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

**ZR Summer of Innovation 2010**
- MA only
- 10 teams
- 200 Students

**ZR Middle School Summer Program 2011**
- MA only
- 5 teams
- 120 Students

**Curriculum Development 2012**

**ZR Middle School Summer Program 2013**
- 5-state expansion (pilot) CA, FL, GA, ID, MA
- 27 teams
- 303 Students

**ZR Middle School Summer Program 2014**
- Expansion to 9 states (added AL, MD, OH, TX)
- 49 teams
- 505 Students

**ZR Middle School Summer Program 2015**
- Expansion to 11 states (added WV and OR)
- 57 teams
- 602 Students

**ZR Middle School Summer Program 2016**
- 70 teams
- 700 Students

**ZR Middle School Summer Program 2017**
- 96 teams
- 930 Students

**ZR Middle School Summer Program 2018**
- 81 teams
- 750 Students

**ZR Middle School Summer Program 2019**
- 86 teams
- 850 Students

**Astrobee Transition 2020-2021**

**ZR -VIRTUAL Middle School Summer Program 2021**
- 24 teams
- 209 Students
- 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 Astrobee robots

https://www.nasa.gov/astrobee
Technical Implementation Approaches

**Programming Environment:**
Integrated Development Environment (IDE)
Text Editor & Graphical Editor available to Students

**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.
Summer 2022
Zero Robotics Middle School Game
The Great AstroSpelling Bee!
The MIT ZR Team performed 2 Granite Lab tests in April 2022
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)

1 2 3 4 5

6 7 8 9 10
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

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Base → site #8 → site #9

site #9 → site #6 → site #3

site 3 → site 2

site 2 → Base
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.
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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://zero.gravityfilm.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 25th, 2023
Please visit us on zerorobotics.mit.edu for more information!
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!