Student Space Activities at UNSW Canberra

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Keyword: Propulsion, fluid dynamics, space situational awareness, astrodynamics, formation flying.

High-speed flow has been an internationally-recognised research strength at UNSW Canberra for over 25 years, with a focus on hypersonic aerodynamics to aid the development of re-entry vehicles and novel ignition methods for Scramjet engine combustion. The last two years have seen the birth of a space research and development program at UNSW Canberra, lead by a team of engineers with a combined 45+ years of experience on international planetary, orbital, and sub-orbital missions. This program has resulted in a significant increase in space research projects available to students within Australia and provides the opportunity to contribute to in-orbit missions, with a minimum of four nanosat missions to be flown by 2020.

The first PhD project of the space program was undertaken by Courtney Bright in 2014 and combines the university's high-speed flow expertise with spacecraft navigation and control. Ms. Bright is investigating fluidic thrust vectoring for chemical spacecraft propulsion - a technique that has previously only been considered for supersonic aircraft, missiles, and rockets. Fluidic thrust vectoring, shown in Figure 1, involves asymmetric injection of a secondary fluid into a supersonic nozzle to deflect the thrust through an oblique shock wave and momentum of the secondary fluid. The aim is to improve the efficiency and precision of spacecraft maneuvering by maintaining correct alignment of the thrust vector without the need for additional thruster burns. Analysis combines numerical simulation with validation experiments using UNSW Canberra's thermal vacuum chamber and a biaxial thrust stand that Ms. Bright is developing as part of her PhD.

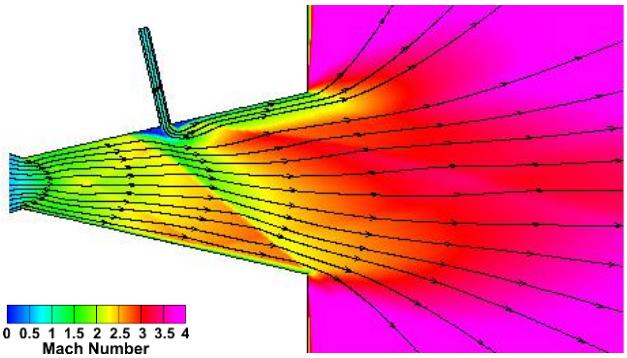

Figure 1. Fluidic thrust vectoring nozzle exhausting into vacuum, 5° vector angle

The team of space PhD students has now expanded to include students working on spacecraft thermal interactions with extra-terrestrial planetary environments, propellantless control of small satellites, and development of high-fidelity astrodynamics simulation software for satellite formation control and space debris tracking. Research projects for future students are currently available in the following areas:

- Spacecraft and mission design and analysis
- Space situational awareness
- Astrodynamics simulations
- Orbital and re-entry aerodynamics
- High-speed flow experimentation with advanced diagnostics
- Advanced space-based instrumentation
- Spacecraft thermal control
- Propulsion

- Active debris removal techniques (e.g. harpoon capture of space debris)
- Satellite formation flying
- Multi-disciplinary design optimisation
- Advanced imaging and remote sensing systems
- Ground-based optical telescope and passive radar space surveillance/tracking
- Guidance, navigation, and control of unmanned vehicles
- Thermal and structural analysis

Our student projects are supported by the following ground-based facilities:

- Class 100 clean room for spacecraft assembly and integration
- Thermal vacuum chamber laboratory with two chambers
- 6.6 kN shaker table
- Electronics workshop
- Space-based instrumentation laboratory
- Satellite ground station (UHF/VHF/S-band, under-construction)
- Falcon Telescope
- 64-core workstation for simulation developments
- T-ADFA free-piston shock tunnel

A team of our PhD students are also working on the design of a low-cost, low mass, pathfinder mission to Venus for in-situ atmospheric measurements. The aim of design is to form a basis for multiple future missions, allowing essential data to be gathered in advance of larger missions and enable participation of universities and developing nations in interplanetary missions. The proposed concept of operations is illustrated in Figure 2. The Venus Atmospheric Pathfinder Research Vehicle (VAPR) will be piggybacked to geostationary transfer orbit before commencing a low-thrust Earth to Venus transfer. Upon reaching Venus, the spacecraft will enter a highly elliptical orbit where the measurement phase of the mission will begin. Aerobraking will be used to reduce the semi-major axis of the elliptical orbit through successive passes of the upper atmosphere, while the payload suite is utilised for atmospheric measurements. As the temperature of the spacecraft reaches the operational limit of the on-board equipment, VAPR will take a final mission-ending dive with data transmission continuing for as long as possible. The initial design concept will be presented at the Pre-MIC4 Mission Idea Contest and will be further developed over the coming year.

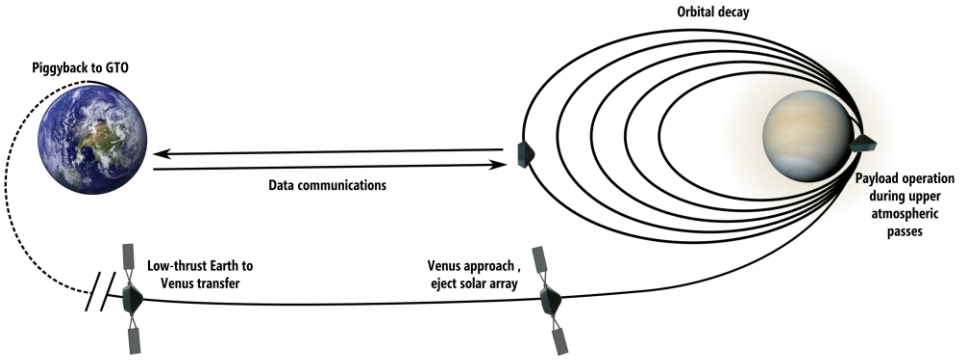

Figure 2. VAPR concept of operations

In addition to space research degrees, UNSW Canberra offers two specialised Master degree programs, in both distance education and intensive delivery modes – the Master of Space Engineering and the Master of Space Operations. The programs are designed for graduates or professionals who wish to develop a high level understanding of the principals and practices of space systems planning, engineering, and operation. Core topics include space systems design and engineering, space operations, satellite communications, global navigation satellite systems, spacecraft testing, and spaceborne imaging technology. Extensive use is made of real-life case studies from the experiences of UNSW Canberra and guest lecturers, which includes over 20 international space missions.

UNISON-Egypt: a look into space education future

Egypt/Africa
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Keyword: Project-Based Space Educations, Basic Space Technologies, Rovers, Capacity building

This presentation will show our **current work** and **future hopes**, and dreams for **space education** in Egypt in general and UNISON-Egypt in particular. It will shed some lights on the **activities** of Space Systems Technology laboratory (SSTLab) in Cairo University such as CanSat training program, Cube satellite systems, quad-copter, rocket motors design and international competition participation and the lessons learned from such activities. The talk will also include our future plans for building audience and reaching more people and financially supporting SSTLab and UNISON-Egypt.

Space Systems Technology Laboratory (SSTLab) is a student based organization at Aerospace Engineering Department, Cairo University, which was established in August 2011. SSTLab trusts it's students and think that they can serve its' main target to found a space technology education in Egypt and be able to achieve its dream to found a governmental space-based foundation. Our vision is represented by this Quote: "*Tell me and I forget. Teach me and I remember. Involve me and I learn*." Benjamin Franklin.

Figure 1: CanSat Training program CTP5

This year, the laboratory began with some Project-Based Space Educations programs to build the critical capacity required for that purpose, SSTLab started with (CTP5) as it provides an affordable way to acquire the students with the basic knowledge to many challenges in building a satellite. Last year 12 people attended the program (CTP4) and made the finest ones in the lab. SSTLab continues the CanSat training series by choosing a teaching team from the educated students last year to deliver the program CTP5 to the youngest ones. Training course (CTP5) was organized to 21 students from different universities, including Cairo, Alexandria and MSA universities, in the period from January 27 to February 9, 2015.

Several technical topics were covered in (CTP5) such as programming with Arduino microcontroller board, using different types of sensors: mems IMUs, temperature, pressure and others, design and implementation of ground stations, design and fabrication of structure and recovery systems and design and fabrication of PCB electronics. CanSat Design and Build Competition is organized for the 21 students, they were dividing into five teams whose CanSats will be tested in April, 2015. SSTLab aims to enter the ARLISS CanSat Competition with the winner design.

Another more advanced project is "CubeSat", this year (2015) is considered to the forth development iteration after the first early one in 2008, the second one in 2013 and the third one in 2014. Undergraduate students in second year started this forth development cycle. They aim to build the CubeSat with a new technique. Their mission is a data acquisition. They use Raspberry Pi 2 as an onboard computer. The CubeSat will communicate with several satellites and the range of ground station will be around 600 km. First module will be finished in July, 2015 then further development will be occurred. They aim to participate at the following MIC competition.

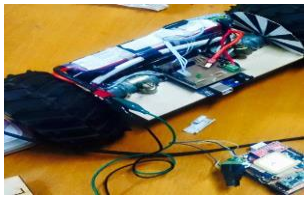

Figure 2: Rover prototype

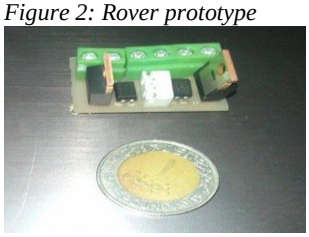

Figure 3: First prototype of motor control module of the rover

SSTLab also continues the rover back full program started last year (2014). The lab hold "Rover Back" training program including two major sub-teams: mechanical and electronic. The mechanical sub-team modified the last model which participated in ARLISS competition last year (2014). They developed the stabilizer system of the rover and solved the problems concerning with fixing the hub of the motors with the wheels. Their next steps are to solve the power problem and design the parachuting system. The electronic subsystem solved the problem of large size of the components. They made a BCP shield for the sensors. They design a small H-Bridge circuit, that controls the rover's motors to rotate clockwise or counterclockwise, instead of buying one. They designed a PCB for the power system. Their next step is to design and make a specific macro-controller instead of using Arduino board which is large in size and weight and contains a lot of unneeded functions. They aim to participate at the next ARLISS competition in September, 2015.

Figure 4: The huge reduction in the rover's components

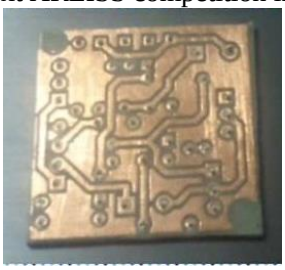

Figure 5: The H-Bridge circuit

Figure 6: Last year (2014) Quad copter test

Last year (2014), Quad copter was manufactured in the lab, There were three teams which learnt manufacture and control design of Quad copter by different types of control techniques: Classic, Modern and Fuzzy. This year (2015), the three teams are working on the development of these techniques using 1-D stand. They will make educational sessions for undergraduate students in April, 2015.

Figure 7: 1D test for fuzzy control

Using the innovation of our members and simple tools, we managed to make a CNC machine with high specification: large work area, dual motors on the Y axis, standard, dual Maker Slide on the X, gantry improves stiffness, completely redesigned Z axis makes changing bits easier and improves stiffness, open front and back for larger materials, easy to expand, easy to assemble and improved belt design keeps dust out of teeth. We improved its ability to of drawing PCB lines.

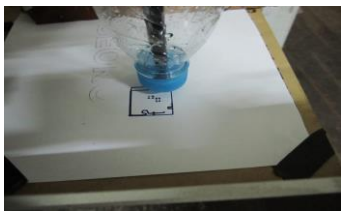

Figure 9: Testing our CNC machine ability of drawing PCB lines

Figure 8: Milling our logo with our shapeoko 2 CNC milling machine

SSTLab's future hopes are spreading the importance of the space applications by making educational events to the undergraduate students. Making undergraduate space project and graduation projects such as Cube-Sats, Can-Sats, Rovers, Quad-copters and Rockets will be a powerful tool to make the students engaged to space activities and qualified to work in space industry after the university. It also encourage undergraduate students to participate in international space competitions. Making simple sessions and projects about space applications for students in high schools will encourage them to study aerospace by entering the AE department. In the next year, SSTLab seeks to increase its' ability and capacity to get more and more students to its' project-training programs, as the lab got more good reputation in Engineering-based universities

SSTLab also have plans to share its' knowledge and experience with other UNISEC-Egypt universities. it can provide trainings such as CanSat and Rover Back category to transfer such knowledge .

Electric propulsion system on a Cubesat – ongoing student satellite projects

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Keyword: UWE, NetSat, CubeSat, Electric Propulsion, Formation

Two different satellite projects are currently in development in the region of Wuerzburg, Germany. UWE-4 (**U**niversity **W**uerzburg **E**xperimental-satellite) is a 1U-CubeSat project at the Julius-Maximilians University with the mission objective of achieving attitude and orbit control using an electric propulsion system in the pico-satellite regime. NetSat (**Net**worked Pico-**Sat**ellite Distributed System Control) is a space project with the goal of 3D formation flying using pico-satellites at the Zentrum fuer Telematik in Gerbrunn, Germany.

A central part of both projects is orbit control of the spacecrafts and thus the incorporation of a propulsion system. For this reason several propulsion technologies have been taken into consideration for their suitability. On the one hand the mission requirements imply a certain Δv capability on the propulsion system. On the other hand the CubeSat Standard Specifications[1] put constraints on several aspects such as e.g. physical size, mass and propellant storage.

A Vacuum Arc Thruster (VAT)[2] and a miniaturized field emission electric propulsion system (NanoFEEP)[3] have been investigated experimentally and their integration into the UWE platform has been implemented in CAD software and analyzed for thermal balancing and mechanical stress by students of the Joint European Master program "Space Science and Technology" at the Julius-Maximilians University. The CAD model of UWE-4 with integrated NanoFEEP thrusters is shown in Figure 1. A simulation has been implemented for a de-orbiting maneuver using four NanoFEEP thrusters integrated in the UWE platform as depicted in Figure 1. The result of the simulation is shown in Figure 2. The presentation will summarize the different aspects of investigation done by an international student team in different thesis works.

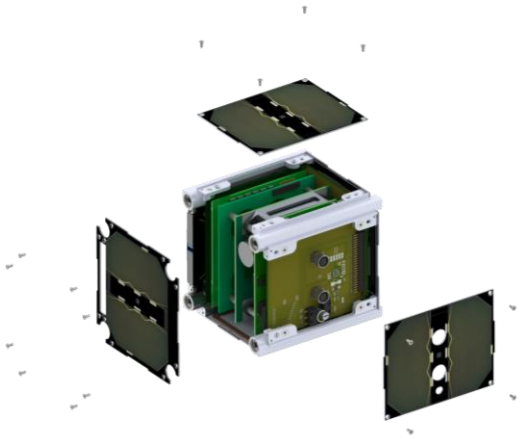

Figure 1: The UWE 4 CAD model with four NanoFEEP thrusters integrated in the bars.

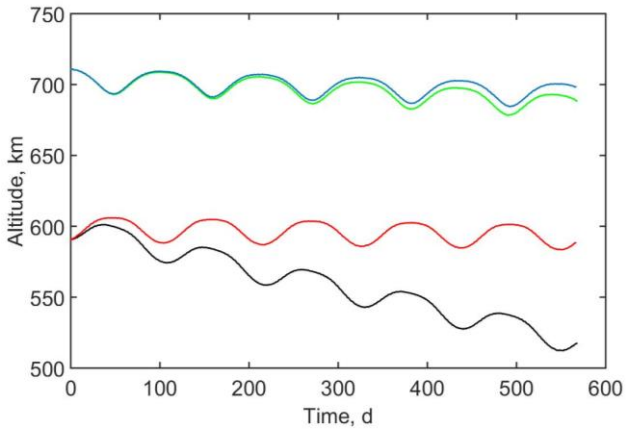

Figure 2: This figure shows the natural progression of apogee (blue) and perigee (red) in comparison to the apogee (green) and perigee (black) progression using NanoFEEP thrusters for a de-orbiting scenario.

References:

[1]"*CubeSat Design Specification Rev. 12*", California State Polytechnic University, Retrieved 2015-05-26.

[2]Kronhaus, I., Schilling, K., Jayakumar, S., Kramer, A., Pietzka, M., and Schein, J., "*Design of the UWE-4 Picosatellite Orbit Control System using Vacuum-Arc-Thrusters",* presented at the 33rd International Electric Propulsion Conference, October 6-10 2013, Washington, USA.

[3]Bock, D., Bethge, M., and Tajmar, M., "*Highly miniaturized FEEP thrusters for CubeSat applications*," Proceedings of the 4th Spacecraft Propulsion Conference,Cologne , 2014.

In-orbit experience with the UWE-3
Attitude Determination and Control System

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Keyword: Pico-Satellite Mission, In-Orbit Results, Attitude Determination and Control

The CubeSat UWE-3 (shown in Figure 1) was launched in November 2013 as the third satellite of the University Wuerzburg Experimental Satellite series. It was dedicated to demonstrate a new modular and robust satellite platform design, as well as to perform real-time attitude determination and control for the first time in this series.

Only hours after launch first signals were decoded and two-way communication established, followed by a sequence of experiments to characterize the satellite bus' performance. Having proven a very well positive power budget of the platform the ADCS was switched on for the first time about two weeks after launch. The first weeks of ADCS operations were dedicated to check the sensors and the satellite's movement, during which a natural rotation deceleration of about 0.5 deg/s per day was discovered. In January 2014, in-orbit calibration of the magnetometers was achieved and a first consistent attitude determination with an accuracy of about 5 deg was in place. The in-orbit calibration was necessary although calibration efforts were made prior to launch. It was found that predominantly an offset of the magnetic field could be measured, indicating that the magnetic field within the satellite changed.

Having established a well working attitude determination, the satellite's movement became again focus of the operations, this time because a motion dominating torque was seen to be acting on the satellite. By mapping this torque to the instantaneous magnetic field it became clear, that the disturbance is caused by a residual magnetic dipole inherent to the satellite. By measuring the angular velocity and magnetic field simultaneous, an estimate of the dipole's strength and direction could be made. It was found that it is predominantly in the body z-direction with some extent in the y-direction, leaving a magnetization of the satellite's antennas the most probable cause for the disturbance. The strength of the magnetic dipole is of the same order as what the magnetic actuators can produce, complicating any attitude control with those by a lot.

While attitude determination and the identification of the magnetic dipole was primary focus for the first half of 2014, attitude control based on magnetic actuators became the main focus in the second half. Already in December 2013, about four weeks after launch, the attitude control system demonstrated its capabilities to detumble the satellite from 16 deg/s. In July 2014 a detumbling from spin rates of more than 80 deg/s could be performed within less than 40 minutes. Precise spin-axis control was the target of an experiment sequence in end of July 2014, where the desired spin axis could be retained with an RMS of 0.25 deg/s as shown in Figure 2. During an experiment in October 2014 the angular velocity could be minimized to less than 0.3 deg/s, despite the dominating influence of the residual magnetic dipole.

Because none of the implemented controllers took the disturbance torque into account, only limited control over the satellite's attitude could be gained. Therefore, in February 2015, the satellite's software was updated to include new features such as easily exchangeable attitude controllers, a new attitude control architecture and improved timing to optimize the usage of the torquers. Furthermore, with the software update, the in-orbit calibration of the complete sensor suit of the ADCS became feasible, which was performed in April 2015. A concluding analysis of the attitude estimation accuracy with this setup is pending.

Future operations with the UWE-3 attitude determination and control system will have the aim to further improve attitude control and to cope with the high disturbance torque created by the residual dipole. It is envisaged, that students can use the newly introduced scripting language "Tinytus" to upload new controllers and estimators on a daily basis.

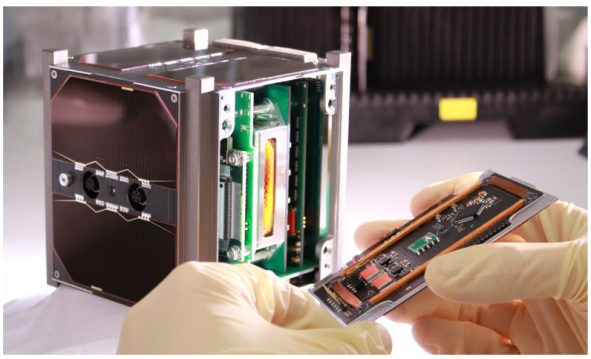

Figure 1: The UWE-3 Flight Model during final integration of the last side-panel.

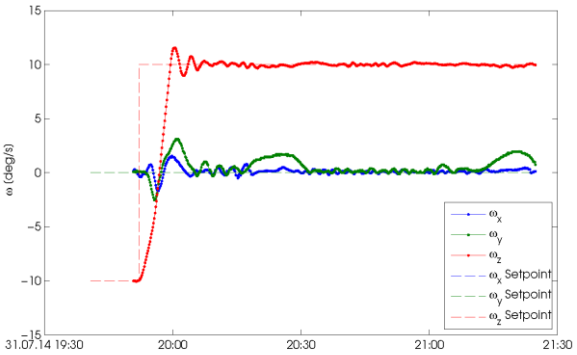

Figure 2: Angular rate vector during spin-up to setpoint +10 deg/s from an initial setpoint of -10 deg/s about the body z-axis.

The next satellite in the UWE series will expand the ADCS towards an Attitude and Orbit Control System (AOCS) by incorporating an electric propulsion system. Besides this, the usage of this flexible software approach shall be further extended and new sensors will allow for a more precise attitude determination. The cause for the residual magnetic dipole in UWE-3 has already been eliminated for the UWE-4 satellite.

Cellularizing Space Using Nano-Satellite Formation Flights

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Keyword: Nano-satellite constellations, Formation Flights, Membrane optics, Seamless cellular communication, Inter Satellite Link

Clusters of satellites flying in formation present a lucrative alternative to a large standalone satellite and help explore new areas of space research that were otherwise not possible with conventional satellites. A direct application of such a system would be to replace a geostationary satellite with Nano-satellites flying in formation in LEO which can achieve finer temporal and spatial resolutions. Indian Institute of Technology Hyderabad's Student Satellite Project (IITHSSP) aims at successful demonstration of such a system. The objective of the project is to build a satellite based seamless communication system for the Indian sub-continent, put in our terms is 'cellularizing space', using a constellation of nano-satellite clusters, with 4-5 satellites in each cluster and n such clusters. In order to achieve this objective, the required technologies like, formation flight and communication handoffs between clusters can be prototyped by flying a cluster and a standalone satellite. The project is intended to deliver this prototype system by 2017-18, which can later be extended to fulfil the overall objective.

The primary payload of satellites in the cluster is a communication system and for the standalone satellite it is a state of art membrane optics based imaging system. The standalone satellite can be used to demonstrate the inter cluster communication system that is required to extend the project further and to test a diffraction based imaging system for space applications. In order to achieve the intra and inter cluster communication it is necessary that the satellites fly in a tight formation. Since formation flight of more than two satellites is not established, it would be a key take away from the project and would pave way for many interesting constellation based space applications. Some of the key components of the project are explained below.

Communication, the primary payload, is RF based for intra-cluster, mobile-to-satellite and ground-station-to-satellite links and is laser based for inter-cluster link, which can transmit at higher data rates. The ground station to satellite link is for command and telemetry purposes whose operating frequency for the uplink and downlink is in VHF and UHF respectively. The mobile to satellite link is for transferring the voice call data from the mobile phone to the satellite under whose footprint the user is present. The proposed operating frequency for uplink and downlink for this segment is in the L-band. The intra- cluster link is for transferring calls between the satellites so that the signal received by one satellite from user A in its footprint is routed to another satellite under whose footprint the recipient B is present. Inter-cluster link is used for exchanging positional information between the clusters and also to handoff the signal between clusters to ensure seamless communication. This is extremely important because only multiple clusters having an established communication link can provide continuous coverage in LEO. For the purpose of demonstration, in the first phase, the system uses 2G communication standards, a bandwidth of around 2MHz to provide communication to 300 users.

Formation flying is the key requirement for a cluster or constellation of satellites to work together and achieve the group objectives. Formation flying of more than two satellites is an extremely challenging task because its needs to address the n body problem. This calls for state-of-the-art technologies, Hybrid evolutionary optimization algorithms and distributed cooperative control strategies. Distributed cooperative control enables a group objective to be achieved by distributing the control actions such that all the group members apart from achieving their individual goals also achieve that of the group in a cooperative manner. Distributed cooperative control, is needed for providing autonomous nature to the system which is highly required for satellite formation flying because the communication delays associated with its centralized counterparts are infeasible. The proposed LASER communication demands accuracies of 90arcsec in attitude determination which can be

successfully achieved using miniature star sensors and 200arcsec precise control needed to agree with the bandwidth limits of LASER (1.2mrads) can achieved using a combination of micro-Pulse Plasma Thrusters and miniaturized reaction wheels.

Conventional satellite systems employ a reflective/refractive based imaging systems, however, such systems are often bulky and may not suit the requirements of nano-satellites. We propose to use an imaging system that is based on diffractive optics and can address the size and weight constraints of conventional optics. A foldable low-cost light-weight membrane is used as a prime component of the proposed system which would provide various cost benefits and eliminates the need for carrying heavy payload for nano-scale satellites. The heart of such an optical system is a photon sieve, which is fabricated by etching millions of pinholes of suitable dimension at appropriate locations. The phase of the light passing through these holes get altered and the desired intensity profile can be achieved. Though the maximal efficacy of such a sieve is only 40% (amount of light that can pass through the sieve), focusing parameters can be optimized by tuning the positions and dimension of the holes to provide resolution on-par with conventional optics. Our system intends to capture images of the earth with a resolution of approximately 5 square-meters and can cover an area larger than 100 square-kilometres.

IITHSSP, when completed, provides a unified platform for flying various challenging missions, apart from the above mentioned.

Sapienza Space Systems and Space Surveillance Laboratory activity

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Keyword: space systems, small satellites, space debris observation, active debris removal, attitude control systems.

Sapienza Space Systems and Space Surveillance Laboratory (**S^{5}Lab)** is a laboratory of Sapienza - University of Rome, supervised by prof. Fabio Santoni and prof. Fabrizio Piergentili. The main research activities are in satellite systems design, including on-board systems and sub-systems, and space surveillance systems, including optical observation systems design and operations, data analysis, orbiting objects' orbital determination and active debris removal systems. The **S^{5}Lab** Team is composed by students at different levels, including PhD, Master's and Bachelor's degree, with different backgrounds, mainly aerospace engineers, of Sapienza – University of Rome. Many of them are involved in different laboratory activities, like education and research programs, international contests and competitions.

The on-going space related research and educational activities of the **S^{5}Lab** include:

- Participation in the **QB50** project, a space science project lead by the Von Karman Institute (VKI) in Belgium that aims to investigate the lower Thermosphere properties by in-situ measurements with 50 CubeSats. In the framework of QB50, **S^{5}Lab** develops the 3U CubeSat **URSA MAIOR** (University of Rome la SApienza Micro Attitude In ORbit testing), carrying the mNLP (multi-Needle Langmuir Probes) science unit designed by the University of Oslo (UiO). URSA MAIOR has been selected to board an Attitude Control Unit system developed by University of Surrey. The experimental micropropulsion system MEMIT developed at La Sapienza and funded by ASI (Italian Space Agency) is installed on-board as a technological experiment. In the framework of a cooperation established by **S^{5}Lab** with Space Mind – New Production Concepts (NPC) – an experimental drag sail has been developed and will be tested as deorbiting system.

- Participation in the **FOAM** project for the development of a polyurethane foam system for active debris removal, under Aviospace-AIRBUS contract. **S^{5}Lab** is responsible for the foam ground testing and for the study of foam formation system in orbit from the on-board stored reagents. A cooperation with the Sapienza Laboratory SASLab – Scientific Aerospace Solution Laboratory – has been established for the foam characterization and mechanical testing on ground.

- Full responsibility for the development of the programme **EQUO -** EQUatorial Italian Observatory – under ASI contract for the establishment of an equatorial observatory settled at the Broglio Space Center in Malindi, Kenya, to develop research activity and to support the Italian space debris monitoring capability.

- Participation in all of the space debris observation campaigns of the IADC – Inter Agency space Debris Committee. **S^{5}Lab** owns and operates dedicated observatories located in Italy and develops its own algorithms for data reduction, orbit determination and space debris attitude motion reconstruction. A cooperation has been established with the Loiano astronomical observatory, close to Bologna, for spectrometric analyses of orbiting objects in GEO.

- Development of miniaturized systems for nanosatellite application mainly focused on attitude determination and control systems. A fully instrumented testing facility for ground testing of satellite attitude determination and control system is available at the **S^{5}Lab**, including a frictionless spherical air bearing, a 3D Helmholtz coil system for the emulation of the magnetic field in orbit, an instrumented platform based on a three axis magnetometer, an IMU and camera system.

- Cooperation with **IMT**, a SME active in space systems and components, for the development of a deployable and orientable solar panel system for CubeSats. A prototype of the system has been developed for ground testing.

- Participation in **CanSat Competition**, an annual student design-build-launch competition for space-related topics, organized by The American Astronautical Society (AAS) and American Institute of Aeronautics and Astronautics (AIAA). Students by **S^{5}Lab** participate to this competition with the Sapienza Space Team, supported by SASA Sapienza Aerospace Student Association. The 2015 mission simulates a Science Vehicle traveling through a planetary atmosphere sampling the atmospheric composition during descent.

- Participation in REXUS/BEXUS campaigns - Rocket&Baloon Experiments for University Students – a DLR-SNSB-ESA education programme with several experiments focused on on-board sensor systems for attitude determination and microgravity experiments related to polyurethane foams formation in a vacuum.

- Participating at the **Pre-4th Mission Idea Contest** (Pre-MIC4) Workshop with "HORUS constellation", aimed at a better quantification of the atmosphere state and land surface properties through a multi-angle capability with a high revisit sampling. The constellation is based on a "convoy idea" and is composed by four 3U CubeSats, placed into Sun Synchronous Orbits. The **S^{5}Lab** team receives scientific and technical support by two ESRIN (ESA) experts.

The **S^{5}Lab** supports the "Space Systems Laboratory course" offered during the third year of the Bachelor's Degree in Aerospace Engineering at Sapienza. The main goal is to give theoretical basis, techniques and instruments to realize infrastructures and to design and verify space systems. In particular, in these months, three student teams are developing three projects: the realization of a thermal regulation system for the **S^{5}Lab**'s vacuum chamber, the design, realization and testing of an autonomous quad-copter and the optimization of an observatory for space debris observations. Several students from the Bachelor's course of Aerospace Engineering at Sapienza are currently bound to study the effects of space environment on different types of sensitive materials and structures for their final theses due to the collaboration between **S^{5}Lab** and SASLab. For instance, different type of Foams are currently under examination in the SASLab in order to test the effect on these samples of a simulated environment similar to Low Earth Orbits one.

S^{5}Lab aims at enhancing the students' understanding of concepts by means of practical work and challenging activities in order to improve their skills and problem solving abilities and their interest and motivation. During 2015, the collaboration between "Sapienza – University of Rome" and "University of Bologna" is allowing Italy to join UNISEC – Global international cooperative body. This will improve the connections with Universities around the world, increasing Italian participation to international educational projects. It is a unique opportunity to share experiences and to join one of the essential features in space field: the international cooperation to achieve goals.

UNISEC Italian Chapter Creation

Italy
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Keyword: Italy, Chapter, Educational, Satellite, Cubesat

The presentation will explain the creation of Italian Chapter of Unisec.
Thanks to participations of University of Bologna to the First and Second edition of Unison Global Meeting, the students experienced how much this meeting could be useful to improve the relationship with other countries and to have new contact. To give continuity to the student activities at Unisec and Unison was decided to create the Italian chapter. This was possible thanks to a collaboration between University of Bologna and Rome "La Sapienza". The Italian local chapter will allows to coordinate the activities in official way and proposing more ideas. In particular this will be the base for a strong network in Italy where start new activities oriented to Unisec/Unison. We know how much are important the educational projects and activities like internship. Trying to build such opportunity oriented to Unisec members will be very important because will increase the opportunity for students in future, especially for the international environment. Moreover the collaboration between universities will increase the cultural exchange and level of education. There are a lot of possible activities to set: from the telematic lectures to the student space missions. This kind of activities needs budgets and strong management and for this these need to be planned in the right way.
Moreover the presentation will briefly explain the past and present space projects of the universities involved in the chapter from the laboratories activities to ESA educational projects and QB50.

(End)

Present State and Next Step about Space Engineering by Japanese Students

Japan
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Keyword: Space development, Rocket, Nano-Satellite, CanSat, Balloon-Sat

The Japanese government has been developing the advanced space projects to compete with other space faring nations such as the USA, Russia, Europe and so on. For example, some of them illustrate the launching rockets (H-IIA/B, Epsilon), the observation satellites (ALOS, GCOM) and the exploration spacecraft (*HAYABUSA*). In addition, Japan has constructed the International Space Station with the other countries. These projects are carried out by the implementing agency of JAXA and private companies of electrical machinery / heavy industry manufacturers.

We point out that there are two important things in the space engineering field from a viewpoint of the Japanese students. One thing is technical education. Students have to learn skills in developing complex space systems. Students should master the study of many fields, because spacecraft is composed of many subsystems, which extend over various fields. In addition, space engineers require technical knowledge of system engineering and project management. Students ought to learn about not only the theory but also the practical aspects of development and operation in order that Japan should be one of the front runners in space. Therefore, UNISEC-Japan has set up UNISON-Japan, which is managed and executed by university and college students. More than 800 students are involved in developing rockets, nano-pico-satellites, CanSats or Balloon-Sats.

Another important thing of student's space activity is outreach activities. They are in a position to make direct contact with the society in general. Space development has a huge potential to produce high value-added products. However, it is also necessary to consider long-term investment. Some people oppose to space development. Students must explain the need for space development to their neighbors, friends and to the general public as a whole. For example, Noshiro Space Event, which is a collaborative experiment of Rocket and CanSat, invites a great number of ordinary people. Last year, each student team offered some experience programs for participated ordinary people in Noshiro Space Event.

UNISON-Japan is composed of working groups for engineering (Rocket WG, Satellite WG, Ground Station Network WG, CanSat WG, Balloon-Sat WG) and working groups for outreach activities (Publicity WG, Networking Event WG). Rocket WG has a collaborative launch experiment three times a year, and make a record of altitude every year. Last year, one of the student rocket teams accomplished the highest altitude over than 2 km. Besides, we conduct "CanSat-Rocket Collaboration Project", a student's rocket aboard a student's CanSat. Satellite and rocket engineers collaborate each other. The Satellite WG has shared information to learn about advanced technology in Internet. In addition, the Satellite WG holds an opportunity of discussion to share technical information several times a year. National space technology is top secret. Because students want to make an open relationship, UNISON-Japan will learn about the advanced technology by information sharing. Similarly, the ground station network WG has been sharing information on the ground stations of each organization by using the Internet. The CanSat WG participates in the international CanSat competition, called ARLISS (A Rocket Launch for International Student Satellites). The teams from different countries participate in ARLISS. SPindle (Systems Engineering (SE) / Project Management (PM) introductory lesson) is a CanSat education program which aims to learn not only engineering skill but also SE / PM skill. Furthermore, we plan to build a Balloon-Sat which flies at the attitude of higher than CanSat. The Balloon-Sat WG is working on technical and safety and legal issues for the launch this year. At the Publicity WG and Networking Event WG, many students from different fields gather together due to personal connections, and plan a networking event.

In this way, UNISON-Japan has a variety of activities. However, we believe it is necessary to determine a common goal of UNISON-Japan as a next step. The reason for the existence of a UNISEC and UNISON is to achieve a purpose which cannot be achieved by only each team. UNISON-Japan has accumulated a lot of information through various activities. If the students with the various technologies may cooperate one another, we believe that we can achieve an advanced project. We are considering a new goal of UNISON-Japan.

Current student space projects and future plans in Korea

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Keyword: Student, space, project, roadmap

In the recent ten years, CubeSat has started to grow active within Korea. The first Korean CubeSat was launched in 2006, however, due to rocket failure, was not able to reach space. Since then, there were two CubeSat launches, and currently, there are seven CubeSats to be launched in 2016. Current space program updates since the second UNISEC-Global meeting are introduced.

As the Korean CubeSat community is growing quickly, it is also important to have a sustainable space program roadmap that the CubeSats can follow. Regarding the direction of mid and long term space development plan in Korea, the CubeSat is planned to be utilized in order to foster professionals in the national program level.

In Seoul National University, the first draft of the space program roadmap is set such that the primary aim is on space education, while the secondary aim from developing infrastructure up to application level space programs. The space program takes education and technology advancement as its goal, with space grant opportunities to make the program practical and realistic. The roadmap utilizes grants from International cooperation in science and technology program, Space core technology development project, and CubeSat competition.

Apart from activities within Korea, UNISON-Global activities were continued throughout the year. The original goal for year 2015 for was to join CanSat competition of Noshiro space event, come up with communication solution and set an online meeting to continue the activities. Participation of Noshiro space event activity is currently under discussion, and the online meeting of UNISON-Global was held twice using Skype.

(End)

CALCULATE THE VEGETATION INDEX [NDVI] USING SMARTPHONE BASED MINIATURIZED SATELLITE

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KEY WORDS: smartphone, vegetation index, small satellites

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The primary goal of this research is to interface a smartphone with a low-level device without modifying it and calculate the Vegetation index [NDVI] using near-infrared camera. The low-level device can be modified and should be able to exchange data with other peripherals such as sensors. The idea is to use the smartphone as a computer and wireless communication device and a low-level device to forward data from sensors to the smartphone or control actuators and communicate with NIR camera by USB port.

The ultimate goal is to launch a PhoneSat project into earth's orbit using the smartphone as a cheap, powerful embedded system for the on-board computer and use the low-level device for things such as talking to sensors, actuators and other devices on the satellite, this projects brings the interface between the smartphone and external devices.

The reason why a modern smartphone was chosen for this project is mainly because of the highly integrated nature: the combination of an array of very interesting sensors, in a compact form all while using very little power makes it a perfect candidate for a satellite computer. Moreover smartphones are cheap and much more available compared to space grade electronics.

Figure 1: The actual physical framework setup: the Android phone is connected to the Arduino Nano via a Bluetooth module and the Arduino board is connected to a GY-80 Multi sensor board with power and data lines. And "Infragram" USB camera.

(3rd UNISON-Global meeting)

Nigeria/West Africa

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Keyword: UNISEC Nigeria

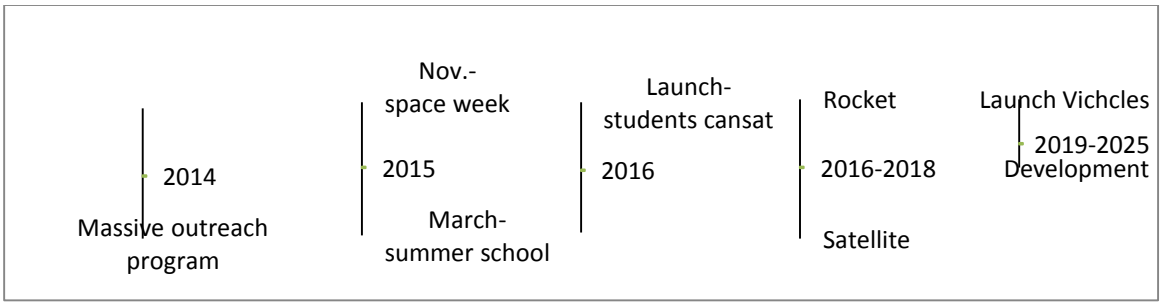
We have been working very hard to follow the set targets and road map which we stipulated for UNISEC Nigeria since the first global meeting. The recognition of UNISEC Nigeria by UNISEC-GLOBAL as one of the local chapter has made our work more compelling.

We in my institution has been trying very hard to work on some of the points raised in the second Global-meeting country report, though in the area of sensitization lot of progress has been recorded. Currently, we are planning to hold a workshop at Federal University of Science and Technology Ebony State-Nigeria and its been facilitated by Chika Ogbodo- a lecturer in Physics department of the University Also, concrete arrangement are being made to hold this same workshop in about four other Universities within the South-East and Middle Belt Region.

We are also planning to hold a seminar in partnership with the school of engineering University of Nigeria Nsukka in the coming months of which we believe will lead to establishment of minor workshop that might lead to research in Pico-Sats.

It is worthy to note that though the level of sensitization of UNISEC activities in Nigeria is increasing not so much has been done in the area of practical work i.e (Can-Sat activities). I participated in the CLTP5 can-sat lecture training via-on line last year, but I did not join the practical session; I have actually taught can-sat theory to some students in the school but we have not been able to build a real can-sat. This is still one of the challenges we are having, even though the regional coordinator has been working so hard in this regards in the west to teach Can-Sat to students.

UNISEC NIGERIA ROAD MAP (REFERENCED FROM THE PAPER IN THE FIRST GLOBAL MEETING)



We have been trying to follow this timeline in our activities, though there are hitches here and there some times. We still strive for human development in the area of Can-Sat activities for us to be able to achieve the stipulated outlined map.

In the coming meeting, we shall report all the activities we have been able to carry out since the end of second Global meeting and the activities we plan to hold in the future.

Abstract:

UNISEC-South Africa: Present and future aspirations

On the 3rd and 4th of November 2014, South Africa hosted the 2nd African CubeSat workshop themed: small satellites with big ideas. Delegates from various companies, organisations and Universities in and outside South Africa were present. During the workshop topics such as value proposition and business opportunities, emerging technologies and STEM education and awareness were covered. The workshop was a great success and steps have been taken to move it to other African nations.

Also, for the next MIC competition, it is envisaged to collaborate with more South African Universities. A number of other African Universities also showed a keen interest in participating in the MIC. UNISEC-South Africa is heavily involved in community outreach as well with the use of CANSATS and our excursions will be presented. A status update on South Africa's TsepisoSat will be given and our ideas for our next CubeSat, Zacube-2, will be presented.

Furthermore, UNISEC-South Africa wishes to invite UNISEC to a United Nations Basic Space Technology Symposium that will take place in Cape Town at the University of Cape Town from 1-4 September, with the theme "Small satellite missions for scientific and technological advancement."

Student experiments: Developing in University a Humanitarian Space Program

Tunisia/Monastir
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Keywords: Nano satellite, Water monitoring, Cubesat, Bluetooth

Big satellites continue to be affordable for major national projects or extremely wealthy organizations. As such, small organizations and emerging countries adopt smaller satellite as a means of spatial exploration. Accordingly, micro and nano satellites will be an important development interest in our country. Thus, we founded a consortium to develop new ideas especially for our region needs toward spatial applications. The program provides hands-on projects to apply multidisciplinary knowledge to real world. Several teams work together through a complete design cycle and must develop a system engineering mind-set for humanitarian applications. As an important project, we are currently developing a new mission to control water quality and quantity in order to improve the routine of water quality monitoring and to reduce the risk of accidental or deliberate contamination.

Figure 1 presents the hierarchy of our mission implementation including the laboratories participated in this project.

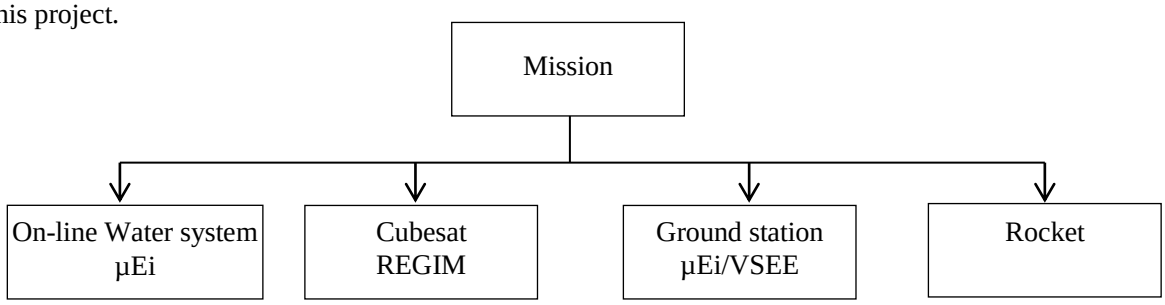

Figure. 1 *Entire mission bloc diagram*

REGIM-Lab (Sfax University) will be responsible for the development of satellite's data processing algorithms as well as ADCS/EPS development and Cubesat bus design. While the Microelectronic and Instrumentation-Lab µEi (Monastir University) will be responsible for the development of the water quality measurement system, including commercializing sensors and a Bridge Bluetooth/UHF.

In consequence, Microelectronic and Instrumentation-Lab was succeeded to develop an autonomous and reliable water monitoring system including a low cost solution in order to be related to the field of pathogen particle detection in water within a LAB On Chip system. While the REGIM-Lab was succeeded to develop antennas and electrical power subsystem Fuzzy Logic controlled which are compatible with the Cubesat standard.

To develop technical means, the ground station is under construction at the University of Monastir. It can be included in GENSO project. It's a radio amateur network which supports the university application related to the space technology. Communication network Management will be developed by VSEE team (Sousse University).

The satellite is conceived to use a standard Cubesat structure that can be launched using a Poly-Pico Satellites Deployed (PPOD) launcher system. In addition, the satellite design is based on COTS components.

Extended Abstract by UNISON-TR (ITU Space Lab) Student Representative for the Student Session (2nd UNISON-Global meeting)
UNISEC-TR Student Activities

Turkey
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Keyword: UNISON-TR, CubeSat, Hands-on Experience, CanSat, QB50

Since the establishment of the "Space system design and test laboratory", projects are being carried out. As a laboratory aim is not only finishing projects but to create a dynamic team and spread this knowledge throughout projects. With every project each person in the laboratory increases his/her capabilities in order to reach the project needs and get the job done. In each project requirements and challenges are different so as a result building a space system is not only for a one discipline but for multiple disciplines. Every project gives an opportunity to turn the knowledge in to experience. Throughout the projects students from different departments such as; Astronautical engineering, electrical/electronic engineering, mechanical engineering, physics. This kind of work improves teamwork and ability to search for true and useful information. Not only applying the knowledge by building something but also applying and using our knowledge by doing TVAC and vibration test. These tests have been being done since 2009. Creating test procedures, preparing the object to test, data handling and test methods are gained as experience directly.

This year QB50 projects (BEEAGLESAT & HAVELSAT) continues with all its momentum. In addition to that a new satellite project takes place. This satellite is called UBAKSAT. UBAKSAT is the newer version of 3U-SAT which was sent in April 2013. This version will be less complex with respect to its previous version. New subsystems will be tested in this satellite. Also we have half of the satellite empty which means that anyone is welcome if they want to test anything in space. Parallel to this satellite project, a new cooperation is going to be made between ITU and JPF (Japan Space Forum), KIT (Kyushu Institute of Technology). According to this cooperation environmental and functional tests of UBAKSAT will be made in KIT. A researcher from ITU will go to KIT and make the tests with researchers from KIT which will increase communication and cooperation between two universities and countries. After all tests satellite is going to be launched from ISS, with sponsorship of JSF.

A second CANSAT leader training program is being planned. All participants will build their own CANSATs' which includes PCB design & manufacturing, embedded systems & coding, structural design & manufacturing, system engineering and documentation. By making this program every year we intend to increase the number of people who can build CANSATs and start a national CANSAT competition.

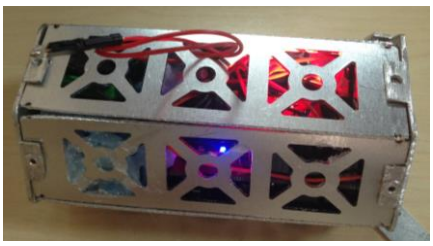

Figure 1: A CanSat built by participants

In order to increase awareness of space technologies and to show children new horizons once in every two weeks different schools (kindergarten, primary/secondary/high schools) are visiting our laboratory. Depending on their crowd, they can dress and get in to clean room to experience laboratory atmosphere. In addition to these potential engineers/scientists different projects and courses are being made in university. From freshmen to seniors, students are attending to CANSAT, Rocketry and Lander development programs. In all these programs students have the opportunity to build their own systems and test them.

These programs have a lot of sub courses which are embedded systems, data handling, structural design, mission analysis etc. Students are not only attending courses but also they are the teacher. Every week two students have their topics and the following week they need to teach their topics to whole class. With this the aim is to give the students hands-on experience in building systems and increase their capability to express themselves and to transfer & share their knowledge and experience with others.

Figure 2 : Kindergarten students visiting our laboratory

Figure 3 : High School students visiting our laboratory

Figure 4 : University students giving their topic lectures each week