

Satellite Development and Research at Stellenbosch University and the Cape Peninsula University of Technology

South Africa

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Stellenbosch University (SU) and the Cape Peninsula University of Technology (CPUT) are the two largest academic institutions focusing on satellite research and development in South Africa. SU and CPUT collaborate in satellite research and development on a continual basis. The past, on-going and future developments at these institutions are discussed in this paper.

Stellenbosch University

The Electronic Systems Laboratory (ESL) at SU has been involved in satellite research for over 20 years. During this time the ESL built SUNSAT, Africa's first locally developed and launched satellite. SU was also heavily involved in the research and human capital development projects, as well as managing the satellite development, of the Sumbandila Sat programme.

Recently, the focus of the ESL's satellite division has shifted to CubeSat research and development. A number of postgraduate projects have developed CubeSat components which have been commercialised. These components include:

- CubeComputer: An ADCS OBC that can also be used as a main OBC;
- CubeSense: A collection of attitude sensors;
- CubeControl: A collection of attitude actuators;
- CubeStar: A star tracker;
- Torquer rods for magnetic actuation;
- Reaction wheels for high accuracy attitude control.

Using the above components, an ADCS stack bundle can be assembled which can function as the ADCS for a CubeSat. Figure 1 shows an engineering model of the stack bundle. Aside from being available on cubesatshop.com, 12 of these bundles have been sold to the von Karman Institute for Fluid Dynamics in preparation for the international QB50 mission. Two bundles were launched in June 2014 as part of the two QB50 precursor flights on board QB50P1 (OSCAR 79) and QB50P2 (OSCAR 80).

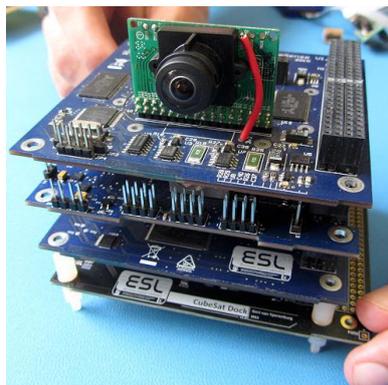


Figure 1: ESL ADCS Stack

Currently the ESL is independently developing ZA-AeroSat as its contribution to the QB50 mission. The satellite will fly one of the QB50 science payloads as well as investigate the passive stabilization of low altitude satellites through aerodynamic drag effects. There are also other on-going collaborative satellite research and commercial projects including: DeOrbit sail, a FP7 EU project, and CubeSail, a project being

done in collaboration with the Surrey Space Centre. Various FP7 and Horizon 2020 projects are planned for the future.

Aside from these activities there are a number of masters and PhD students working on satellite research. Current projects include:

- Procedures and principles for cost-effective and reliable radiation testing of COTS components for use in South African satellite applications;
- The deployment and control of a spinning solar sail CubeSat;
- Design of an ultra-fine pointing AODCS for an astronomical application;
- Advanced ADCS for an agile small LEO satellite;
- Design and development of a flight software framework for a nanosatellite;
- Development of ADCS and HIL testing of a 3-axis stabilized CubeSat;
- GPS Propagator for a CubeSat;
- Development of a control moment gyro for a CubeSat.

Cape Peninsula University of Technology

The French South African Institute of Technology (F'SATI) at CPUT was inaugurated in 2008. Its focus on satellite systems engineering was driven by the fact that space science was one of the grand challenges in the then 10 year innovation plan of South Africa's Department of Science and Technology.

TshepisoSAT (ZACUBE-1), Africa's first nano-satellite, was launched on 21 November 2013. The satellite was developed by CPUT/F'SATI students and staff, in collaboration with SU. Activities at CPUT/F'SATI since, however, have been far from "Tshepiso-centered". Funding was obtained for the development of ZACUBE-2 in collaboration with SU and other universities. Recently, CPUT/F'SATI, University of South Africa (UNISA) and iThemba LABS-National Research Foundation of South Africa started a partnership to drive innovation in nano-science and nano-technology applicable to nano-satellite platforms. It has lead so far to patentable designs for the increase of functionality per unit mass in nano-satellites. From an academic point of view, this collaboration has been a good platform to encourage UNISEC-like inter- and intra- university collaboration. Indeed, realisation of student postgraduate projects has been greatly enhanced by this collaboration.

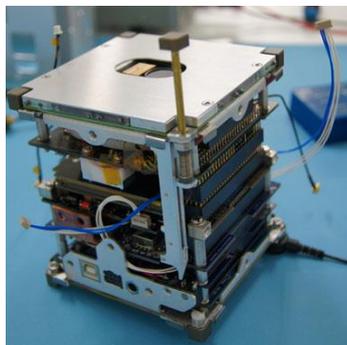


Figure 2a: TshepisoSAT



Figure 2b: TshepisoSAT's First image from space

Activities currently taking place include the commissioning of TshepisoSAT, the development of ZACUBE-2, contribution to the QB50 constellation, commercialisation and innovation within the framework of the Africa Space Innovation Centre (ASIC) at CPUT. Student research work include, but are not limited to, projects related to space radiation effects on satellite subsystems, communications systems, novel antenna design, radiation mitigation methods, novel flight software designs and novel data interface designs. CPUT/F'SATI is also preparing to welcome its new Research Chair in *Innovative Small Satellite Technology and Application for Africa*.

Among the future plans at CPUT/F'SATI, is the extension of a fast growing collaborative network across Africa. Indeed, an official hand shake between CPUT and the University of Buea (UB) in Cameroon is planned for the last week of November 2014. The intention is to build a ground station under the auspices of the UB Departments of Physics, Mathematics, Computer Science and Electrical Engineering, and to initiate exchanges in space physics, space mission design related modelling and programming, and other.