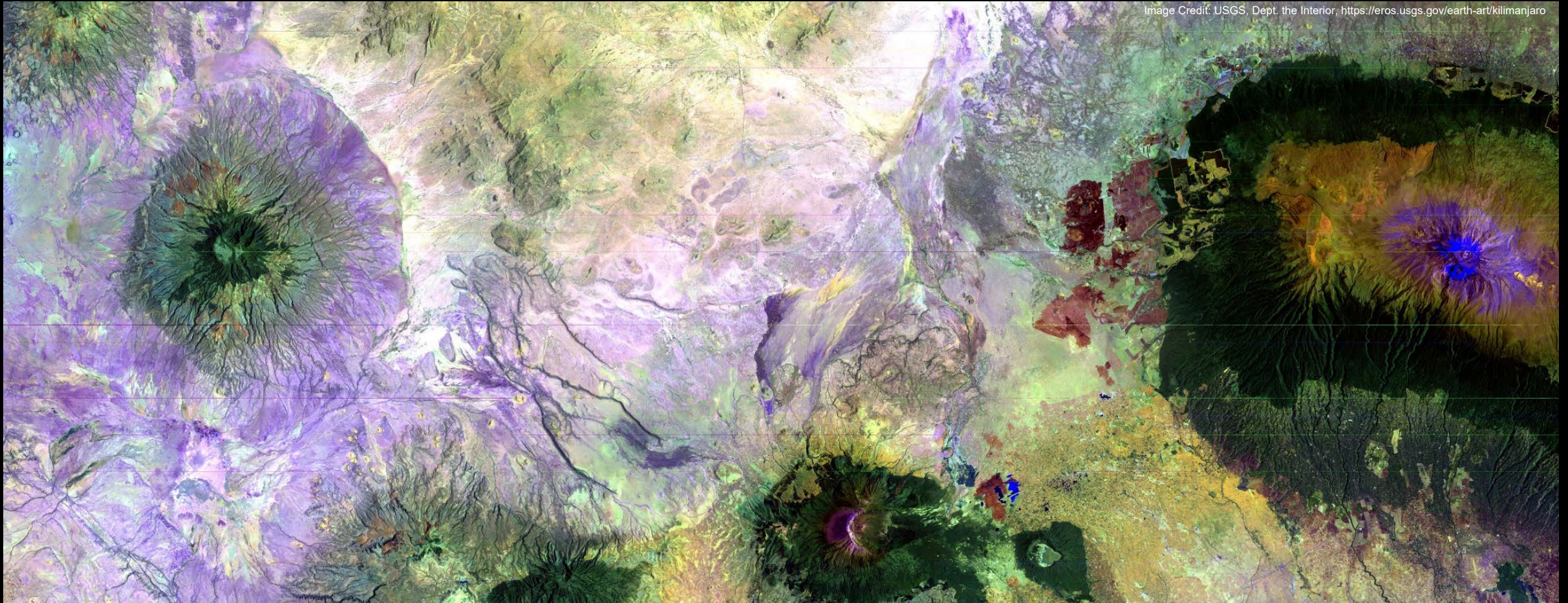


# The Zero Robotics program: training secondary school students to code robots on the International Space Station



Danielle Wood, PhD

Assistant Professor, MIT Media Lab  
Director, Space Enabled research group



# ZER ROBOTICS





# What is Zero Robotics?



## A competition

- Middle School (5 weeks in summer)
- High School (3 months in fall)

## A programming challenge

- Students program on space robots
- Software-based and game-specific



Zero is for **Zero Cost**

- No entry fees

Zero is for **Zero Configuration**

- Everything is programmed online

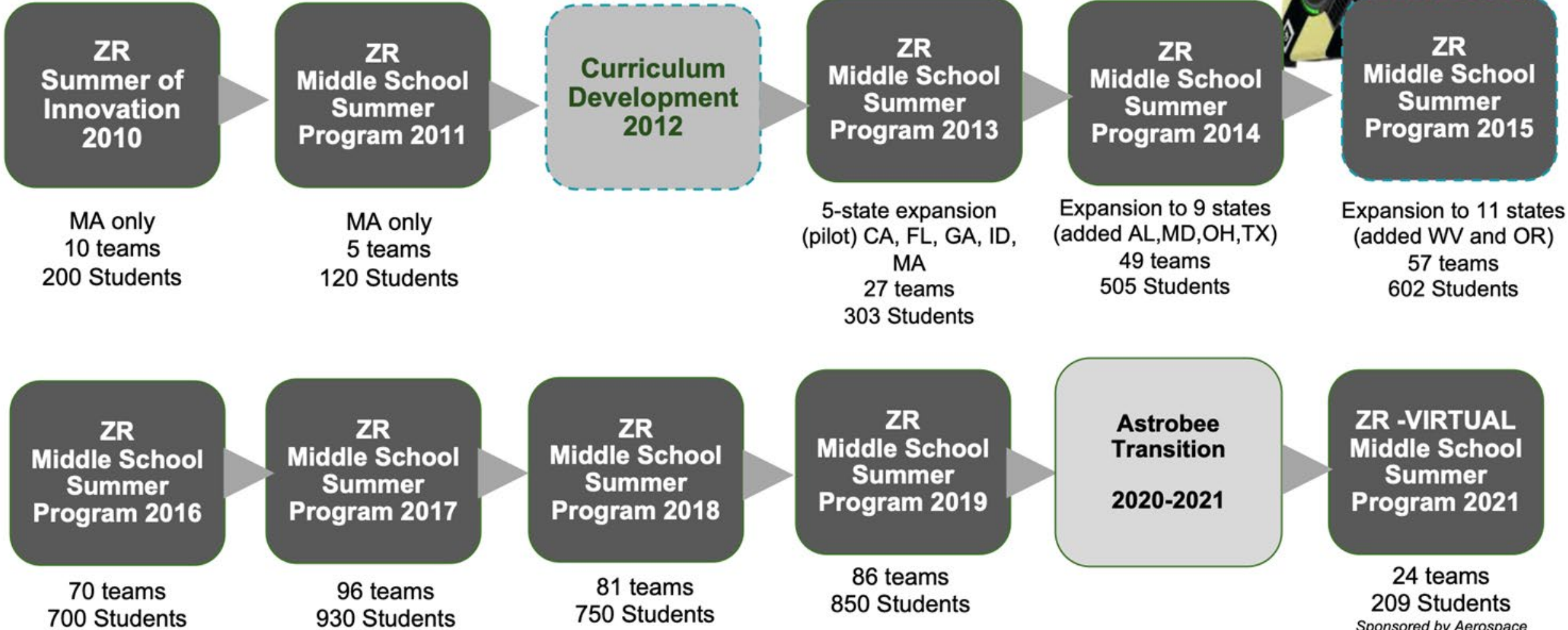
Zero is for **Zero Gravity**

- Final competition occurs aboard the ISS





# History of Zero Robotics – MS



*Sponsored by Aerospace Corporation*



# History of Zero Robotics – HS



ZR  
Pilot  
Program  
2009

- US Pilot
- 2 teams
- 13 students

ZR  
SPHERES  
Challenge  
2010

- 1st US National tournament
- 24 teams

ZR  
SPHERES  
Challenge  
2011

- 1st European tournament
- 122 US teams
- 22 ESA teams

ZR  
High School  
Tournament  
2012

- 144 teams (US and ESA)

ZR  
High School  
Tournament  
2013

- 165 teams (US and ESA)

ZR  
High School  
Tournament  
2014

- First fully international competition
- 178 teams (US & ESA)
- Russian and Mexican Pilot teams

Zero  
Robotics  
High School  
Tournament  
2015

- Australian Pilot
- 171 teams

Zero  
Robotics  
High School  
Tournament  
2016

- 131 teams
- 1600 students

Zero  
Robotics  
High School  
Tournament  
2017

- 231 teams
- 1900 students

Zero  
Robotics  
High School  
Tournament  
2018

- 208 teams
- 2100 students

Astrobee Transition  
Pilot Program  
2020-2022

**15 Countries:**  
*Australia, France, Germany, Guatemala, Hungary, Italy, Mexico, Poland, Portugal, Greece, Romania, Russia, Spain, United Kingdom, United States*



# Zero Robotics: Our Impact

**10** Years of ZR on the International Space Station!

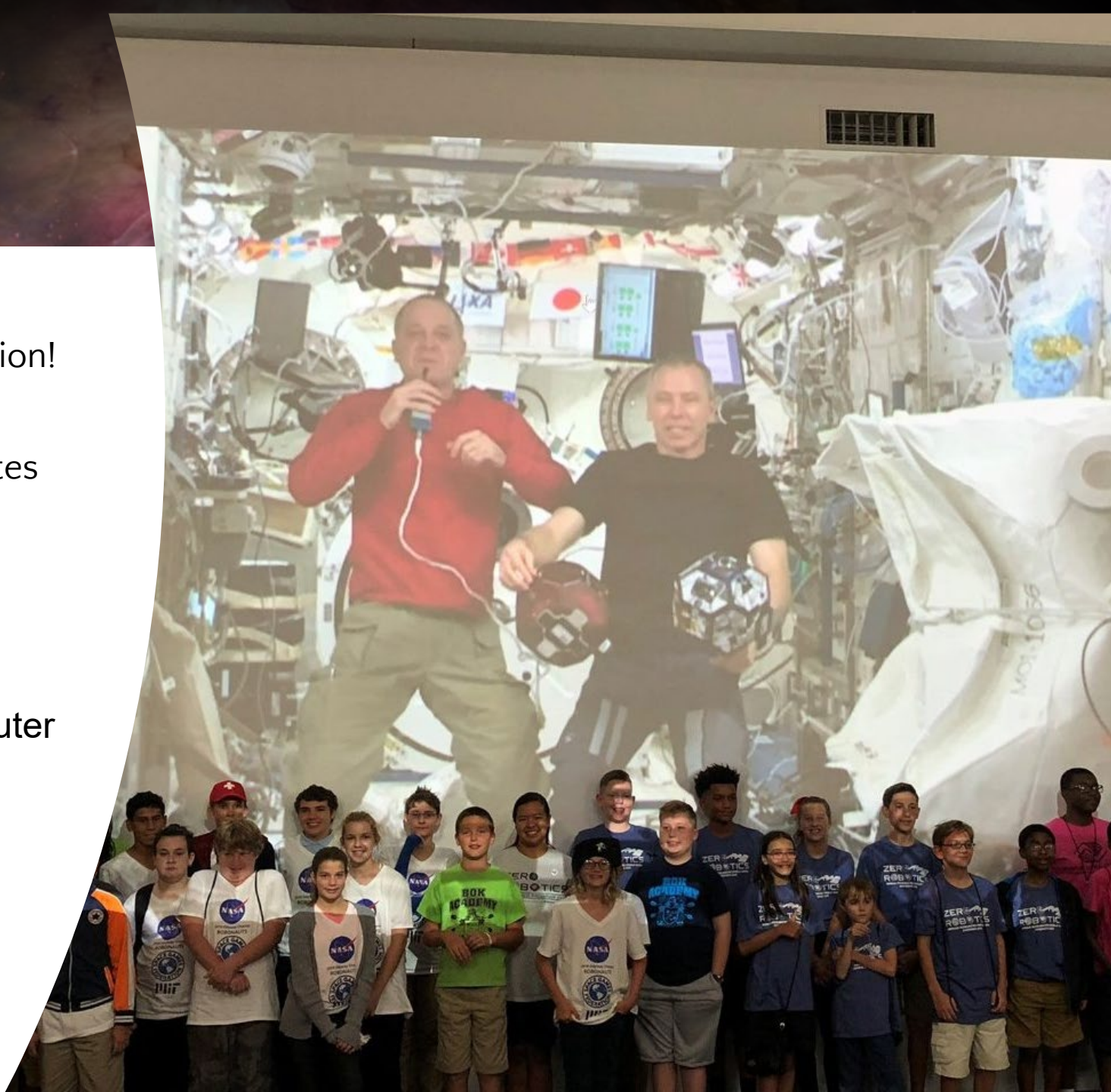
**20,000** Students writing code for satellites

- 15,000 HS students;
- 5,000 MS students
- 1M student/hrs

**4,500** Educators learning to teach Computer Science and Computational Thinking!

**16** states; **16** countries

- 14,000 US students;
- 6,000 International students





# Honey, Bumble & Queen Astrobees robots



<https://www.nasa.gov/astrobee>



# Technical Implementation Approaches

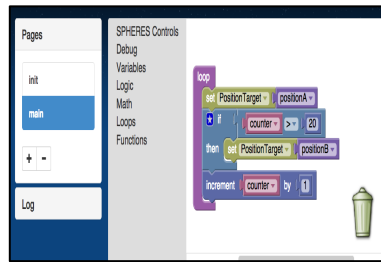


## Programming Environment:

Integrated Development Environment (IDE)

Text Editor & Graphical Editor available to Students

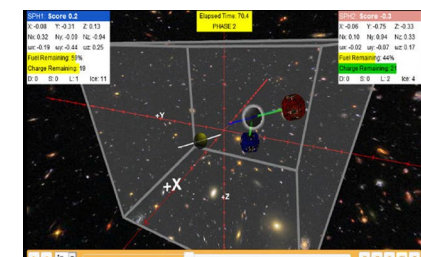
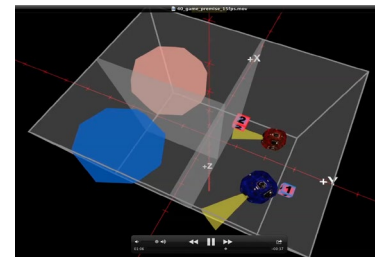
```
1
2 float positionA[3];
3 float positionB[3];
4 int counter;
5
6 void InitC()
7
8 positionA[0]=0;
9 positionA[1]=1;
10 positionA[2]=0;
11 positionB[0]=1;
12 positionB[1]=0;
13 positionB[2]=0;
14 counter=0;
15
16
17 void loopC()
18 api.setPositionTarget(positionA);
19 if (counter>20){
20   api.setPositionTarget(positionB);
21 }
22 counter=counter++;
23
24
```



## Simulation Environment:

Students compile & simulate code online

Venue for intramural competitions



Middle School students continued to program in the IDE using C-based coding in a graphical editor.

The Simulation Environment was updated to more closely reflect the dynamics of the Astrobee

The MIT team converted the logic of the C Code developed by students into an APK that Astrobee can read, then pursued extensive testing to ensure performance.



# Celebrating the successful transition of Zero Robotics to Astrobee!



In August 2022 FIRST group of middle school students used the Astrobee hardware for the Zero Robotics programming competition.

ZER 

R  B  TICS





**Summer 2022**

**Zero Robotics Middle**

**School Game**

**The Great AstroSpelling Bee!**





The MIT ZR Team performed  
2 Granite Lab tests in April  
2022

## People

Share invite

Currently in this meeting (12)

- DW Danielle Wood (MIT) (Guest)
- JB Barlow, Jonathan S. (ARC-TI)...
- DN Darius Nguepi (Guest)
- RR Garcia Ruiz, Ruben M. (ARC-...
- KM Kathleen Magrane
- KA Kristen Joyce Ammons
- AV Mora Vargas, Andres E. (ARC... Organizer
- VN Nguyen, Victoria H
- JS Scharff, John A.
- SD Scott Dorrington (MIT) (Gue...
- RT Thompson, Ryan
- YZ Yiyun Zhang



# Middle School Student Demographics for ZR



Here are is an overview of student demographics:

- **20** teams with 178 middle school students participated in the 2022 MS program
- **6** US states (California, Massachusetts, Illinois, Minnesota, Arizona, and New Jersey) and 3 Tribal Nations (Navajo, Hopi and Zuni) are involved
- **40** of the middle school students are from Long Beach, Los Angeles, and Paramount Unified Districts.
- The Navajo Technical University and CalState Long Beach help the program reach student in their regions with funding from NASA
- Sixty-seven adults have supported the program operations in the summer, including 37 educators and 30 college students.





**The 2022 Zero Robotics Finals was held on August 3, 2022. Every team successfully ran their code twice.**





**The 2022 Zero Robotics Middle School Competition provided the opportunity for university-level interns, graduate students and post docs at MIT and Innovation Learning Center to provide technical leadership and mentoring to the program participants.**





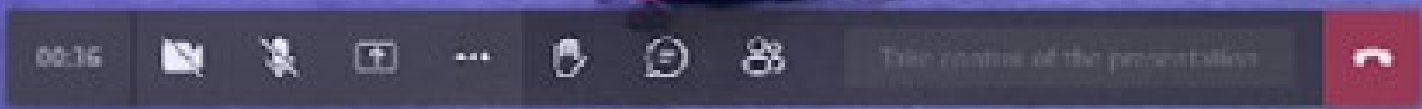
**Summer 2023**  
**Zero Robotics Middle**  
**School Game**

**LUNABEE – a moon-based science adventure**



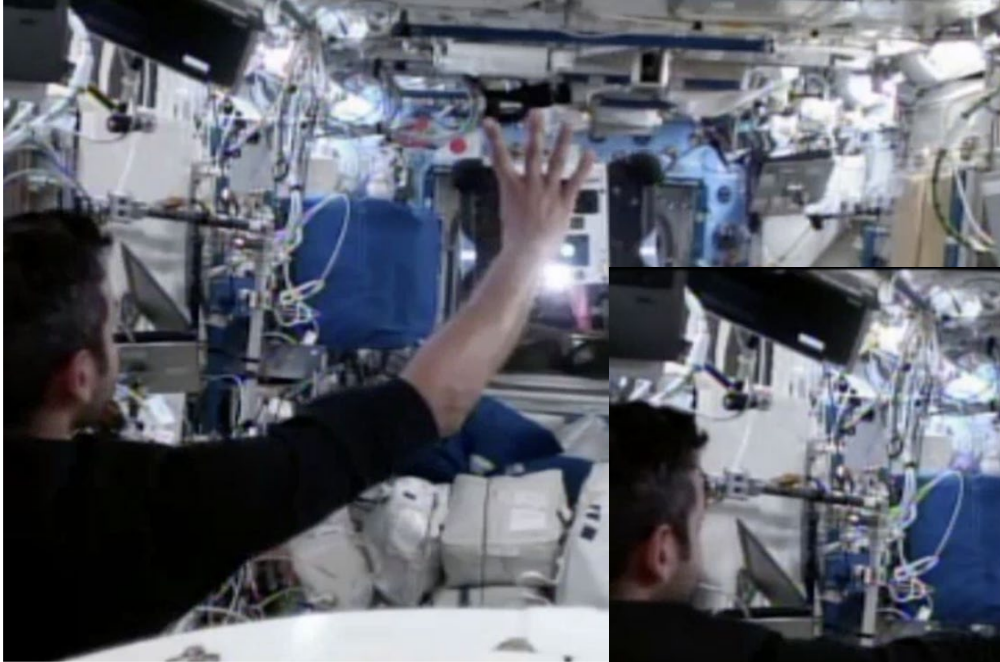


The MIT ZR Team performed several Granite Lab tests and ISS Technology Demo events between January and May 2023 to prepare for the summer 2023 sessions.





# LUNABEE – a moon-based science adventure



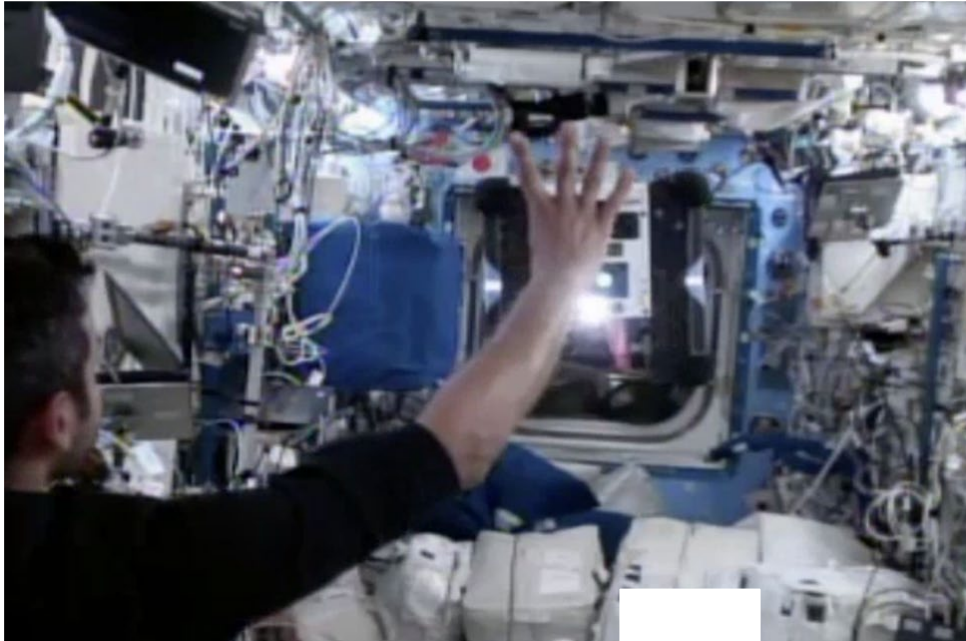
**This 2023 Zero Robotics Middle School Competition will include the gesture recognition on Astrobee for the first time and expects to have 500-700 student participants.**



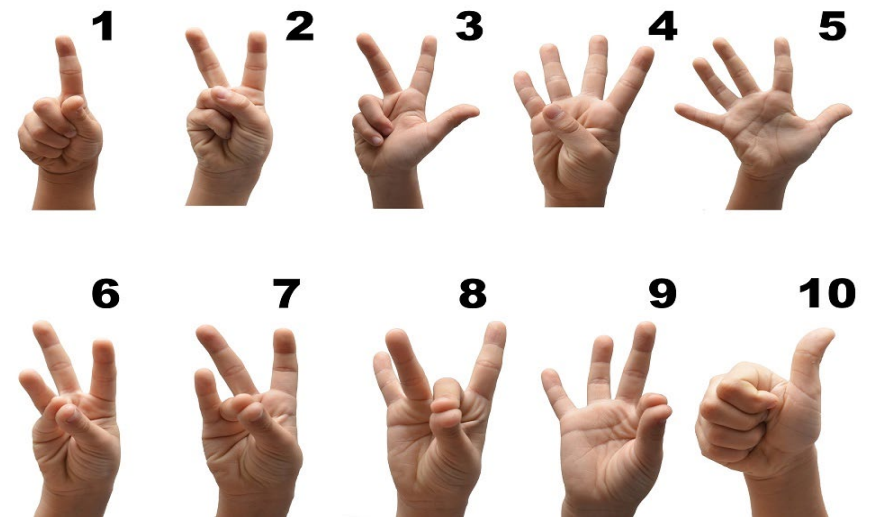
# LUNABEE – a moon-based science adventure



## Game Phase 1: Hand Signal Recognition



### American Sign Language (ASL)





# LUNABEE Game Overview



**Your Mission:** Retrieve lunar dust samples for analysis as part of the Artemis Engineering Team.

**Your Goal:** Program the Astrobee Robot to receive visual indication of active research sites on the Moon, collect 24 grams of lunar dust samples, and successfully drop them to the base station!



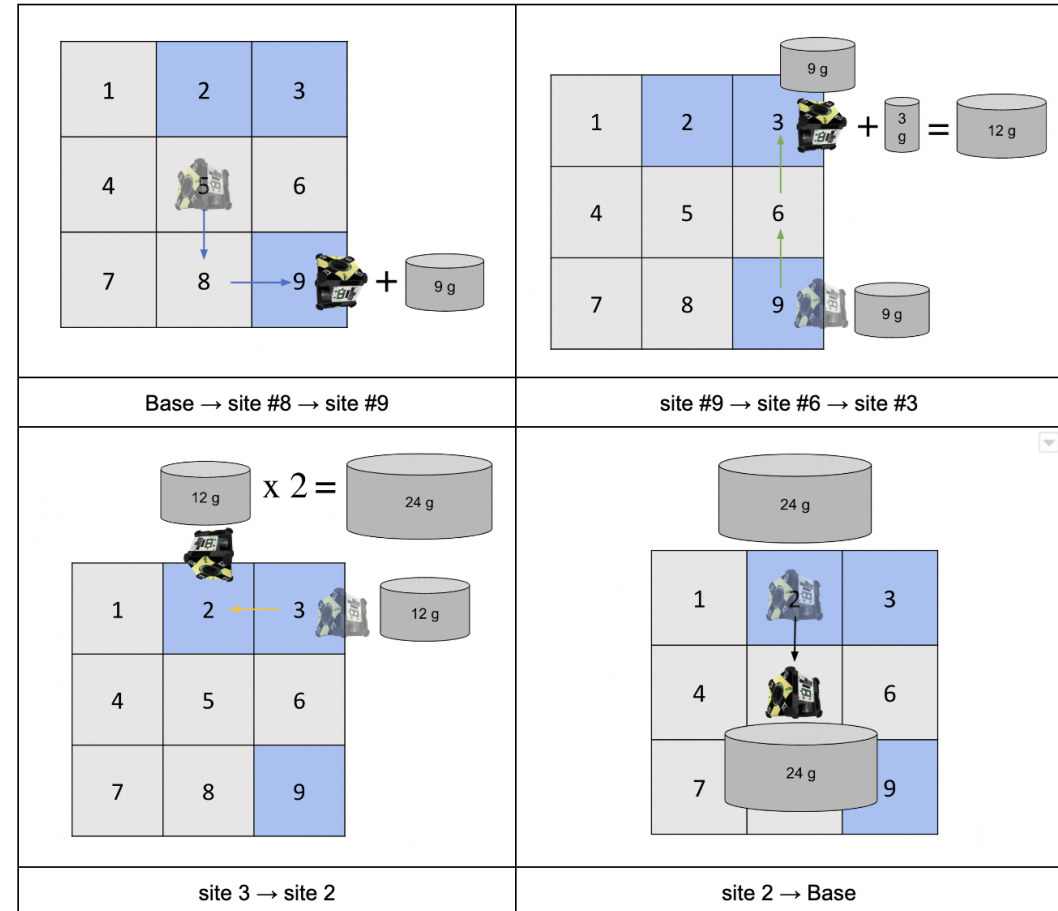
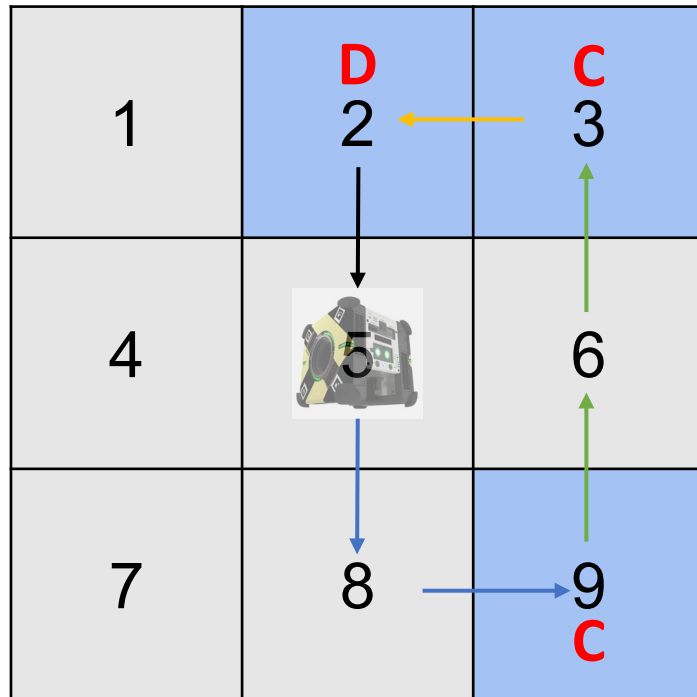


# LUNABEE – a moon-based science adventure



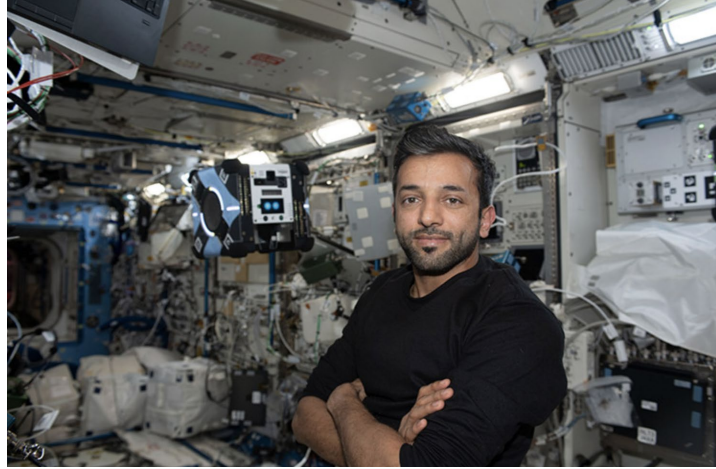
## Game Phase 2: Path Planning

Research Sites Map





# UAE Zero Robotics Programming Challenge



**The first UAE Zero Robotics Programming Challenge (ZRPC) is being held this spring with 7 UAE teams, with the final event schedule in this June.**



**The CHIERS team met at Navajo Technical University in January 2023**

**CHIERS is the Consortium on Hispanic and Indigenous Education in Space. The team includes MIT, NTU, ILC, KARMA and CSULB**





**The CHIERS team met at  
Navajo Technical  
University in January  
2023**

**CHIERS is the  
Consortium on Hispanic  
and Indigenous  
Education in Space. The  
team includes MIT, NTU,  
ILC, KARMA and CSULB**





**The CHIERS team met at  
Navajo Technical  
University in January  
2023**

**CHIERS is the  
Consortium on Hispanic  
and Indigenous  
Education in Space. The  
team includes MIT, NTU,  
ILC, KARMA and CSULB**



# AWARD WINNING DOCUMENTARY



**Zero Gravity** is a feature documentary that follows a diverse group of middle-school students from San Jose, CA, who compete in the ZR nationwide tournament to code satellites aboard the International Space Station.

<http://zerogravityfilm.com/>



54th Worldfest Houston International Film Festival - April 2021 (WINNER - Gold Award - **Best Feature Documentary**)

Only The Best International Film Awards - May 2021 (WINNER - Jury Award - **Best Feature Documentary**)

Desertscape International Film Festival - June 2021 (WINNER - **Best Feature Documentary**)



# Towards an Identity-Oriented Design Framework in Education Programs

Yiyun Zhang  
Aeronautics and Astronautics Engineering, MIT  
Doctoral Thesis Proposal Defense  
May 25<sup>th</sup>, 2023

**A doctoral  
student  
defended her  
thesis proposal  
on Zero  
Robotics.**



# Zero Robotics Website



Please visit us on [zerorobotics.mit.edu](https://zerorobotics.mit.edu) for more information!

A screenshot of the Zero Robotics website homepage. The page has a dark blue header with navigation links: "Zero Robotics", "About ZR", "Tournaments", and "Resources". On the right side of the header is a "Sign in with Google" button. The main content area is divided into two columns. The left column features a "Welcome to Zero Robotics" section with a large image of five people (three women and two men) standing next to a NASA astronaut suit. Below this image is a carousel of smaller images, with the first one showing a group of people in front of an Astrobee robot. The right column is titled "Announcements" and contains several news items, each with a date and a "Read more" link. The first announcement is dated April 21, 2023, and is about summer 2023 applications for middle school teams. The second is dated July 08, 2022, and is about a virtual career day. The third is dated April 01, 2022, and is about the summer 2022 middle school program. The fourth is dated September 22, 2021, and is about a film premiere. At the bottom of the page, there are two columns of "Middle School" program information for 2023 and 2022, each with an "INFO" button and a small image of the Astrobee robot. A "2021 Aerospace Space Coders Camp" section is also visible at the bottom.

**1** NO  
POVERTY



**2** NO  
HUNGER



**3** GOOD  
HEALTH



**4** QUALITY  
EDUCATION



**5** GENDER  
EQUALITY



**6** CLEAN WATER  
AND SANITATION



**7** RENEWABLE  
ENERGY



**8** GOOD JOBS AND  
ECONOMIC GROWTH



**9** INNOVATION AND  
INFRASTRUCTURE



**10** REDUCED  
INEQUALITIES



**11** SUSTAINABLE CITIES  
AND COMMUNITIES



**12** RESPONSIBLE  
CONSUMPTION



**13** CLIMATE  
ACTION



**14** LIFE BELOW  
WATER



**15** LIFE  
ON LAND



**16** PEACE AND  
JUSTICE



**17** PARTNERSHIPS  
FOR THE GOALS



**THE GLOBAL GOALS**  
For Sustainable Development



# Thanking the Zero Robotics Team!



- Danielle Wood, MIT, Principal Investigator
- Katie Magrane & Intern Team, Innovation Learning Center
- Alvar Saenz-Otero, MIT ZR Co-Founder and Technical Expert
- Wendy Feenstra, Aurora Flight Sciences,
- Mizanul Chowdhury, STEMX365, Technical Expert
- Scott Dorrington, MIT Postdoc
- Yiyun Zhang, MIT Grad Student
- MIT Undergraduate Students and Interns
- Collaborators from California State University, Long Beach and Navajo Technical University
- + Many collaborators, educators and supporters around the world!