

BEXUS – Balloon Experiments for University Students

Technical Overview:

This overview provides the technical basis to write a proposal for a BEXUS experiment.

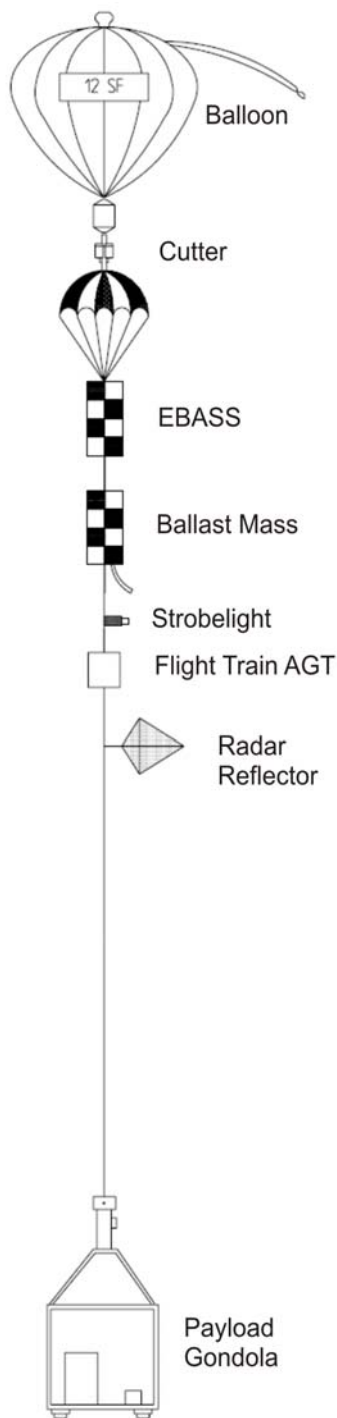


Fig. 1: BEXUS flight train

1. Launch Vehicle:

A typical BEXUS vehicle (flight train) consists of a balloon, a cutter, a parachute, the EBASS service system a strobe light, an Argos GPS receiver and transmitter (AGT), a radar reflector and the experiment gondola (Fig. 1). The performance of the BEXUS balloon may be adapted to the respective experiment requirements.

a) Balloon System

There are two different launch vehicles: a large balloon and gondola for a total lifting capacity of 117 kg and a small one. The balloon is nominally a ZODIAC 12SF plastic balloon filled with Helium gas. The balloon has a volume of 12,000 m³ and the diameter of the filled balloon is 14 m. At lower payload mass a smaller size balloon might be used. The total length of the balloon system may vary between 65 and 100 m. The maximum altitude is 35 km.

b) EBASS Service System

The ESRANGE Balloon Service System EBASS is operational since 2001. It provides functions for altitude control, flight termination, load cell controlled termination, GPS, temperature and air pressure sensors, Z-accelerometer and three serial channels for experiment data and control. The service system is enclosed in a glass-fibre armed insulation box. Load cell termination means that if the balloon bursts, the flight train is automatically disconnected from the balloon envelope when it senses a loss of lift tension to avoid entangling of the flight train.



Fig. 2: Hercules launch truck with a large payload gondola

c) Payload Gondola and launch truck (see Fig. 2)

The experiments are placed in the payload gondola. Available for BEXUS is a large gondola and with a first flight in June 2008 a small gondola EGOL (Estrange Gondola Lite). Parameters are given in table 2. The gondola payload mass influences the maximum altitude.

The launch truck has a weight of 50 t and a length of 17 m. It can carry a maximum load of 4 t and has a crane height of 12 m.

2. Flight Profile and Conditions

The BEXUS balloon is launched from ESRANGE, Sweden (). The Coordination of the balloon trajectory with the Air Traffic Control (ATC) is very important. The balloon trajectory is predicted in real time, based on wind profile, meteorological models and trajectory tracking. Main flight termination criteria are: no inhabitants under cut down point, authorization from ATC and good recovery conditions. Two ATC transponders are required, one for the payload with the parachute and one for the balloon.

a) Launch Requirements

The most important launch requirements are the desired trajectory and the winds. If higher altitude winds are strong, then the flight time will be reduced. Ground winds have to be lower than 5 m/s and preferably around 2 m/s.

b) Flight Profile

After the ascent phase, the balloon floats in the stratosphere at an altitude between 20 and 35 km. A valve and ballast function for altitude control is optional and normally not flown on BEXUS. After a flight duration of 2 to 5 hours the payload gondola is cut down from the balloon and recovered with a parachute system (Figure 3).

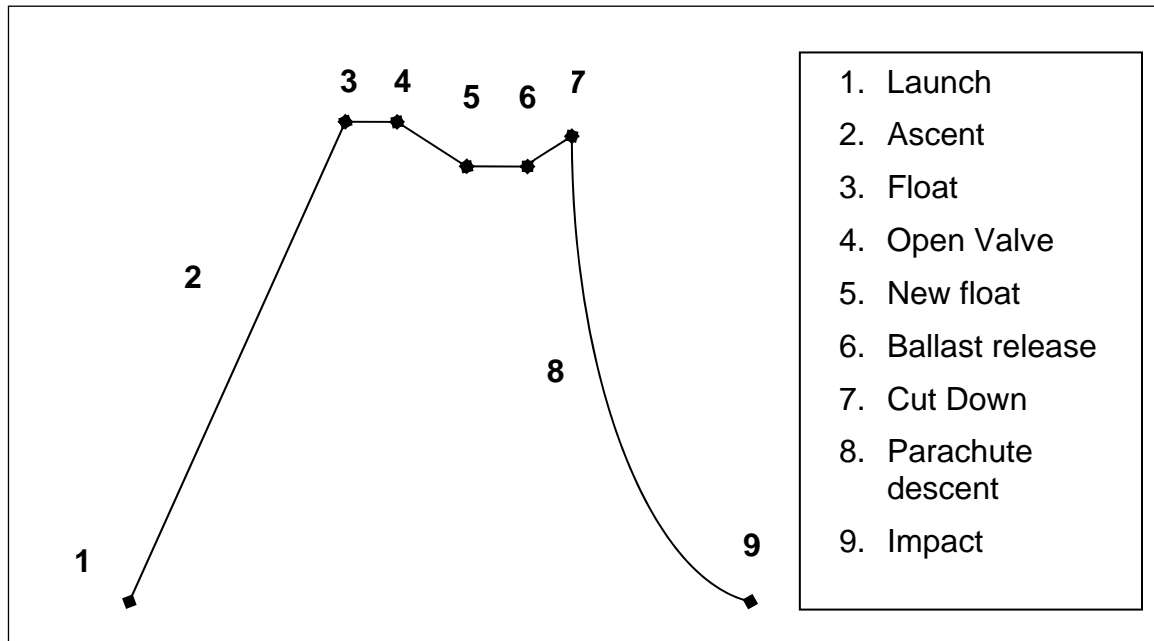


Figure 3: BEXUS Flight Profile

Flight duration and cut down will be based on calculations for a safe landing within the Swedish border. The gondola will be picked up by a helicopter (Figure 4). The payload is normally brought back to ESRANGE within a day or two after launch.

c) Environmental Conditions

The environmental conditions of the balloon flight are temperatures as low as $-70\text{ }^{\circ}\text{C}$ and an air pressure of 10 mbar.

The temperature during the transport to the launch pad and after landing can be $-20\text{ }^{\circ}\text{C}$ with an exposure time of up to several hours at launch and typically one to two days after landing. It is recommended that heat sensitive experiments that create high temperatures within the gondola include temperature regulation in the experiment design. Due to vacuum conditions, it should be verified that systems, especially electrical ones, have nominal performance in the absence of convective cooling.



Figure 4: BEXUS Recovery

d) Loads during Launch and Flight

Experiments should be able to withstand certain loads. The acceleration design loads during the launch, flight and descent phases are 10 g vertically and 5 g horizontally. The landing velocity is approximately 8 m/s. The shock at impact depends on the nature of the ground surface. Nominally, the landing is gentle, causing no damage to the experiments.

The flight parameters are summarized in Table 1.

Table 1: BEXUS Flight Parameters

<i>Flight Parameter</i>	
<i>Ascent velocity</i>	5 m/s
<i>Acceleration during</i>	10 g
<i>Parachute Deployment</i>	
<i>Mission Duration</i>	2 -5 hours
<i>Altitude</i>	20 – 35 km
<i>Landing Velocity</i>	8 m/s

3. Experiment Interfaces:

Depending on the mass of each experiment and the required altitude, up to 8 Experiments can be accommodated in the Gondola (Figure 5).

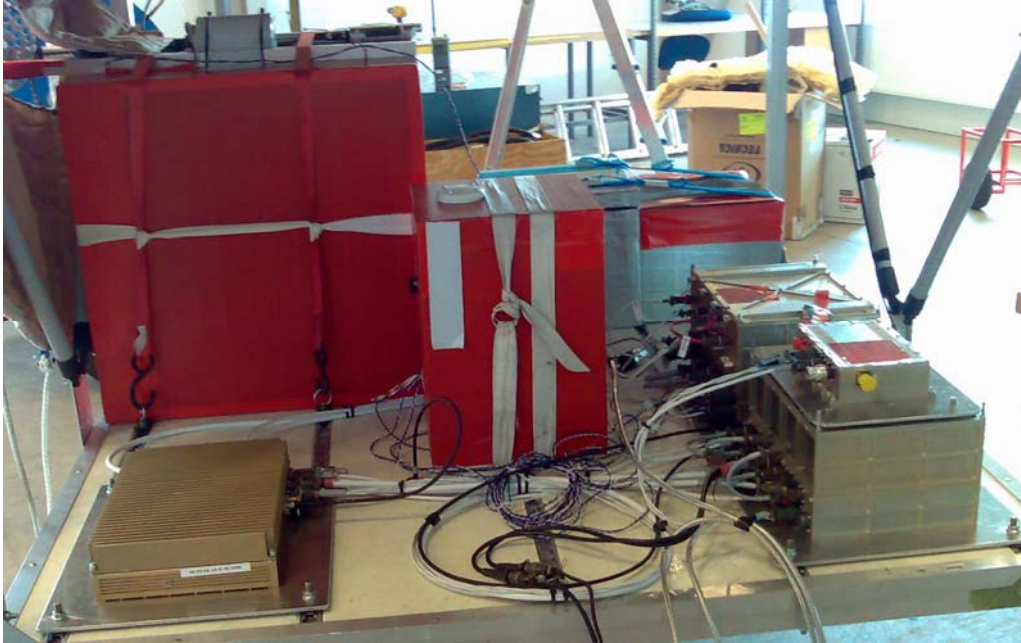


Figure 5: Experiment Accommodation within the Gondola

The electrical interfaces comprise data, command and power wires. The experimenters have to provide their own battery power. Batteries must be certified to handle low pressure and temperatures. 28 V is common.

Each experiment is connected to the EBASS (Service System) or the E-Link. The E-Link is a telemetry system with a standard Ethernet interface. It can handle TCP/IP and UDP/IP communication and other types of synchronous and asynchronous user interfaces. Details are described in the BEXUS user manual.

Table 2: BEXUS Experiment Data

Experiment Data	
Data uplink	two channels 9.6 kbps
Data downlink	one channel 4.8 kbps
Total experiment mass	
<i>large gondola</i>	40 – 100 kg
<i>small gondola</i>	40 – 100 kg
Payload Volume	
<i>large gondola</i>	1.4 m x 1.4 m x 1.2 m
<i>small gondola</i>	0.75 m x 0.75 m x 0.63 m
Experiment length (max)	0.5 m

4. Abbreviations

AGT	Argos GPS receiver/transmitter (box on the flight-train also containing an air traffic transponder with altitude reporting)
ATC	Air Traffic Control
BEXUS	Balloon Experiments for University Students
EBASS	ESRANGE BALloon Service System (control and piloting system)
EGOL	Estrange Gondola Lite
E-Link	Ethernet up & downlink
ESRANGE	European Sounding Rocket Launching Range
GPS	Global Positioning System