PROPOSAL FOR A NEW HYPER SPECTRAL IMAGING MICRO SATELLITE: SVALBIRD

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ABSTRACT

This document describes a proposal to construct and launch a new generation of polar orbiting micro satellites for Earth observation. The project is a joint venture with the Technical University of Berlin (TUB), University Centre on Svalbard (UNIS) and SVALSAT. The proposed micro satellite is designed for interactive Earth observation using a hyper spectral imager. The mission objective, the final configuration of the satellite, the ground segment, and the operation is described.

1. INTRODUCTION

The Technical University of Berlin (TUB) has developed expertise in construction and launch of 6 micro satellites in polar orbit with special emphasise on attitude control and environmental / house keeping aspects (the TUBSAT series) [1]. The attitude is controlled by using fibre optical gyros, reaction wheels, magnetic torque coils and a star sensor. Their most advanced satellite is capable of tracking a ground based object in real time at a resolution of 6 m at ground level for approximately 5 minutes (max. 10 min). The payloads have so far been monochrome video cameras with rather limited use when it comes to number of possible applications.

The TUBSAT series ability to lock on a ground target and sweep slowly over the terrain makes it ideal for a line scanning instrument such as a hyper spectral imager. The University Centre on Svalbard (UNIS) has developed small airborne hyper spectral imagers that image objects with both high spatial and spectral resolution [2]. These instruments have proven to be a successful tool on a large number of applications in remote sensing. We therefore propose to go one step further by adding a spectral imager to the proposed satellite.
2. THE GROUND SEGMENT

The partners of this proposal have already finished the ground segment including an installed and operative command station at the roof of UNIS and a data downlink from SVALSAT. Fig. 1 shows an image gallery of the key elements of the ground segment.

Figure 1. The Ground Segment. Panel (A): The SVALSAT ground station close to Longyearbyen, Svalbard (78N, 15 E). Panel (B): The tracking Yagi-antenna mounted at the roof of UNIS. Panel (C): The University Centre on Svalbard (UNIS).

The above ground segment is tested on the TUBSAT A, DLR-TUBSAT and MAROC-TUBSAT presently in orbit. The video stream or digital pictures of the payloads are received via S-Band with the 13 m-antenna at SVALSAT. The data is then either grabbed by a video server or stored on video tapes, or send by FTP directly down to UNIS. All units at UNIS are controlled via INTERNET in real time from Berlin. The images can also be
downloaded by a 3m S-band antenna in Berlin. In general, a request from UNIS and TUB is send by e-mail to the Tromsø Network Operations Centre (TNOC) to find out if the 13m antenna is available (free) to track a selected pass. The TNOC operator then programs the S-band antenna to track the satellite. TUB or UNIS can then prepare the satellite for its mission by sending commands in advance or in real time to the satellite. The high speed of the internet through the fibre optical connection between Svalbard and Norway makes these operations possible. The ground segment has been operating successfully since May 2003.

3. THE SATELLITE BUS

The proposed SVALBIRD satellite is based on the LAPAN-TUBSAT architecture. The configuration of the space segment is shown in Fig. 2

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**Figure 2.** A 3D colour view of the satellite (SVALBIRD). Each side is labelled by letters. STS is Star Tracker Sensor. XYZ-coils are the magnetic torque coils, RW - Reaction Wheels, TX - Transmitter (S-Band), TTC - Telemetry Telecommand Control units, PCDH - Power Control Data Handling, and WDE - Wheel Drive Electronics. Axis configuration: z - yaw axis, x - flight direction (roll), and y - pitch axis of satellite.
The cube shaped satellite measures 45 x 45 x 28 cm³ and weighs 57 kg. The cube is made out of 5 mm aluminium plates. The S-band antenna is physically located on the same side as the front optics of the payload. The S-band transmitter is located close to the antenna. Analog video transmission is performed within a bandwidth of 8 MHz, the transmission of single pictures occurs at 125 kbaud. The beam width of the antenna is 70 degree.

3. THE PAYLOAD

The payload contains one fore field camera (50 mm focal length objective) with medium resolution (120 m resolution at ground level) and a high resolution telescope (6 m resolution) with a focal length of 1m as front optics to the spectral imager. Fig. 3 shows the design of the proposed spectral imager onboard SVALBIRD.

![Payload: Optical diagram for the proposed hyper spectral imager on board SVALBIRD.](image)

A concave ion edged holographic reflective grating reduces the amount of optical components to a minimum. The design is based on an instrument that was tested in spring 2001 at UNIS. It can be further optimized according to size by matching the f/value of the telescope to the concave grating.

4. APPLICATIONS

Typical example data from our airborne campaigns in the arctic will be presented. Provided funding, we aim to make observations covering a number of applications including (but not limited to):

1. Ocean Colour, Algae blooming surveillance
2. Vegetation mapping
3. Sea Ice Mapping and Sea Ice Dynamics
4. Snow covered area mapping
5. Natural resource management
6. Glacial Mass Balance
7. Weather data for forecast modelling (clouds versus snow cover)
8. Cloud liquid content, aerosols, trace gases, cloud transmission
9. Polar Search and Rescue studies

5. PRELIMINARY CONCLUSION

Based on experiments both with airborne hyper spectral imagers and the highly sophisticated attitude control systems on the TUBSAT series, it is believed that these micro satellites will have multi-wavelength band sensors capability very soon.

6. REFERENCES
