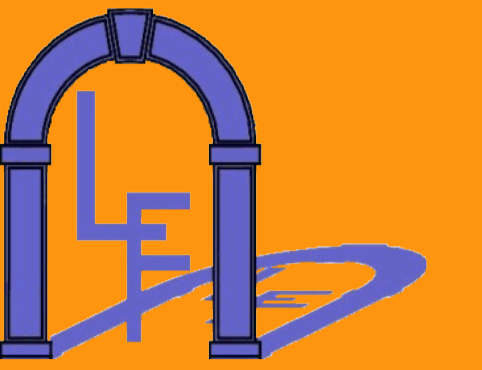


ZERO ROBOTICS: A LAUNCHING RAMP FOR HIGH SCHOOL STUDENTS TO STEM UNIVERSITY FACULTIES



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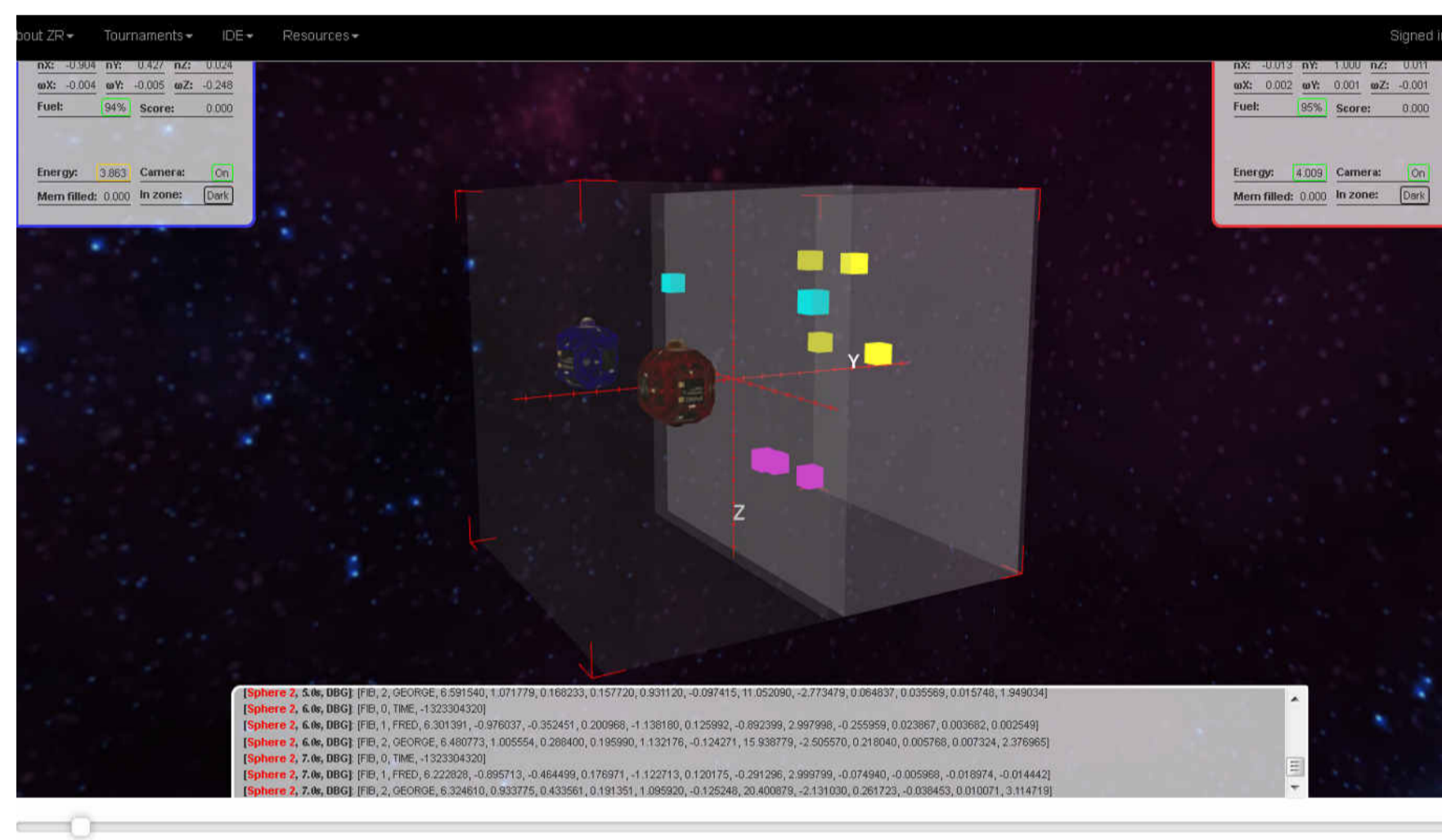


The High School Liceo "E.Fermi" students driving real mini-satellites on ISS

WHAT

Since 2009, Zero Robotics (ZR) is a High School competition focused on programming and driving SPHERES in a zero gravity environment. The SPHERES are small satellites inside the ISS that NASA and MIT's scientists use to study the possibilities of robots' self-organization in a practical and economical manner. In the near future robot satellites will be used in space activities such as maintenance activities and/or recovery of disused satellites or their parts, space debris collection, preparation of large-scale experiments [1]. MIT and NASA give students the opportunity of working with these SPHERES and face with real space challenges in a tournament involving more than 140 teams [2]. The educational aim of the competition is to involve as many students as possible to face and solve problems with unconventional methods typical of scientific research and encourage an informed and positive attitude towards space activities. Teams are formed of 3 to 20 students, led by a teacher-mentor.

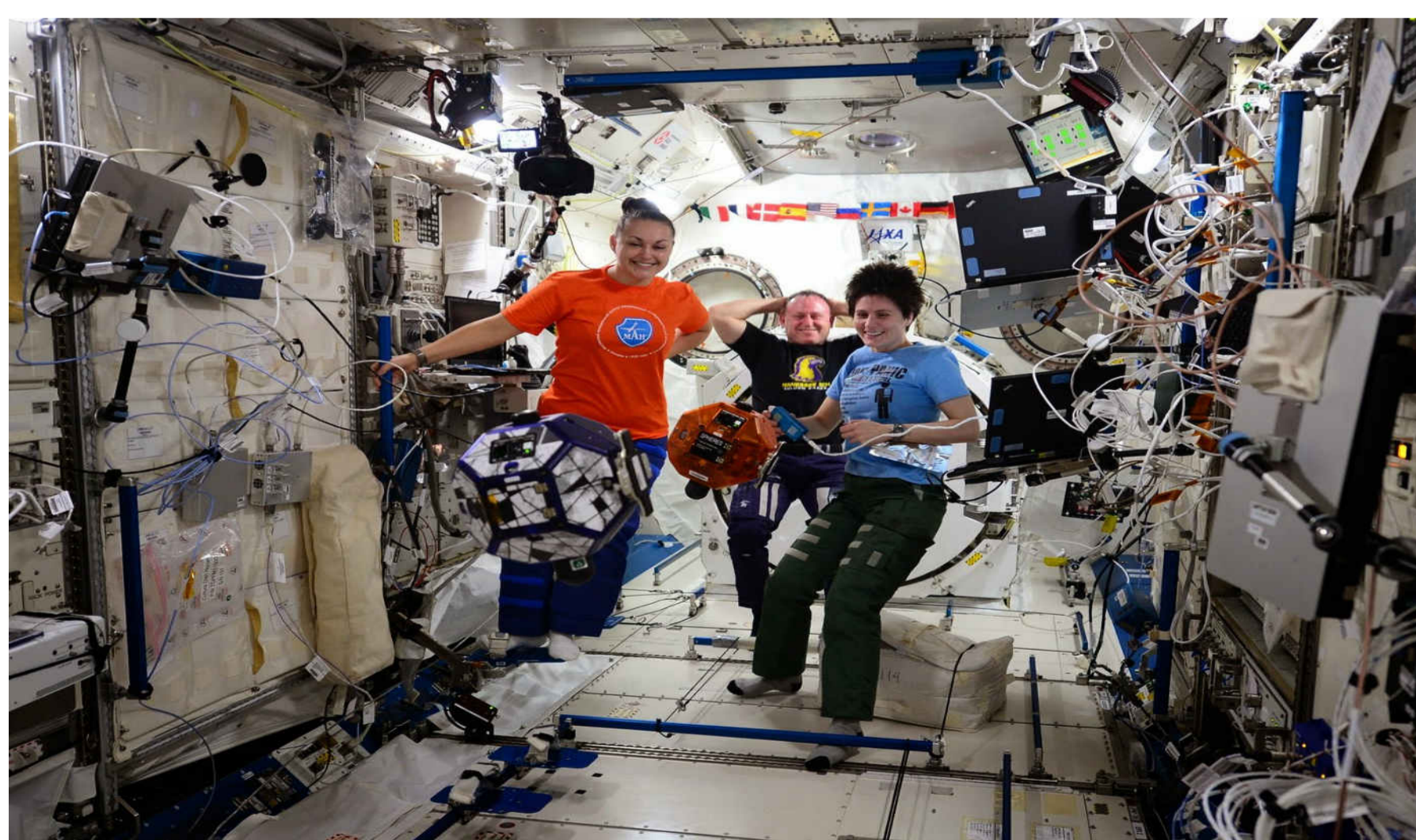
Teams of Liceo Scientifico "E.Fermi", Padova, have participated since 2010, reaching excellent results (two first places and one second place in the European finals). Our school experience shows that such activities help students to validate their choice of University career path in science faculties.



ZR web simulation environment

HOW

Students have to write a C++ code on an IDE platform provided by MIT, using the API set prepared for the game in order to drive the SPHERE to accomplish some task. Codes can be tested in a virtual environment that mimic real space situations and the game conditions (this year they should take pictures of the opposite satellite, taking into account the periodic change of sunlight, energy and fuel amount). Matches are played daily in a win/lose format between two SPHERES and the leaderboard is updated consequently. The tournament develops from September to December in selective steps. In November, teams must then group together in international alliances formed by three teams each, and continue the tournament to establish the 14 alliances that will upload their codes on the real SPHERES on ISS, where the astronauts-referee will supervise the finals.



A final match running on ISS under surveillance of Samantha Cristoforetti, Elena Serova e Barry Wilmore (Jan 2015)

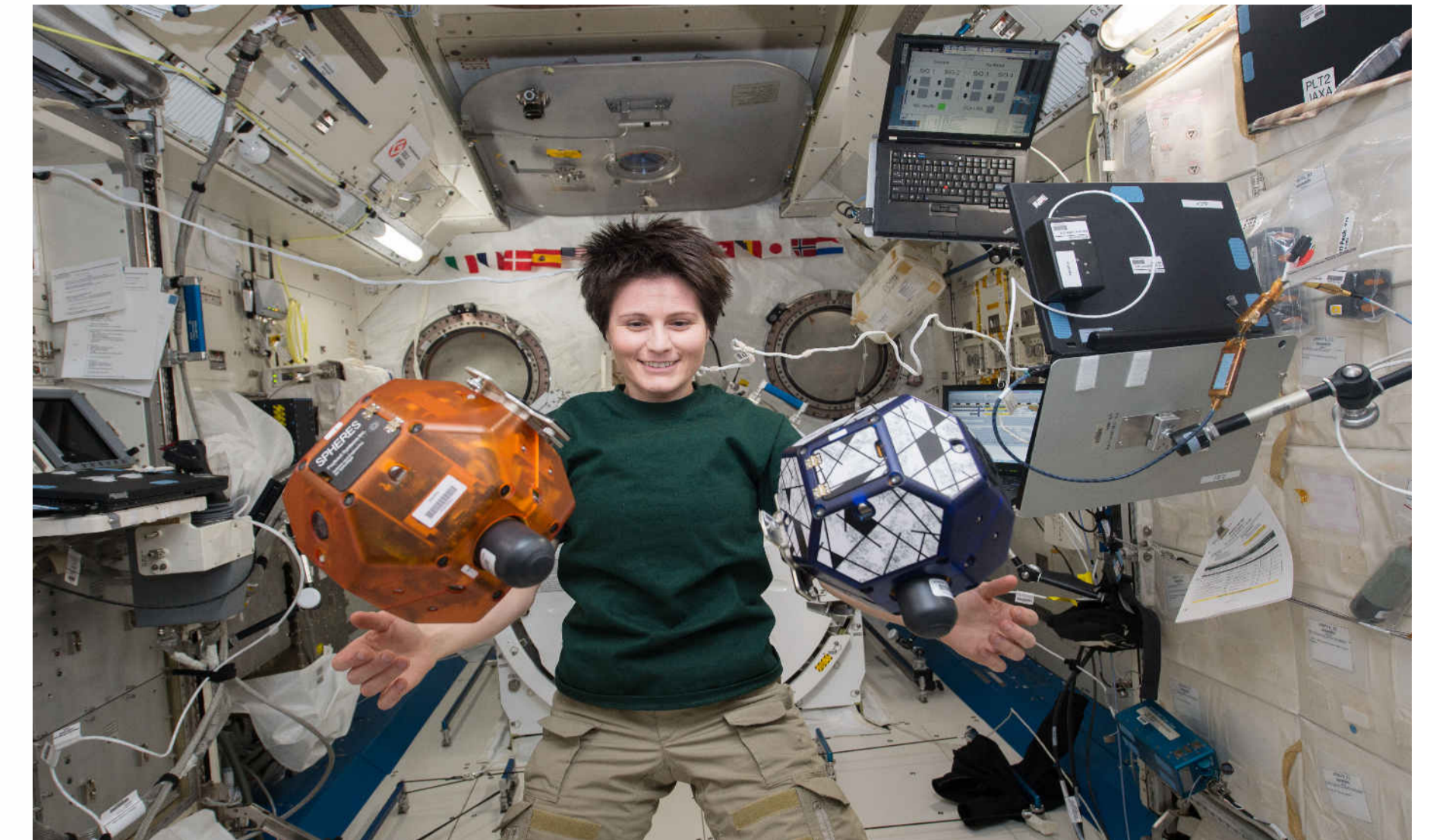
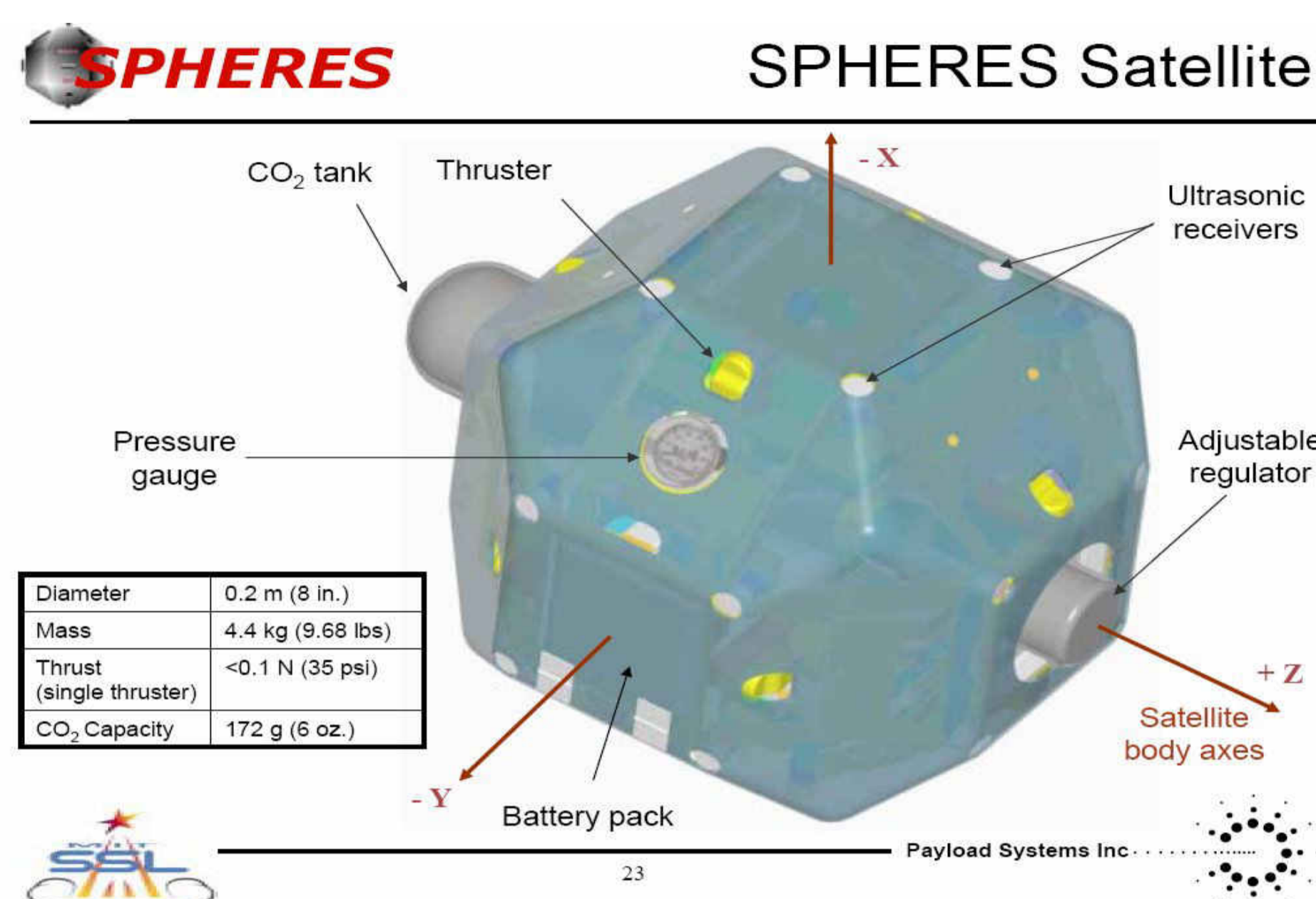
Robotics is particularly suitable as a linking field between High School activities and University research. Its application to space exploration is extremely exciting and motivating for the students, but we believe that it's possible to find many other collaboration areas in space research. As for example: data collection and analysis; simulations; construction of small mechanical and electronic equipments. Zero Robotics is organized in Italy by a Guidance Committee composed of Politecnico di Torino, Università degli Studi di Padova, Istituto Italiano di Tecnologia IIT@POLITO, Rete Robotica a Scuola, Ufficio Scolastico Regionale per il Piemonte, Agenzia Spaziale Italiana. It is an excellent example of how a strong collaboration between High School and University can be developed and we hope it encourages the dissemination of other similar experiences. ----- High School teachers are ready ! -----

References and infos

- History of SPHERES: <http://www.nasa.gov/spheres/history.html>
 - MIT's Zero Robotics website: <http://zerorobotics.mit.edu/>
 - Main SPHERES characteristics and a complete list of articles on SPHERES on <http://www.nasa.gov/spheres/satellites.html>. Other technical info on: <http://ssl.mit.edu/spheres/>
 - Website of Morpheus Project: <http://roverunipd.wix.com/morpheusteam>
 - Roberto Mancin (Servizi Informatici del Centro d'Ateneo di Ricerca e Servizi per la Disabilità, la Riabilitazione e l'Integrazione, University of Padova), "Baby-Goldrake@pediatria.unipd.it: a study about Pediatric Robots (Social & Educational Robots)", <https://www.facebook.com/notes/10155605655715444/>, 2015.
 - Experience and informations reported on fb pages of Liceo Fermi team: <https://www.facebook.com/Nao-BabyGoldrake-Liceo-Fermi-Padova-768153083220918/?fref=nf>
- Acknowledgments: many thanks to all ex-ZR students for their collaboration; to Alessandra Baciga and Lorenzo Drago for texts revision.

SPHERES

(Synchronized Position Hold Engage and Reorient Experimental Satellite)



Samantha Cristoforetti with two SPHERES on ISS (2015)

SPHERES are mini-robots equipped with twelve carbon dioxide thrusters for autonomous propulsion that allow precise manoeuvring in a zero gravity environment; an ultrasound system to collect kinetic data from the beacons installed in the test area inside the ISS' Japanese module which is activated periodically by means of infrared impulses; a wireless link to a laptop that controls the SPHERES' processor [3]. Students provide the code to drive a SPHERE against another in matches played in a virtual environment first, and then on ISS for the finals, in definite time and space limits (time = 180s; space = 1.3m x 1.6m x 1.3m).

University faculties attended by ex-Zero Robotics students (since 2011)

	Faculty						Tot
	Engineering				Math	Physics	
students	Aerospace	Mech	IT	others			
attending Master courses on	1	1	1	2	-	-	5
attending Bachelor courses on	2	1	3	2	4	2	16
Tot	3	2	4	4	4	2	21

WHY

The ZR challenge develops skills and working abilities needed for real scientific research:

- teamwork and cooperation capabilities in an international environment;
- ability to collaborate and provide mutual support between teams in the game (by means of the dedicated forum, for example), but at the same time to maintain a certain degree of competitiveness;
- technical skills: math, physics, programming, communication in English;
- problem solving skills;
- ability to adapt to changes, to face with unexpected events and to consider the troubles of life (server downtime, class assignments; sickness; computer malfunctions) as a part of the problem without forgetting the objectives;
- ability to work with the ZR staff to manage the structure of the game itself (e.g. bug reports; propose changes to game rules);
- the need to choose between different options;
- ability to meet deadlines.

RESULTS: impact on school

The four year commitment of our school in ZR give very interesting results. We started with 10 students and 1 teacher, now we have about 40 students, 3 ZR teams and 5 teacher; we're preparing a robotlab and other projects; last May another team won the first prize at the NAO Italian Challenge 2015 and today that team is involved in a University project for the use of the NAO humanoid robot in pediatrics for the assistance of young children waiting for major operations, or just after them, during the convalescence period [5] (a project noted by Microsoft's CEO Satya Nadella himself). With ZR and NAO we participated in two editions of the *Maker Faire* (Rome), the biggest fair of innovation in Europe [6].

NEXT

RESULTS: impact on University

In Table 1 the choices of students engaged in the ZR. A significant percentage (3/21) has chosen the Aerospace specialization. For some of them it has been just the result of their participation in the ZR competition. G.Scomparin (3rd year Bachelor degree in Aerospace Engineering, Padova Univ.) said: "Zero Robotics was really a great experience for me. It gave me an idea of what working in a team means and made me think in a different way about mathematics, physics and programming, since I had the opportunity to apply them to real-world problems. After the challenge I was 100% sure that I wanted to work in the space field" and G.Mingardo (1st year of Master in Science Aerospace Engineering at TU, Delft): "ZR has been the starting point to choose Aerospace Engineering, from which I then achieved my current specialization in Flight Performance and Propulsion". Even students who have chosen other specializations maintained special attention to space activities: I.Naranjo De Candido (1st year Master in Mechanical Engineering, Pisa Univ.) attended a summer internship at JPL; she said "Zero Robotics has been a great opportunity for me. It made me become fascinated with space exploration history and current space programs [...] This summer I had an internship at Jet Propulsion Laboratory that made me confirm the interest in space and engineering research, started with the Zero Robotics experience". S.Fogarollo (2nd year of Bachelor degree in Information Engineering, Padova Univ.) is a member of the Padova University Morpheus Team whose task is to build a fully functional rover [4].

