ZERO ROBOTICS
SPHERES ISS CHALLENGE

A robotics programming competition aboard the International Space Station

Zero Robotics (ZR) is a robotics programming competition that utilizes the SPHERES Facility both on the ground and **aboard the International Space Station** (ISS) to create an outreach program **for grade school students** and enable crowd-sourcing for SPHERES investigations. By participating in the program students build critical engineering skills such as problem solving, design thought process, operations training, team work, physics, mathematics, and, of course, programming.

2011 HS Tournament ISS Finals

The Massachusetts Institute of Technology (MIT) Space Systems Laboratory (SSL), which originally designed SPHERES, runs the Zero Robotics program with our partners: Top Coder (TC), the Massachusetts After-school Partnership (MAP), and Aurora Flight Sciences Corporation (AFS). ZR gains access to the ISS through agreements with the Center for the Advancement of Science in Space (CASIS) for use of the International Space Station (ISS) and with DARPA & NASA as government sponsors for *upgrades* of the hardware available aboard the ISS for Zero Robotics.

The MIT SSL and our partners intend to create a self-sustaining program funded through sponsorships and donations to the Institute, specifically directed to support Zero Robotics. This support enables the partners to create a team of dedicated staff to ensure growth of the program nationally. The staff team will work directly with the Principal Investigator and a team of graduate students who bring in new ideas and hardware as part of the DARPA/NASA sponsorships. The staff will address general program management, system administration, event management, curriculum development, program evaluation, program outreach, and creation of new partnerships.

Zero Robotics reaches out to grade school students through *software competitions* which culminate with the testing of student-programs aboard the ISS in *zero*-gravity. ZR provides an online programming environment which does not require the installation of any special tools nor the purchase of software licenses or entry fees: *zero* also stands for zero-cost and zero-configuration.

Zero Robotics tournaments consist of several steps: programming in simulation; elimination rounds, and finals aboard the ISS. All participants first program and test their programs in the ZR online simulation. Depending on the age range, different elimination rounds take place, including in some cases creation of alliances between teams. In all cases the finalists will have their code tested aboard the International Space Station. In each step students write programs that control a SPHERES satellite in a sequence of more realistic environments: 2D simulation, 3D simulation, and in hardware aboard the ISS.

The Zero Robotics infrastructure is based completely online. Students participate in ZR by writing programs on the Zero Robotics website. The students use either a graphics based, high level language (HLL) or directly program in the C language. The website Integrated Development Environment (IDE) creates a bridge between the detailed SPHERES Application Programming Interface (API) and high-level calls that allow grade-school students to play the Zero Robotics game. The HLL makes a second bridge by removing the complex syntax requirements of textual C programming and creating graphical representations of the C language constructs.

Government Sponsors

DARPA & NASA sponsored all original Zero Robotics competitions and continue to sponsor *upgrades* of the program, which will provide new hardware for use aboard ISS!

The ISS is a National Laboratory operated by NASA. The SPHERES Facility is managed by NASA Ames Research Center.

ISS Utilization Sponsor

Zero Robotics has access to the International Space Station through agreements with the Center for the Advancement of Science in Space.

Zero Robotics consists of three main types of competitions:

- High School Tournament - an open competition that runs through the Fall (September to December) where a national audience of high-school teams competes through several elimination rounds for the opportunity to reach the finals. The finalists' code is uploaded to the ISS where astronauts run the matches during a live transmission to the teams assembled at MIT (which is webcast from MIT over the internet).

- Middle School Summer Program - a five week summer program designed to immerse middle students into programming and the math behind micro-gravity physics (dynamics of spacecraft). During this program the students compete in different stages culminating in the finalists' code being run aboard the ISS by astronauts. The middle school program is in the pilot phase, with curriculum development ongoing to grow from a program centered regionally around MIT. The curriculum will allow expansion to other selected locations which can provide support to MS summer-school teachers. Curriculum development and testing will take place during 2012 and 2013. The program is expected to be present in multiple pilot locations in 2013 and start a national program by Summer of 2014.

- One or more "open challenges", to take place at different times during the year (based on both ground personnel and ISS crew availability) open to any person worldwide, to help develop algorithms relevant to SPHERES research objectives. Open challenges allow not just grade-school students but any interested party, to contribute to the research objectives of the SPHERES Facility. Open Challenges seek to use crowd-sourcing to enhance research aboard the ISS.

The standard calendar of Zero Robotics events is expected to have activities throughout the year by 2014 (possibly 2013):

Activity	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan
Game Design	■	■	■	■	■	■						
Middle School												
Mentor Training					■							
Summer Program						■	■					
ISS Finals							■					
High School												
Kickoff								■				
2D Competition									■			
3D Elimination Round										■		
Semi-Finals (Alliances)										■	■	
ISS Finals												■
Open Challenge		■	■									

Vision

Zero Robotics lets kids "touch space"!

Zero Robotics seeks to **inspire** students by allowing them to participate directly in the space program. Grade-school students will take the concept of working in space projects as "normal" and will grow up to push the limits of space exploration, engineering, and development. At the same time, we aspire to create a **change in society** by bringing arena robotics to new heights, literally: aboard the ISS. By leveraging this unique environment, arena robotics, where the brain is the muscle, shall become as engaging as regular sporting events. Zero Robotics shall reconnect society with the sense of wonder that comes from the stars and space travel. We accomplish this by **reaching** a national audience of different ages without any entry fees and creating learning opportunities without the need for prior experience. Further, we **create a bridge** between students and professionals by encouraging industry leaders to mentor the student teams. Lastly, Zero Robotics shall always maintain a close link to academic **research**, truly allowing students to become part of the space program.

Benefits

Zero Robotics directly addresses a clear national problem that fewer U.S. graduates are pursuing careers in science, technology, engineering, and mathematics (STEM) disciplines, while creating an important avenue to make the ISS reach across the nation:

- Allows educators and students to participate in the ISS mission
- Teaches programming concepts to students at the MS and HS level
- Encourages collaboration across different teams
- The no-cost/no-funding model allows access to underserved groups
- Actively encourages participation by professionals to mentor students
- Creates partnerships with Afterschool Networks, NASA Centers, other robotics competitions, and industry.

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