KLETSKOUS CubeSat Project
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Introduction

AMSAT SA has decided to embark on the development and launching of a South African Amateur satellite. The satellite will be based on the CubeSat principle. The subject of this paper will be a basic satellite with a short time to launch.

Mission (Purpose) of the CubeSat

While radio amateurs all over the world raved about SumbandilaSat, local Hams missed out as the vast majority of Southern African passes were used to download images, the primary mission of SumbandilaSat. During these times the amateur transponder was switched off. It can thus be argued that SumbandilaSat did not fulfil its secondary mission of education and creating an interest in science, technology, engineering, mathematics (STEM) and space in Southern Africa.

The mission of the new satellite is to give radio amateurs (and educational institutions) in Southern Africa easy access to a Low Earth Orbit (LEO) satellite on as many of the available passes as possible and thus stimulate interest and activity in space, satellites and amateur radio. A secondary mission is to provide the opportunity for scientific research and observations. This will further increase the participation of the youth in the project, helping to create interest in science and technology.

The development phase of the CubeSat is currently known as (Project) KLETSKOUS. This reflects nicely on the mission and functionality of the satellite: “Klets” is an Afrikaans word for talking a lot. We want the Southern African radio amateurs to talk and operate much more via satellite. “Kous” is the Afrikaans word for a sock. The transponder that is planned for the satellite can also be referred to as a “bent-pipe” transponder, aligning the idea to the “sock”.

Once the satellite nears completion a competition may be run to decide on an applicable name for the satellite, as was the case for SumbandilaSat. On the other hand it seems as if most people have grown fond of the project name and the satellite may end up being referred to as KO xxx, indicating KLETSKOUS OSCAR xxx.

Payload

While it is considered that a 2 m uplink and 70 cm downlink is desirable from a user perspective, the International Radio Union (IRU) advises that 2 metre uplinks are problematic as in many parts of the world there are too many illegal, non-amateur transmissions. The satellite may receive these transmissions and make matters worse by re-broadcasting them on 70 cm over a wide area.

Given that most hand-held transceivers sold today are both 70 cm and 2 m capable, the problem of non availability of 70 cm transmitting equipment will fall away and KLETSKOUS should be as easy and convenient to work as what SumbandilaSat was.

For KLETSKOUS the uplink is on 70 cm, and the downlink on 2 m. A linear transponder with a bandwidth of at least 20 kHz is utilised for FM, SSB and CW. On SSB it may be challenging to continuously compensate for the Doppler shift but fortunately the 20 kHz transponder bandwidth will allow more than one FM QSO at a time. A sub-carrier for a telemetry downlink will be included. For command and control purposes a separate 70 cm frequency will be used. Currently frequencies in the 435.100 to 435.140 MHz range are considered for the uplink and 145.860 to 145.980 MHz for the downlink. The above architecture will ensure that the transponder is accessible for general use while the satellite is being commanded and controlled by the ground station. Maximum access by Southern African Hams to KLETSKOUS is thus ensured.

Scientific Experimentation

The telemetry that will include parameters such as battery voltages of the different solar panels, radiation sensors, various temperatures, etc. will offer a great opportunity for scientific observations and experimentation. Educational institutions will be able to use this data for various educational purposes.

Design Philosophy

KLETSKOUS will be a 1U CubeSat. The dimensions are 10 cm x 10 cm x 10 cm. The total volume of the satellite is 1 litre and the maximum weight 1.3 kg. This is indeed very compact.

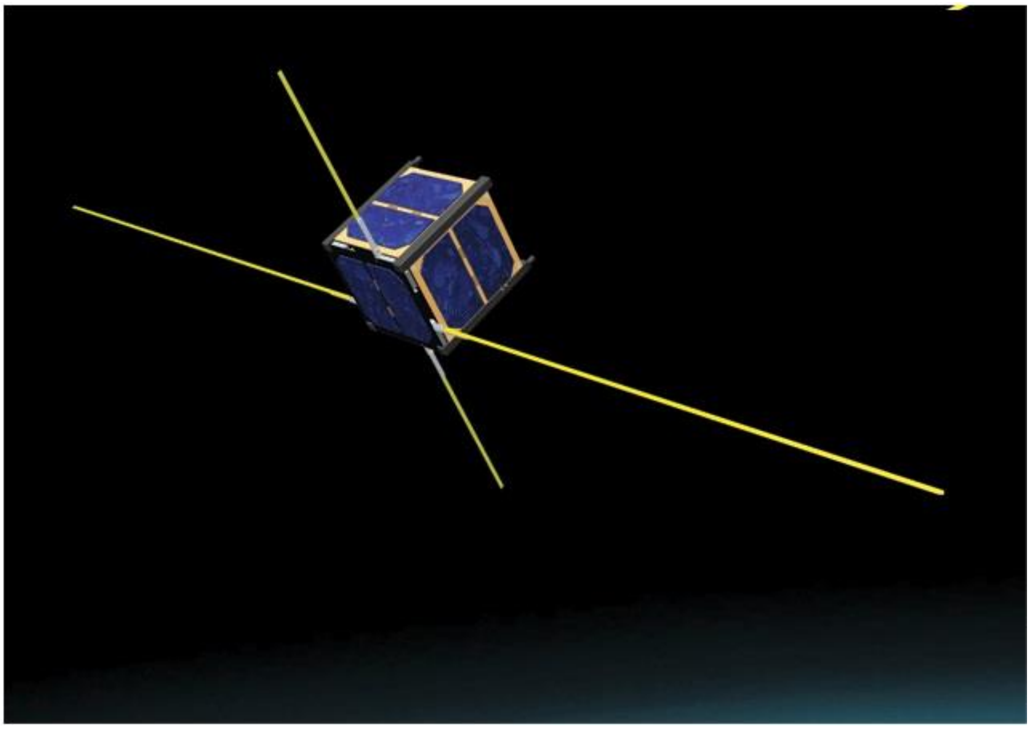

Figure 1: ISIS impression of a 1U CubeSat in Space.

Modules required for KLETSKOUS

Space Frame and Antennas

Frik Wolff, ZS6FZ is leading the team developing the flight model space frame as well as the solar panel and antenna deployment mechanisms.

House Keeping and On Board Controller (OBC)

A Command Link will be required for housekeeping purposes and also maybe for in-flight reprogramming of the onboard controller, although this is risky business as the satellite may be killed if the reprogramming is unsuccessful. The best option would be to launch the satellite with flawless software already loaded, if at all possible.

A Scheduler will switch the transponder on and off at pre-determined times. These times will correlate to certain areas being over flown by the satellite. It will be possible to set the onboard clock of the Controller to ensure that the Scheduler performs correctly.

A Telemetry Downlink will be required. Some of the parameters that must be monitored on the ground include battery voltage and temperatures, orientation of the satellite via the radiation sensors in the centres of the solar panels and the output voltages of the solar panels. It is planned that the Command and Telemetry functions be based on those implemented on the High Altitude

Balloon Experiment, HABEX. All the above functionality is under the control of the OBC.

The third prototype On Board Controller (OBC) has been completed and the house keeping software is currently being developed and tested by Brian McKenzie, ZS6BMC.

Electric Power System (EPS)

Fritz Sutherland jnr. is developing the EPS for KLETSKOUS. The latest prototype of the EPS is performing very well. Use is made of a new generation, high power density LiFe battery. Integration with the OBC has also commenced.

During flight all the electronics, especially the Transponder, must be powered by the solar panels with any surplus power being used to charge the battery. When the battery eventually fails the satellite should be able to function when it is lit by sunlight.

With the small amount of power available from the solar panels (around 2.8 W peak) the maximum RF output of the satellite cannot exceed 0.5 W. In general the output power will have to be reduced to 200 mW or less. Experience with other Low Earth Orbit (LEO) satellites, including SumbandilaSat, has indicated that successful communications with a modest ground station is not a problem at this power level.

Stabilisation

It will be difficult to implement active stabilisation in a 1U package together with the transponder required for the main payload. A passive (magnetic) stabiliser should keep the antennas adequately orientated during a pass over Southern Africa. This is also the solution implemented on FunCube.

Frik Wolff, ZS6FZ, has made very good progress with the development of the passive stabiliser and damper. A form, fit and function version is ready for integration with the rest of KLETSKOUS.

Antennas

The prototype, 2m and 70cm crossed dipoles are performing well, even in close proximity to the space frame.

Figure 2: Prototype 2m and 70cm Crossed Dipole Antennas.

Transponder

Leon Lessing, ZS6LMG, is developing the transponder. The prototype transponder has flown on the BACAR V and VI missions. Some failures were experienced resulting in less than 100% mission success. These failures are being addressed and the transponder will next be tested on a high site to simulate the congested environment that it will be subjected to in space.

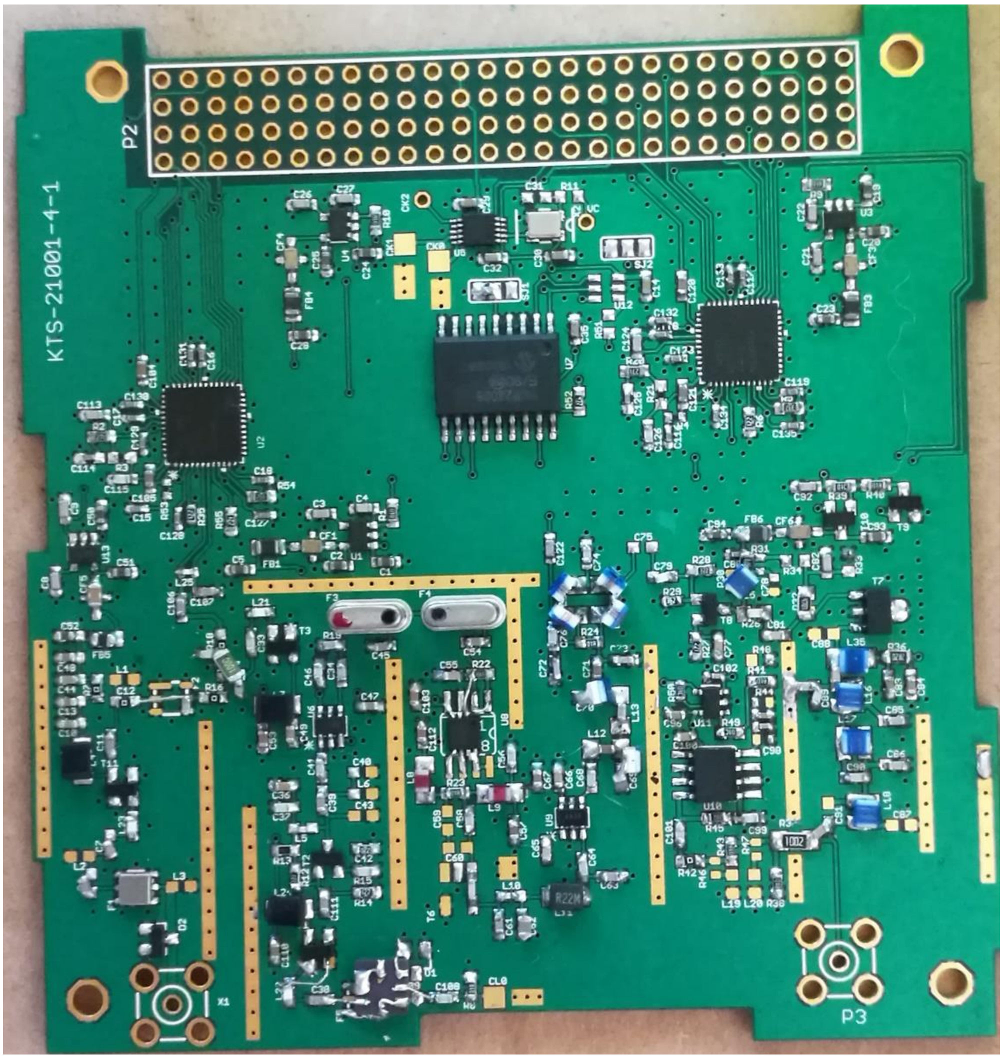

Figure 3: Prototype Transponder.

Project Team

Designing, developing and building a satellite is a huge team effort, even for a small 1U CubeSat as it incorporates all the functionality required by its bigger brethren. A team of capable South African radio amateurs are contributing to the creation of KLETSKOUS. A diverse range of skills are required; from drafting the specifications to manning the ground station(s) and not all members are involved in every phase of the development, but in the end the contribution of every member is required if KLETSKOUS is to be a success.

BACAR-V Flight

As part of the development and qualification process the prototype Kletskous was part of the high altitude balloon flight. The mission was not 100% successful with the antennas being damaged during launch but many lessons were learned that have been applied to the latest version of Kletskous.

BACAR-VI Flight

Kletskous was also flown on the August 2018 BACAR flight that formed part of the international YOTA program. Once again the high altitude balloon proved to be an extremely valuable test platform and the experience gained from operating in near-space is helping in the development of the flight model of Kletskous.

Summary of the Current Status

The main focus is to continue integrating the various electronic modules (EPS, stabilization, OBC etc.) into a functional unit. In this respect the "Flat-Sat" designed and built by Fritz is playing a major role. With the Flat-Sat it is possible to easily access all the modules. The electronic modules will then be integrated with the Space Frame, solar panels and antennas to form a complete and functional CubeSat.

Further reading and Interesting Websites:

www.amsatsa.org.za

www.habex.za.net

www.cput.ac.za/blogs/fsati/zacube-1/

http://webapps.sansa.org.za/zaspace

http://funcube.org.uk/

www.isispace.nl

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