



# HET2 Overview



## What would you say to a Senator that you meet in the elevator?

- The Human Exploration Telerobotics 2 project is developing two remotely operated robots to improve the way humans live and work in space. These robots will perform routine housekeeping and in-flight maintenance jobs.

“HET2 is developing new robots to do chores so that humans can focus on more important work”

### Partnerships

HEOMD STMD other

- ISS: SPHERES Facility
- AES: ASO & Logistics Reduction
- SBIR (2012 HEOMD project & 2015 STMD subtopic)
- NSTRF (5 Ph.D. students)
- NSF/NASA National Robotics Initiative project
- ESI (proposed 2015 topic)
- Army ARDEC
- Google (NRSAA)

### Technology Infusion Plans



### Key Personnel

**Program Element Manager:** Kevin Kempton  
**Project Manager:** Terry Fong  
**Lead Center:** ARC  
**Supporting Centers:** JPL, JSC  
**NASA NPR:** 7120.8  
**Guided or Competed:** Guided  
**Type of Technology:** Push to ISS, Pull from AES

### Key Facts

**GCD Theme:** RRAS  
**Execution Status:** Year 1 of 3  
**Technology State Date:** 10/1/2014  
**Technology End Date:** 9/30/2017  
**Technology TRL Start:** 3  
**Technology TRL End:** 7  
**Technology Current TRL:** 3 (Astrobee) / 6 (R2)  
**Technology Lifecycle:** Astrobee: Phase A (Formulation)  
R2: Phase D (Implementation)



# Astrobee Free-Flyer Element



## What would you say to a Senator that you meet in the elevator?

- Astrobee is a free flying robot for inside the ISS. It will be used by flight controllers for doing mobile sensing and camera tasks. It will replace SPHERES to be used by researchers for 0g robotics testing.

 "Astrobee, free flying robot inside space station for mobile sensing and 0g robotics tests"

## Accomplishments

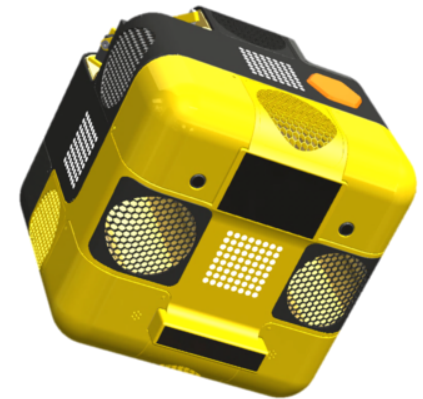
- Completed Prototype 2 testing, including autonomous docking using on-board navigation and vision targets
- Conducted Periodic Technical Review #1 (SRR equivalent – established technical baseline)

## Activities

- Complete Prototype 3 testing by 8/6/15
- Conduct PTR #2 (PDR equivalent) by 9/15/15

## Technology Infusion Plans

- **Potential Customer (PC)**
- **Technology:** Free-flying robot
- **Customer:** HEOMD
- **Use:** (1) SPHERES successor, (2) ISS IVA work that requires mobile sensors (logistics, remote camera, environment survey/monitoring)



## Key Personnel

**Program Element Manager:** Kevin Kempton

**Project Manager:** Terry Fong

**Lead Center:** ARC

**Supporting Centers:** JPL

**NASA NPR:** 7120.8

**Guided or Competed:** Guided

**Type of Technology:** Push to ISS, Pull from AES

## Key Facts

**GCD Theme:** RRAS

**Execution Status:** Year 1 of 3

**Technology State Date:** 10/1/2014

**Technology End Date:** 9/30/2017

**Technology TRL Start:** 3

**Technology TRL End:** 7

**Technology Current TRL:** 3

**Technology Lifecycle:** Phase A (Formulation)



# Robonaut 2 (R2) Element



## What would you say to a Senator that you meet in the elevator?

- R2 is the humanoid robot currently on ISS. R2 is designed to off-load routine and repetitive work from the crew. The crew can then spend more time on science and research.

 "Robonaut 2, humanoid robot inside space station for routine and repetitive work"

## Accomplishments

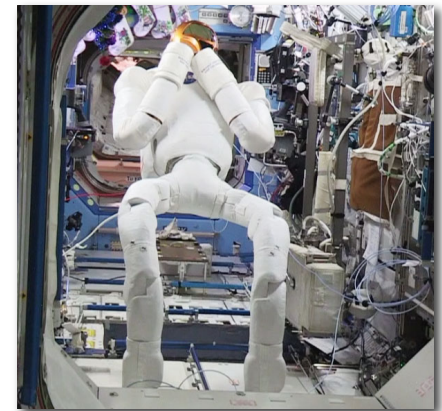
- Successful logic power checkouts and software upgrades of on orbit R2
- Advanced supervisory control interface for robot-environment interactions

## Activities

- 60 deg – multi grip handrail grab ground test (5/31/15)
- IVA task ground demonstration (6/30/15)

## Technology Infusion Plans

- **Potential Customer (PC)**
- **Technology:** Humanoid robot
- **Customer:** HEOMD
- **Use:** ISS IVA work that requires dexterous, mobile manipulation



## Key Personnel

**Program Element Manager:** Kevin Kempton

**Project Manager:** Terry Fong

**Lead Center:** JSC

**Supporting Centers:** n/a

**NASA NPR:** 7120.8

**Guided or Competed:** Guided

**Type of Technology:** Push to ISS

## Key Facts

**GCD Theme:** RRAS

**Execution Status:** Year 1 of 1

**Technology State Date:** 10/1/2014

**Technology End Date:** 9/30/2015

**Technology TRL Start:** 6

**Technology TRL End:** 7

**Technology Current TRL:** 6

**Technology Lifecycle:** Phase D (Implementation)



# Astrobee Penta

## PROBLEM / NEED BEING ADDRESSED

Crew time spent conducting hand-held sensor tasks and setting up cameras and 0g robotics research platform in ISS

### PROJECT DESCRIPTION/ APPROACH

- Astrobee is a free flying robot capable of autonomous flight and performing mobile sensor tasks on ISS.
- Astrobee will provide camera views to flight controllers to improve situational awareness.
- Astrobee will autonomously dock and resupply consumables.
- Astrobee can be pre-positioned for 0g robotics research sessions.

### QUANTITATIVE IMPACT

- Developing ISS free-flying robotic technology to TRL 7: vision-based navigation, fan-based propulsion, ISS 3D path planning, 0g robotic perching.

### PROJECT GOAL

- Deliver (on dock) 2 free-flying robots capable of ISS IVA sensor tasks and autonomous docking.
- Stretch goal: Launch and perform on-orbit checkout.

### STATUS QUO

- Crew performs many tasks that could be performed by a robot
- Crew spends half of a SPHERES session setting up and tearing down equipment

### NEW INSIGHTS

- ISS Program is interested in off loading crew activities.
- ISS Program and AES want to reinvest in ISS as a research platform.
- AES wants to pursue automated logistics management.





# Robonaut 2 Penta

STATUS QUO

- Crew does everything on-orbit (maintenance, science, exploration).

## PROBLEM / NEED BEING ADDRESSED

Relieve crew of dangerous, dull and dirty (3 D's) tasks and free them up to perform more science and exploration.

## PROJECT DESCRIPTION/ APPROACH

- R2 is the humanoid robot currently on ISS designed to be compatible with existing crew interfaces so it can off-load routine and repetitive work normally performed by astronauts.
- R2 will perform a variety of ground and on-orbit tests (using the ISS) to characterize, validate, and demonstrate capabilities.

QUANTITATIVE IMPACT

- Develop the following humanoid robot technologies to TRL 6: legged mobility, autonomous task software, and computer vision.

PROJECT GOAL

- Demonstrate efficient programming, robust mobility and ability to perform a complex IVA task.

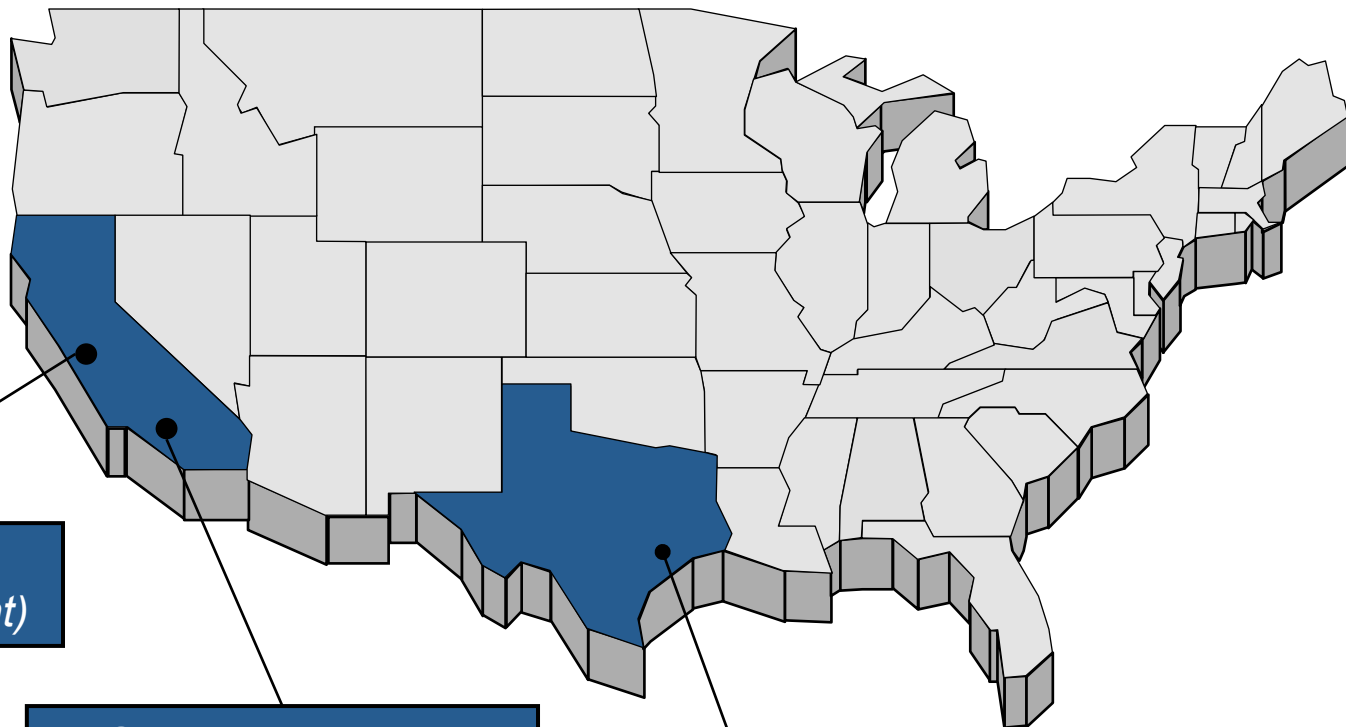
NEW INSIGHTS

- The ISS Program is very interested in off loading routine crew activities wherever possible.





# Organization and Key Members



**NASA ARC (Lead)**  
*Astrobee (Development)*

**NASA JPL**  
*Astrobee (GDS support)*

**NASA JSC**  
*Robonaut 2 (Development)*