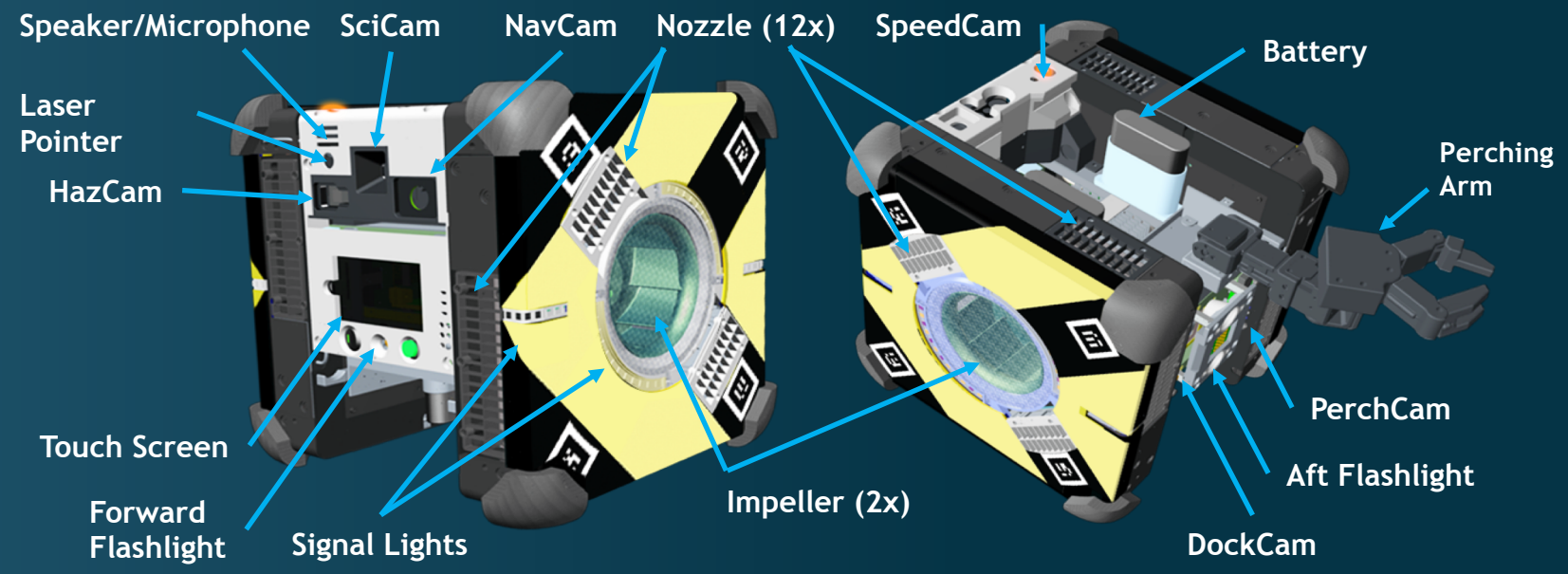
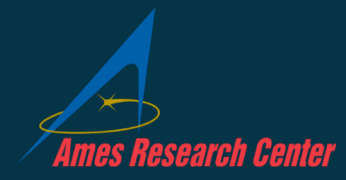




ASTROBEE: Autonomous free-flying robots for the ISS



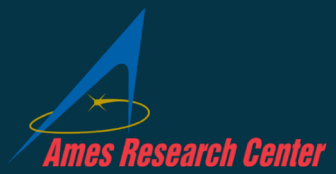
Astrobee Objectives



1. Provide a microgravity robotic research facility in the ISS, which will replace the existing SPHERES facility
2. Provide remotely operated mobile camera views of the ISS to enhance the situation awareness of mission control
3. Perform mobile sensor tasks in the ISS



Benefits



Astrobee will help prove out the concept of “Caretaker Robots” for future exploration architectures (Lunar Gateway).

Monitor the environment

- Ensure crew health and safety

- Maintain vehicle health and longevity

- Sound levels, radiation, air quality

Inspection functions can include:

- Spot checks

- Surveys (RFID localization)

- Automated change detection and trending

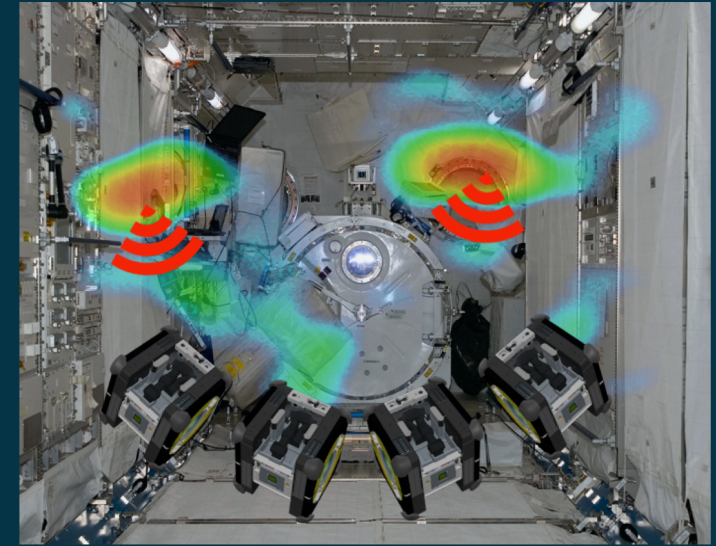
- Localizing problems

With dexterous robotic manipulation, future tasks could include:

- Maintenance

- Repair

- Cargo transfer

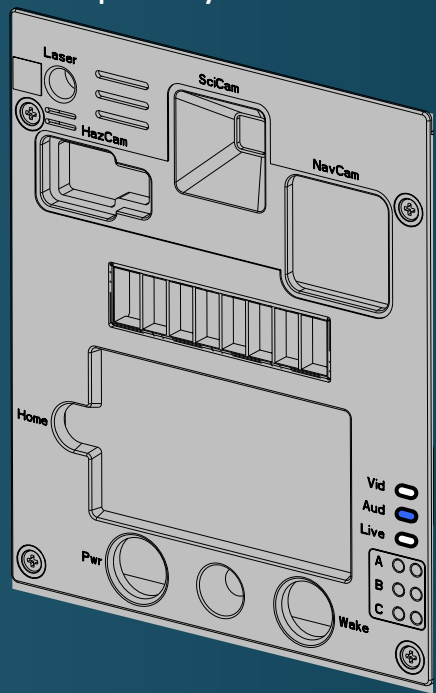




Challenges: safety, privacy, placement



Astrobee forward bezel
privacy status LEDs



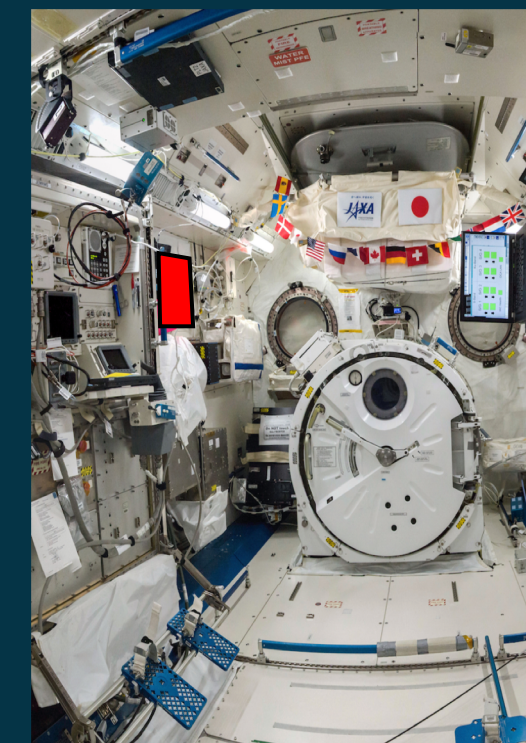
Was difficult to find a “permanent” location for the Dock

Lesson learned: expect to be moved, and be flexible

Bumper collision test rig



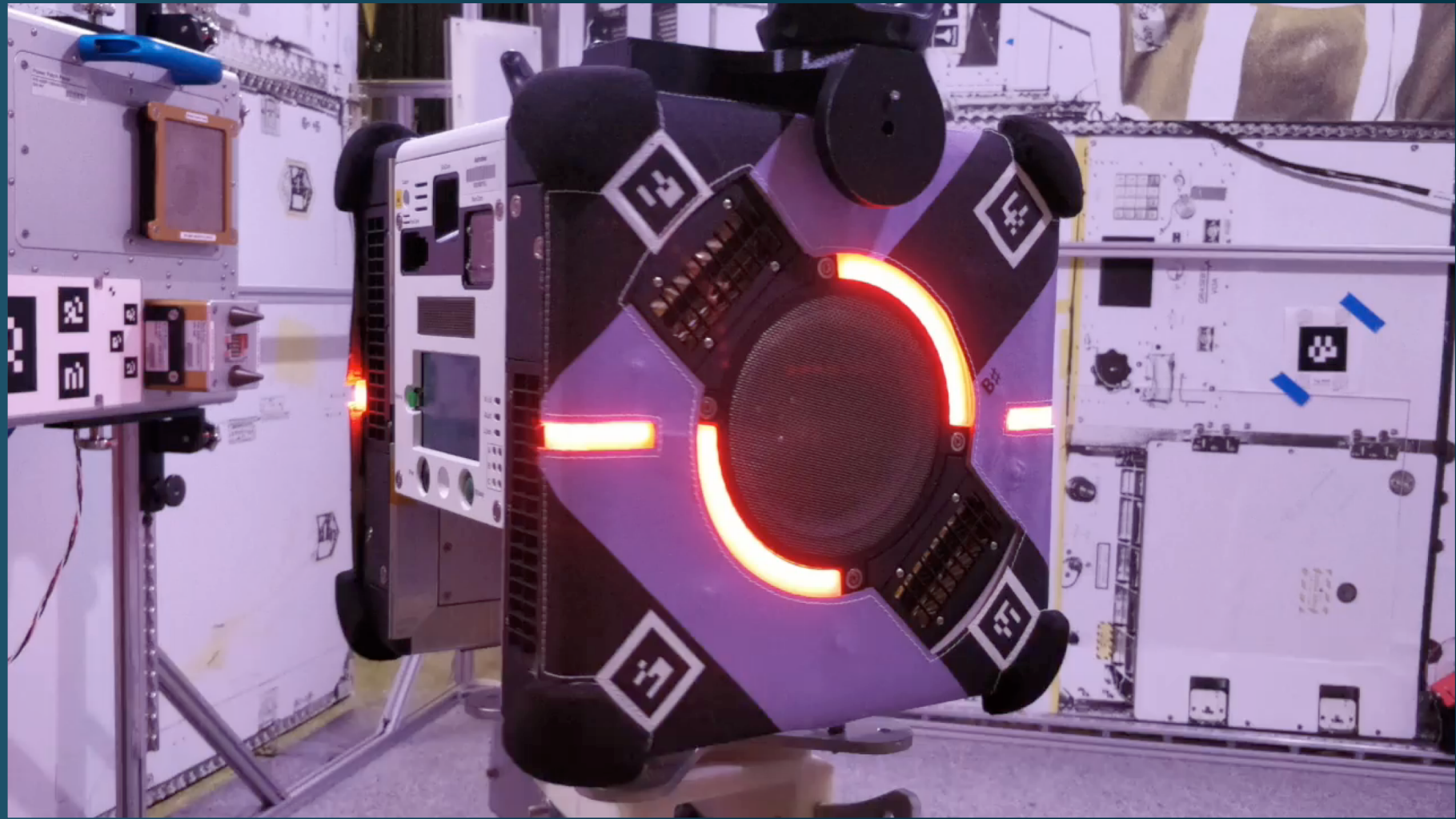
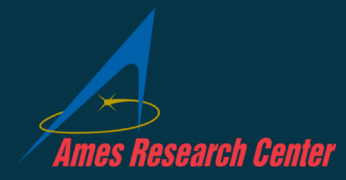
- Collision hazards mitigations
- Light (low mass, ~10 kg)
- Slow (max speed 0.5 m/s)
- Soft (corner bumpers and foam padding)
- Signal lights/noise when entering hatchway

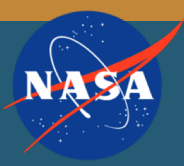


Initial dock location in red, JPM1A7

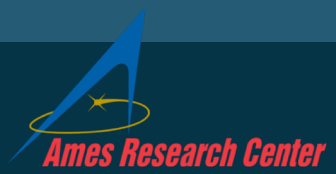


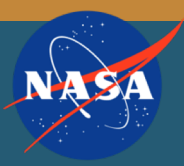
4 year of Astrobees development



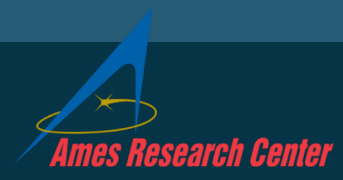


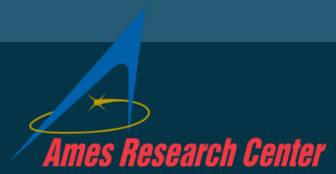
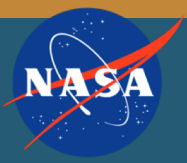
Status: Bumble Bee tested and calibrated on the ISS





Status: Bumble Bee tested and calibrated on the ISS





Take away points

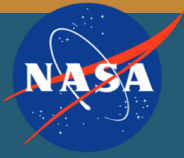
- Latest high-tech may take some time before being fully implemented for Space missions.
- Robotic and Autonomous systems will be essential for future (deep) Space Exploration & Human Spaceflight.
- A lot of challenges (ISS – very challenging environment), but the benefits are endless.

Thanks very much for the attention!



Any questions?





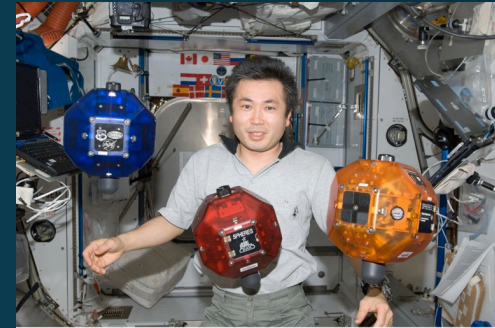
Back up slides

Current IVA Free Flyers

SPHERES (NASA) – launched 2006

Highly successful research platform used for many guest science experiments

Astrobee will replace SPHERES, managed by the same facility team



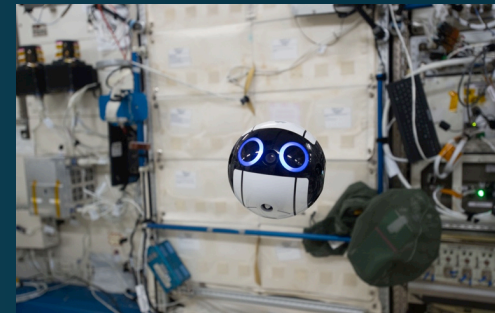
SPHERES

Int-Ball (JAXA) – launched 2017

Successful experiment in building an IVA free flyer with a rapid development cycle (18 months)

Small size (15 cm diameter) enabled by JAXA's miniaturized all-in-one CPU / IMU / 3-axis reaction wheel module

Joint activities between Int-Ball and Astrobee may be possible



Int-Ball

CIMON (DLR) – launched Nov 2018

Enable research on AI for human-robot interaction

International cooperation – CIMON will share from the pool of batteries that Astrobee qualified for ISS



CIMON