ZERO ROBOTICS

SPHERES ISS CHALLENGE

Robotics Alliance Working Group

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What is SPHERES?

- A Facility of the ISS National Laboratory with three nano-satellites designed by MIT to research estimation, control, and autonomy algorithms
- By working aboard ISS under crew supervision, it provides a **risk-tolerant** environment
- The satellites can be reused
  - Replenishable consumables
  - Multiple test sessions assigned per year
- If anything goes wrong, reset and try again!

ISS016E014220

If SPHERES is so "risk tolerant", why can't grade-school students use it? … they can!

What is Zero Robotics?

- Zero is for **Zero-G**: A competition designed to allow Middle- and High-school students access to the International Space Station through SPHERES
- Student teams write *programs* for the SPHERES to solve an MIT-designed challenge using tools on a dedicated website
- Inspired by *FIRST* team model with teams of students led by metnors
- Multiple elimination rounds, then top teams see their code tested aboard the ISS
- Zero is also for **Zero Cost**: no cost to participate

The parts of Zero Robotics

- All Zero Robotics Competitions have:
  - Several elimination rounds
  - Finalists' code tested aboard the ISS
- High School (grades 9-12) Tournament
  - **National open** competition
  - Runs through the Fall (Sep to Dec)
- Middle School (6-8) Summer Program (Planned 2013)
  - Five week summer program
  - Programming *and* physics/math curriculum
  - Currently requires substantial help to summer-school teachers
    - Mentors assigned to each participating school
    - **Centered regionally** around locations which can provide the necessary support.

History of the Zero Robotics Competition

Zero Robotics Pilot Program 2009
- Two high school teams
- 12-09-09 ISS finals

Zero Robotics Summer of Innovation 2010
- 200 middle school students
- 5 week curriculum
- ISS finals Aug. 2010

Zero Robotics SPHERES Challenge 2010
- First nationwide tournament
- 200 High School students
- 24 pilot teams from 19 states
- ISS finals 12-16-10

Zero Robotics Middle School Competition 2011
- First nationwide Middle School Tournament
- ISS finals Aug. 2011

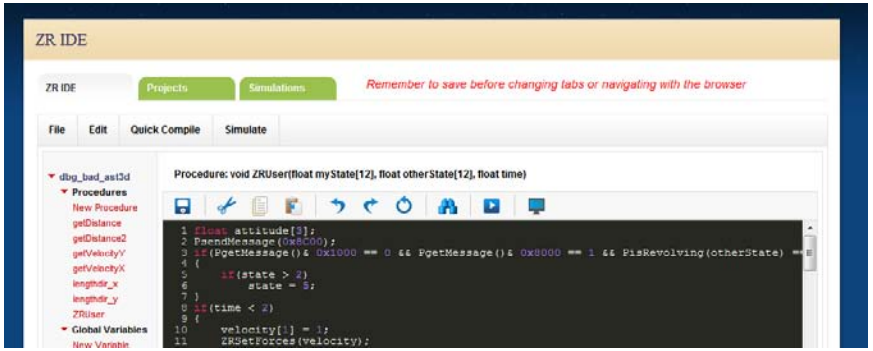
Zero Robotics SPHERES Challenge 2011
- 2nd nationwide tournament
- 1st European tournament
- 1000 High School students
- Teams from 30 states
- ISS finals 1-23-12

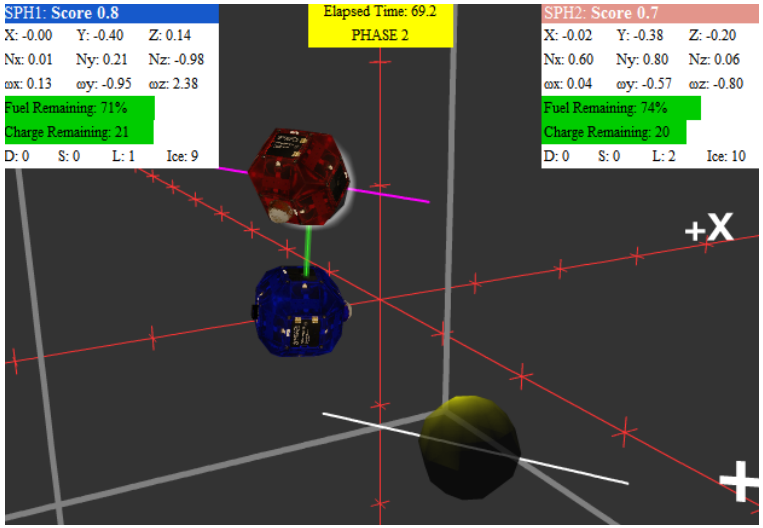
High-School Level

Middle-School Level

High-School Overview

- Fall Semester Tournament
  - A complementary “software” competition to “hardware” events like *FIRST*
  - Strongly centered around local mentoring support
    - Mentors are the Science/Math/Computer teachers and local engineer volunteers
    - Assumed that Mentors can teach programming
- Full programming experience, all from a web browser
  - Both graphical and text programming available
  - ZR provides basic online tutorials, mentors support with additional teaching (working to improve)
- ZR Team supports online
  - MIT undegraduate and graduate student support online (e-mail, forums)
  - Forums allow teams to support each other





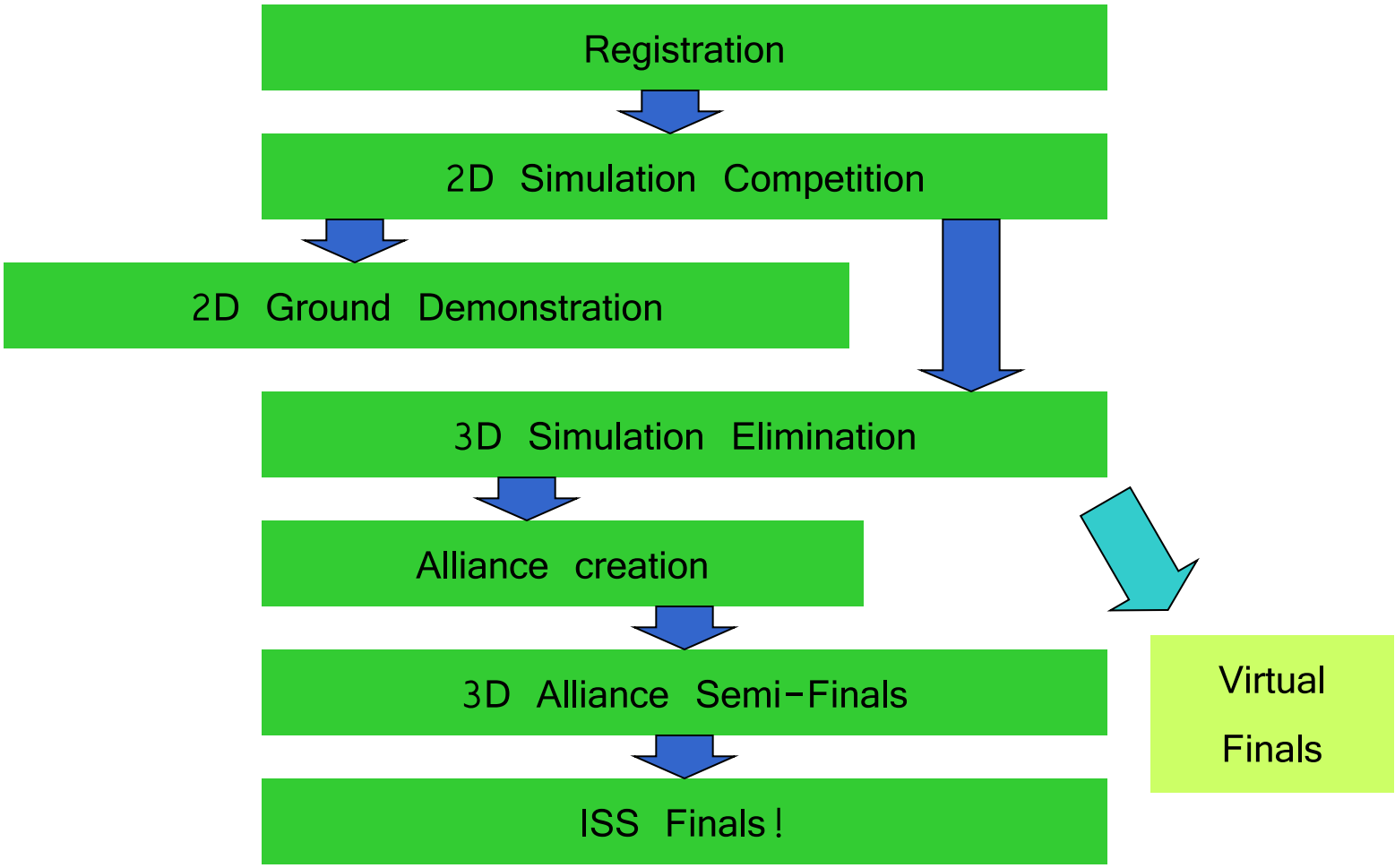
Website Resources

- **Website:** http://www.zerorobotics.org

- **Tournaments:** a list of upcoming tournaments and links to registration forms.
- **Resources:** provides several tools to get started
  - Tutorials to get started with programming and using the website
  - Looking for a team? and Looking for a Mentor? forum links
  - Manage team information
- **Forums (Account Required):** communicate with other teams
- **Support:** submit problems or questions directly to the ZR team
- **Learn More:**
  - News articles about ZR
  - Meet the ZR team
  - Learn more about SPHERES
- **Contact zerorobotics@mit.edu for additional assistance**

HS Tournament Overview

April – Sep
September
October
November
December



Note: Due to ISS availability, the 2011 ISS Finals may take place in January

HS Application Process

- Application window: mid April 2012 to first code deadline (Sep)
- Step 1: Create personal accounts
  - Teachers and any students who will program create their own account
  - Can start using the website as soon as account is created!
- Step 2: Primary Team Mentor registers the team
  - Invite additional students to the team using website tools
- Application contents will include:
    - Contact information for the team including the primary team mentor
    - Names, availability and brief description of mentors
    - Student written application essay
    - Demographics and background of the team (aggregated; not individual)
    - Commitment by primary mentor to provide support and infrastructure to the team
- All teams with ability to support the team will be accepted

Apply starting mid April; can start using the website as soon as account is created!

Tournament Kickoff

- MIT hosts a live webcast
  - Unveiling of the season's challenge and details of the tournament
  - Game available online after the kickoff
- Game documentation available online
  - Game manual
  - Game tutorials
- Live Q&A at end

HELIOSPHERES
ZERO ROBOTICS SPHERES CHALLENGE 2010

AsteroSPHERES

Zero Robotics 2011 Game: AsteroSPHERES

2D Competition

- The game is initially restricted to 2D
  - Several “standard players” will be released so participants can test their code
- All teams submit their projects by the code submission deadline to qualify for the next part of the tournament
- An automated scoring system ranks the teams
  - Based on performance in head-to-head matches
  - All matches viewable online
- Top teams will have their 2D code *demonstrated* in the SPHERES ground satellites at the MIT SSL
- 2D Ground *Demonstration*
  - Shows to teams the differences between simulation and real hardware
  - Does *not* count towards future rounds, only for demonstration purposes
  - The ground demonstrations are recorded and posted online together with the simulation visualizations

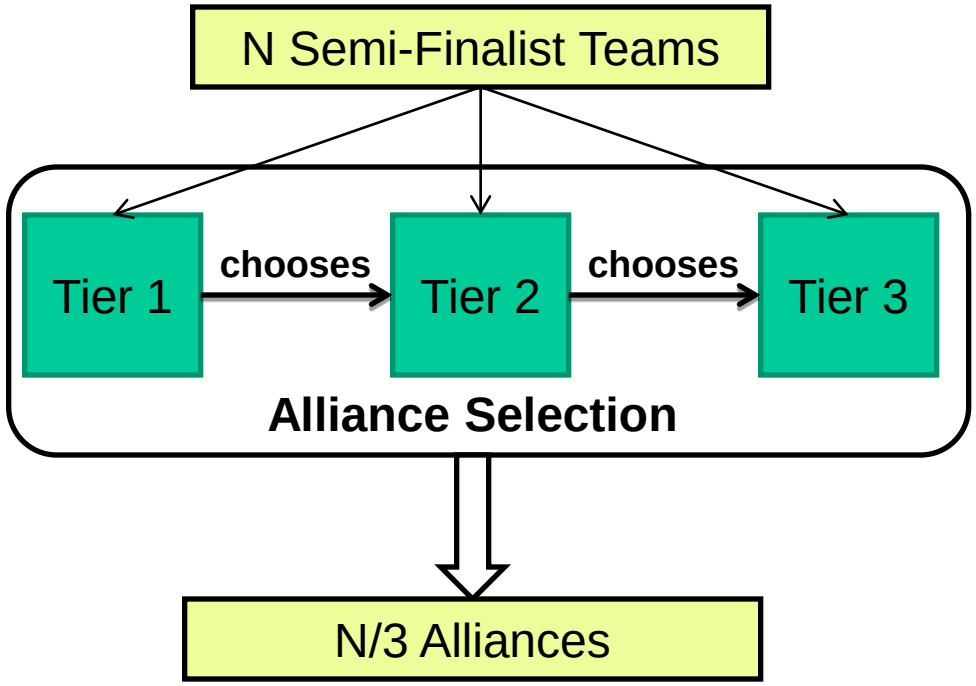
HS 3D Competition

- The 3D competition is an evolution of the 2D game into the 3D domain
  - Extra code required to complete the game
  - Additional game features, but not a completely new game
- Simulated competition in the same format as 2D competition
- Team ranking:
  - A weighted combination of 2D and 3D performance
  - Exact format TBA at kickoff
- This is the **first elimination round**
  - Only the top teams will continue to the semi-finals
  - The top teams (number TBA) will form *alliances...*

The first elimination occurs after the 3D Round Robin

HS Alliances

- Space station time is hard-limited in crew availability
  - About 2 hours to run competition = approximately 10-15 matches
- Objective: maximize number of teams represented in Finals
  - Each alliance sends one “player” to ISS, increasing number of teams represented aboard ISS
  - Requires teams to collaborate in creating the final “player”
  - Additional round of competition to select Alliances for ISS
- Plan to have a “draft day” to form alliances



2011 Alliance Selection Process

Allowed 27 teams to participate aboard ISS in 2011 Finals!

HS Semi-Finals

- Newly formed alliances collaborate to complete final phase of competition
- **New tasks** released in game for alliance to program
- The ZR Website is undergoing major upgrades to improve collaboration
  - New programming interface features allow multiple people to work on the same project
  - Upgraded forums, chat tools, and synchronization between projects for real-time interaction between students
- Automated competition in simulation
- Alliances will be ranked by performance only in 3D Semi-Finals
  - Top alliances (~10, TBD) will be selected as ISS finalists...

The semi-finals are the final elimination round to select the ISS Finalists - all finalists are Alliances

ISS Finals

- Finalist teams have about 2 weeks to refine their code
- Final code submission deadline to allow MIT to test integrated code and send code to ISS
  - There will be an upper limit on the code size - alliances must program efficiently
- Game strategies collected from each team and sent to NASA
  - For public release
  - To the ISS astronauts
- Final broadcast **live** direct to MIT and re-cast by MIT online
  - All teams (finalists and other) invited to MIT for finals (at cost of teams)
  - Special rules for the ISS Finals published in game manual
- Champions determined in real-time based on ISS results
- New idea for 2012:
  - Considering running virtual finals in parallel with ISS challenge to fill dead time

How RAP Can Help

- Near tearm: Publicity
  - ~100 teams participated in the program last year
  - Targeting 400-500 teams this year
  - Need as many outlets as possible to spread the word
- Regional Support Contacts
  - Network of local contacts for teams who want to get started
  - Help pair mentors with teams, establish teams in local schools
  - Built into the website so teams can easily locate help
- Primary Mentors
  - Help start a team or mentor a team
- Long term (2013): SPHERES Experts
  - For Middle School competition, we expect more support will be needed
  - Goal is to establish local experts to help with training middle school mentors
  - Initial training at MIT

ISS Finals

Questions?

zerorobotics@mit.edu