PROJECT SKBALLOON

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ABSTRACT

The project skBalloon aims to construct and launch near-space balloons (Nobuyuki et al, 2004) connected to a payload being able to transport various instruments as CCD cameras, different detectors or commercial load to the earth's stratosphere in approximately 40 km height above the ground. The project intends mainly to raise awareness and interest about space sciences within broad public and remind them on importance of space exploration. Compared to many other countries Slovakia lag behind during last years in this research field with few exceptions. This should be changed in near future by a Slovakian cooperation agreement with the European Space Agency and activities of the Slovak Organization for Space Activities.

Key words: stratospheric ballons; public outreach.

1. INTRODUCTION

Team working on the skBalloon consists of amateurs and professionals from different fields as electronics, engineering, informational technologies and astrophysics, where most of them are still studying at universities. For needs of such project it was necessary to develop the whole balloon system from scratch and other similar foreign projects were taken only as an inspiration. This ambition brought many innovations and improvements, which will in future provide better radio communication with the balloon's payload and less errors at run-time. Related to this fact is receiving of telemetry and system status in real time, mechanisms inhibiting entanglement of balloon to its parachute, a possibility to end its flight before time, auto-navigation of balloon's payload at landing or its repeated usage. Launch of instruments to large distances or altitudes and ability to process received data is a universal need at exploration of space either from an orbit around the Earth or at interplanetary missions.

skBalloon team is meeting regularly on phone conferences and technical sessions discussing its future aims and progress at solving technological or legislative problems. Technical specifications and guide for usage of this balloon system will be provided for everyone interested in using it with new devices or experiments on board.

Figure 1. Flight of our stratospheric balloon and its payload with triangular cross-section named **Julo 1** *shortly after launch.*

The project is dedicated to:

1. *Students*
   - of high schools, which can gain practical information about electronics, atmospheric conditions at large altitudes and telemetry. Further data analysis will prepare them on similar tasks at universities.
   - of universities - the skBalloon is an ideal platform for yearly, bachelors and undergraduate projects (according to university programs of ESA) or training of students for cutting-edge scientific research in their future carrier.
2. *Research institutes*
   - the skBalloon offers a possibility to do a research of atmospheric layers at high altitudes, light pollution or cosmic weather.
3. *Companies*
   - skBalloon allows for testing of components in extreme conditions at high altitudes (temperatures up to -80 ^{o}C, low air densities, intensive cosmic radiation).
4. *Others*
   - the skBalloon can serve as a pre-flight platform for testing of cubesats (microsatelites).

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2. SKBALLOON JULO 1

The first system of our near-space project skBalloon is called **Julo 1** after famous Slovak actor and entertainer Julius Satinsky. Its content with a parachute weight less then 1.3 kg and encompasses various detectors with a module providing telemetry back to the ground. The assembly team of Julo 1 met for the first time on 11th of December 2009.

Julo 1 launched on 10th of October 2010 from Partizánske public observatory in the middle-west of Slovakia (Fig. 1) and reached an altitude of 25100 m. The flight duration was 138 minutes from 10:55 UT to 13:13 UT. The distance from lift-off position of Julo 1 to its landing site was 79.2 km.

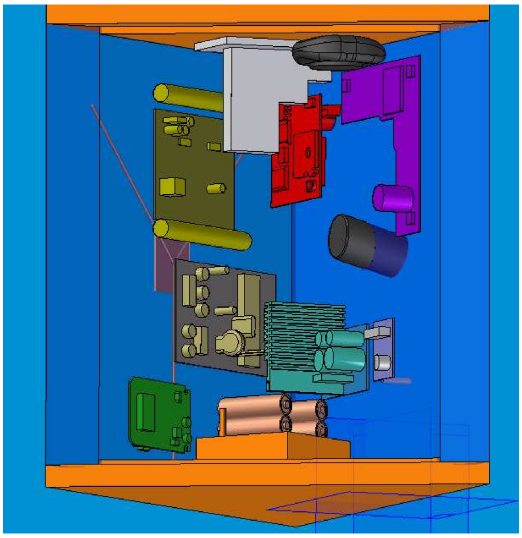

Figure 2. Components of the payload within Julo 1: flight computer (gray), GPS receiver (black at the top), webcam (black in the middle), cosmic ray detector (yellow), accelerometers (purple), battery with electronics (copper, blue), transmitter (green), GSM module (red).

The whole system of skBalloon Julo 1 contained a meteorological balloon inflated by helium, a parachute and a payload (or return gondola) attached to a device for its premature detachment from the balloon.

Figure 2 above represents a view into the payload of Julo 1. The payload's box has a triangular cross-section with three sides and two covers on top and bottom and was made from extruded polystyrene with thickness of 1.5 cm. Its different on-board devices are distinguished by colors.

Flight computer

As an on-board flight computer, we used MikroTik Routerboard RBU441U 300 MHz with RISC processor equipped with one serial and one USB port. Installed operating system was Openwrt Linux 10.03. Its tasks encompassed gathering, storing and analysis of information from neighboring modules like data from GPS module or storing of photographs on USB SSD memory disks. In case of emergency (low power or other unexpected situations), it had a capability to restart all attached modules including itself.

GPS module

The utilized GPS receiver was SiRF Star III, NL-320U with processor StarIII working on a frequency of 1575.42 MHz. So as all sensible GPS devices, it has limitations regarding its acceleration (max 4G), speed (max 515 m/s) and height (max 18 km).

UHF TRX module - transmitter

Our transmitter was a modified transmitter station working in band UHF on free frequency of 446.09375 MHz FM (channel PMR 8). The module contained transmitter SENCOR SMR500 and a control circuit, which turns on the station and governs operation of the whole module.

GSM module

Its purpose was to backup the transmitter in a case of transmitter's failure or other interruption of signal. It uses industry module SIM300C, which by serial link at speed 38400 baud controls processor ATmega8 with AT commands. This processor completes SMS message composed of GPS coordinates. A program checks registration of the module in a network and sends periodically SMS messages either once in hour or after registration within the network (eventually after a call from known numbers).

USB webcam

Utilized on-board camera was USB webcam Canyon CNR-WCAM813 with capabilities of data streaming or periodic sending of pictures. Camera contains CMOS detector with resolution of 1.3 Mpx (640×480). It has been necessary to add drivers for this camera into the operating system OpenWrt. Pictures were saved every 15 seconds on memory flash cards. Focusing of the camera was set to a very large distance.

Sensor board

This module contained sensors for temperature, pressure and humidity.

The sensor for interior's temperature was a thermistor. Voltage from this sensor was channeled into analog converter of microcontroler ATmega16. It has been placed 5 cm from surrounding electronics, so its measurements could not be biased by electronics's heat. The sensor for outer temperature was PT100. This sensor changes resistance as a function of temperature, which requires constant electric current. This was provided by a special circuit within payloads's power supply.

For measuring of pressure, we used a sensor MPX4115A with analog output. Output voltage was converted to a

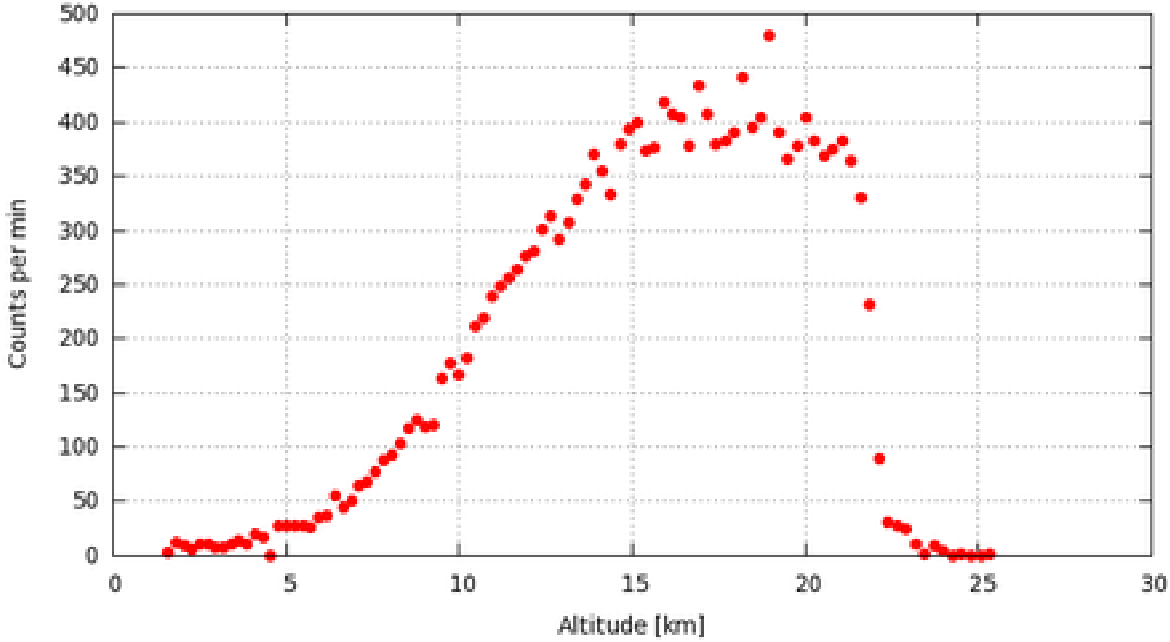

Figure 3. Counts of particles (in counts of CRD detector per minute) as a function of altitude.

digital form by inner analog converter of microprocessor ATmega16 and consequently stored on a memory device.

Humidity sensor was SHT71 developed by Sensirion, which is fully calibrated sensor of absolute humidity and temperature.

Sensor for balloon's blow out

This device served as a detector of tension decrease on a suspension strand carrying balloon's payload. In case of balloon's blow out, it ejects balloon's remnants and prevents their entanglement with payload's parachute. Moreover, it was able to detect functionality of the payload's parachute.

Accelerometers

Module with accelerometers was put together from three sensors of type MAA7260QFS manufactured by Freescale semiconductors, so we were able to measure acceleration of the payload in all 6 degrees of freedom.

Cosmic ray detector

Our cosmic ray detector of high-energy particles used Geiger-Müller tubes. When a particle crosses such a tube, it causes decrease of voltage on the tube. Such a signal is subsequently processed by a series of forming circuits and after delivered on the microprocessor ATmega16 in a form of an impulse. Count of such impulses detected during flight of Julo 1 is shown in the Figure 3.

Power supply

As a power supply, we used 16 lithium AAA cells, which had optimal ratio of capacity to weight.

Terminator

Terminator of Julo 1 is an autonomous device (with battery, radio-receiver, servo-mechanism and micro-computer). It allows for a premature detachment of balloon from rest of the system (e.g. before the blow-up of the balloon) either by a command received trough radio-communication with ground station or after certain time limit.

3. SKBALLOON JULO 2

In near future, we plan to launch second version of the skBalloon and its payload named Julo 2, where all critical systems like GPS and memory devices will be doubled. The payload's design will be modular for further potential use in micro-satellites.

4. FUTURE AIMS

The project skBalloon is intended to be a precursor of first Slovak cubesat called skCUBE, which will be a miniaturized space satellite. Scientific purpose of this mission is already in preparation. First cubesat could be equipped with a small fish-eye camera working in the optical band, second one a wide-field X-ray optics based on the lobster-eye design and third one a small balloon, which will be inflated in the space and test de-orbiting concepts of low-orbit satellites using rapid increase of balloon's diameter, hence boosting its interaction with tail of the Earth's atmosphere.

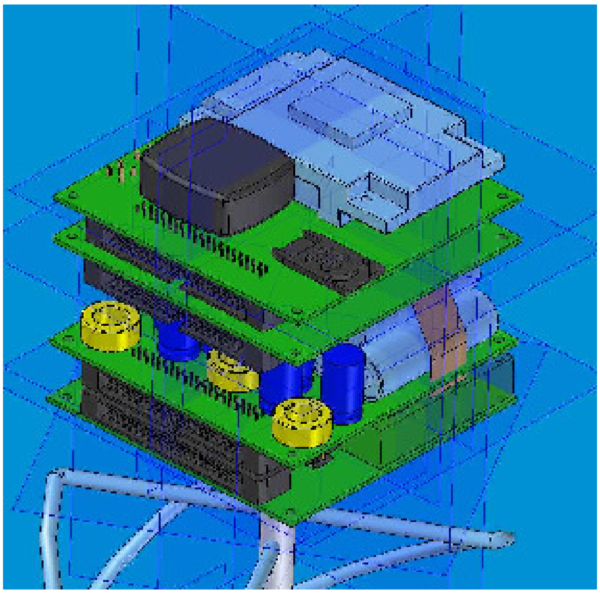

Figure 4. Payload's visualization of skBalloon Julo 2.

5. SUMMARY

We started a project intended to raise public awareness of space research in Slovakia called skBalloon. It aims to launch a series of stratospheric balloons together with various payloads equipped by on-board computers, scientific detectors and other electronic devices.

The first skBalloon is called Julo 1. It has been launched last year in October and succeed to measure temperature, pressure, acceleration and cosmic ray intensity during its flight. Its improved version named as Julo 2 is being constructed right now. With project skBalloon, we aim to conquer space-related technological challenges and eventually build first Slovak microsatellite.

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