REXUS - *Rocket Experiments for University Students*
Technical Overview:

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

1. The Rocket

The student experiments are launched on unguided spin-stabilized solid-propellant single stage rockets.

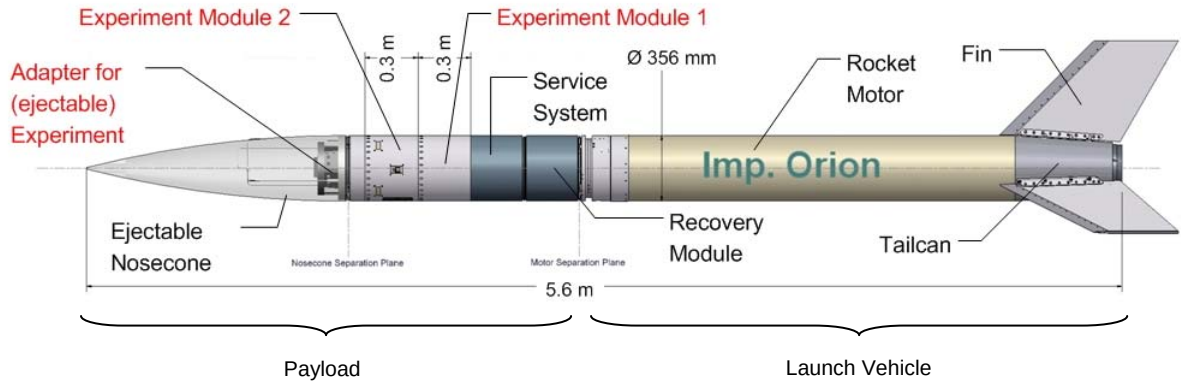

Figure 1: REXUS Standard Configuration

The launch vehicle is composed of an Improved Orion motor with exhaust nozzle extension, a tailcan, three stabilizing fins and a motor adapter with an integrated separation system. See Figure 1.
The total mass of the rocket is around 515 kg comprising a propellant mass of 290 kg, motor and vehicle hardware of around 125 kg and a payload mass of around 100 kg. The total rocket vehicle has a length of approximately 5.6 m depending on the size of the experiments and the diameter is 356 mm.

The standard configuration of this payload comprises the recovery module, the service system, an ejectable nosecone and two experiment modules. The mass of each experiment module structure and bulkhead is approximately 5 kg. The total available mass for the student experiments is normally about 30 kg.

Table 1: REXUS Standard Configuration Mass

Vehicle Component	Mass (kg)
Improved Orion Motor (without Propellant)	125 kg
Propellant	290 kg
Payload (without Experiment Modules)	60 kg
Experiment Modules including Student Experiments	max. 40 kg
Total Vehicle	515 kg

2. The Flight Profile

The rocket accelerates the payload for 26 seconds with a peak acceleration of ~20 g during the boost phase. During flight one rocket configuration will have a spin of approximately 4 Hz (no microgravity environment!). The other rocket configuration uses a yo-yo despin system that will reduce the spin to a maximum spin rate of 0.08 Hz (30°/s). The rockets will usually be launched during daylight. A night launch is possible in case of special requirements of an experiment.

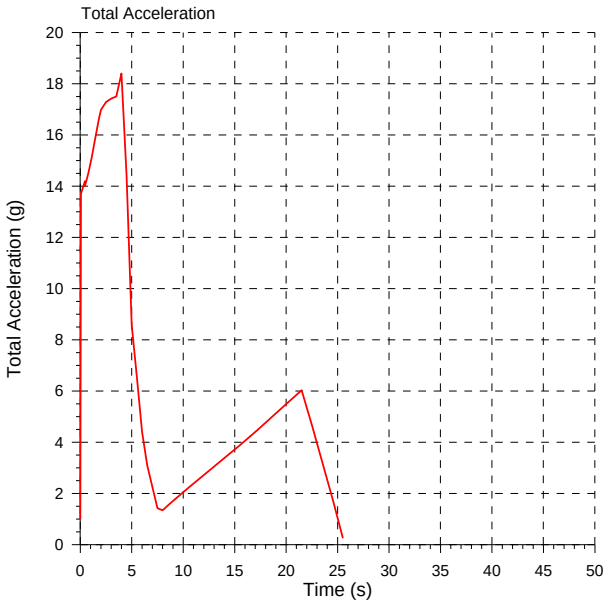

Figure 2: Acceleration during Ascent Phase

The motor burnout is usually at an altitude of around 23 km. The motor separation time depends on the experiment requirements but will not be performed before the nosecone ejection which can take place at altitudes above 55 km. Motor separation is usually performed before apogee which is between 90 -100 km, depending on the payload mass. For reasons of stabilization, the payload can be separated later. The latest separation altitude is about 60 km on descent, before the vehicle enters the lower atmosphere.

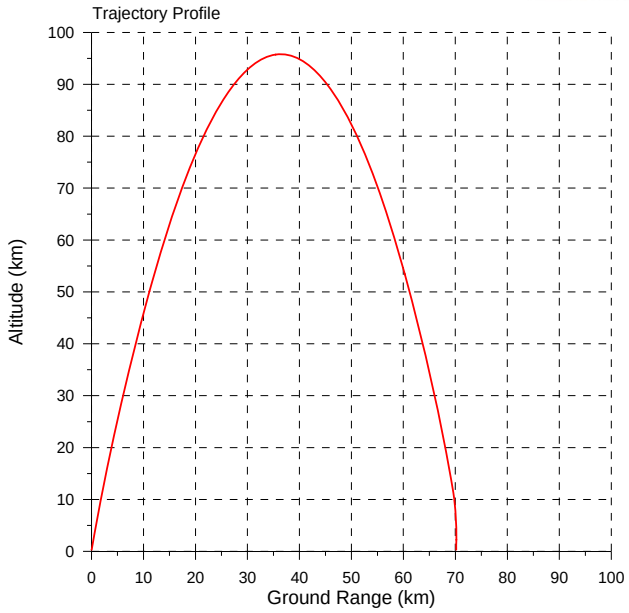

Figure 3: REXUS Flight Profile, Altitude (km) vs. Groundrange (km)

During the descent phase in the lower atmosphere, at an altitude of about 26 km, the payload is decelerated with a maximum acceleration of about 6 g. The recovery sequence is initiated after about 7 minutes of flight, at an altitude of about 5 km. A parachute system decelerates the payload to a terminal velocity of ~10 m/s before landing.

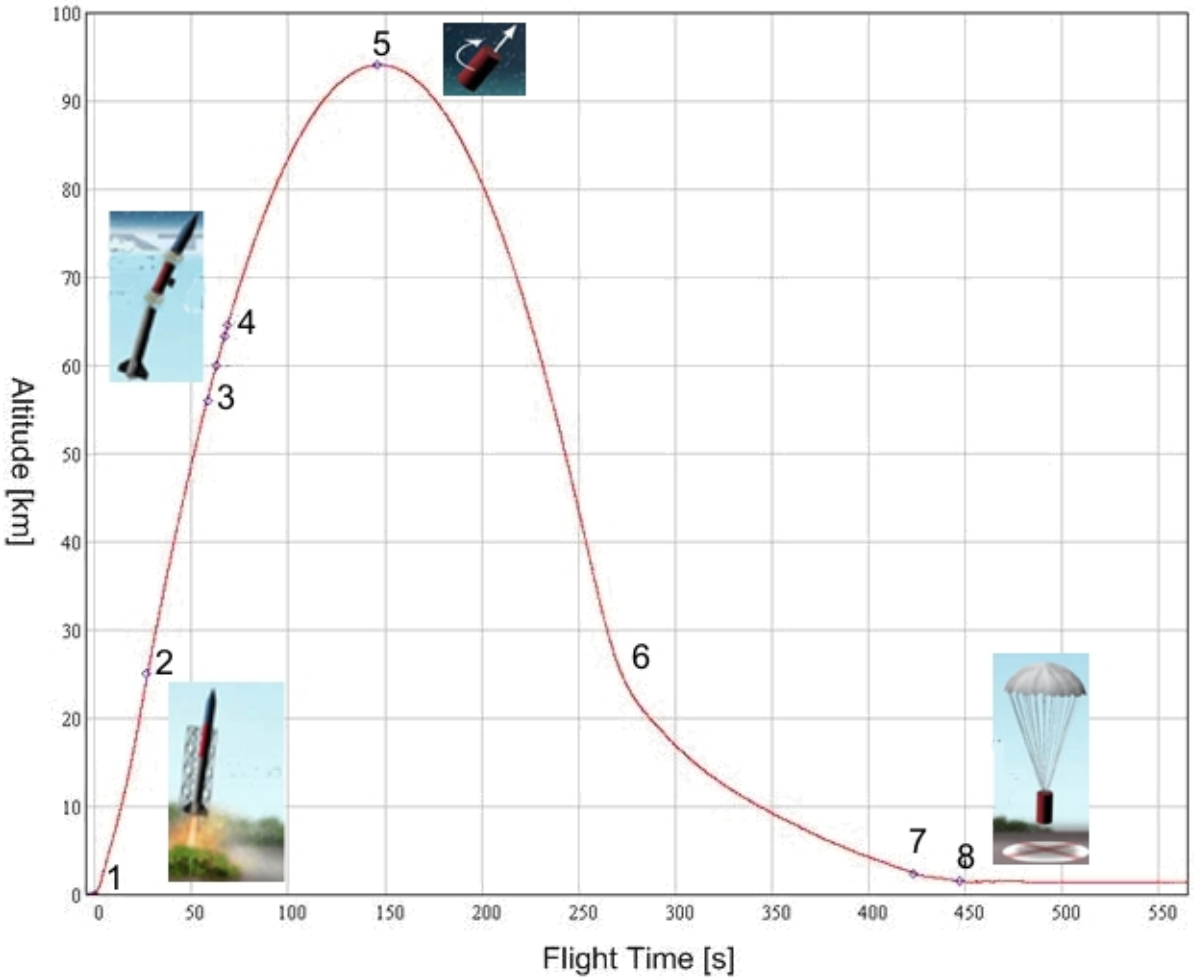

Figure 4: REXUS Flight Profile, Altitude (km) vs. Flight Time (s), Flight Events

Table 2: Typical Flight Sequence (REXUS-3)

No. in Fig.4	Event	Flight Time	Altitude	Range
1	Lift-Off	T0	0.0 km	0.0 km
2	Motor Burn-Out (Imp. Orion)	T0 + 26 s	22.4 km	3.9 km
3	Nosecone Ejection	T0 + 60 s	57.4 km	13.2km
4	Payload/Motor Separation	T0 + 66 s	62.3 km	15.5 km
5	Apogee	T0 + 150 s	95.8 km	35.5 km
6	Max. Deceleration (~ 6 g)	T0 + 270 s	~26.0 km	-
7	Stab Chute Release	T0 + 420 s	5.0 km	70.0 km
8	Main Chute Release	T0 + 447 s		
9	Landing of Payload	T0 + 640 s	0.0 km	70.0 km

3) The Experiments

a) Mechanical Accommodation

The experiments are mounted in the experiment modules. A standard experiment module is an aluminium cylinder of 400 mm height, 356 mm in diameter and a mass of about 3.5 kg.

The experiments can be placed on bulkheads in the experiment modules or directly on the module skin (see Figure 5).

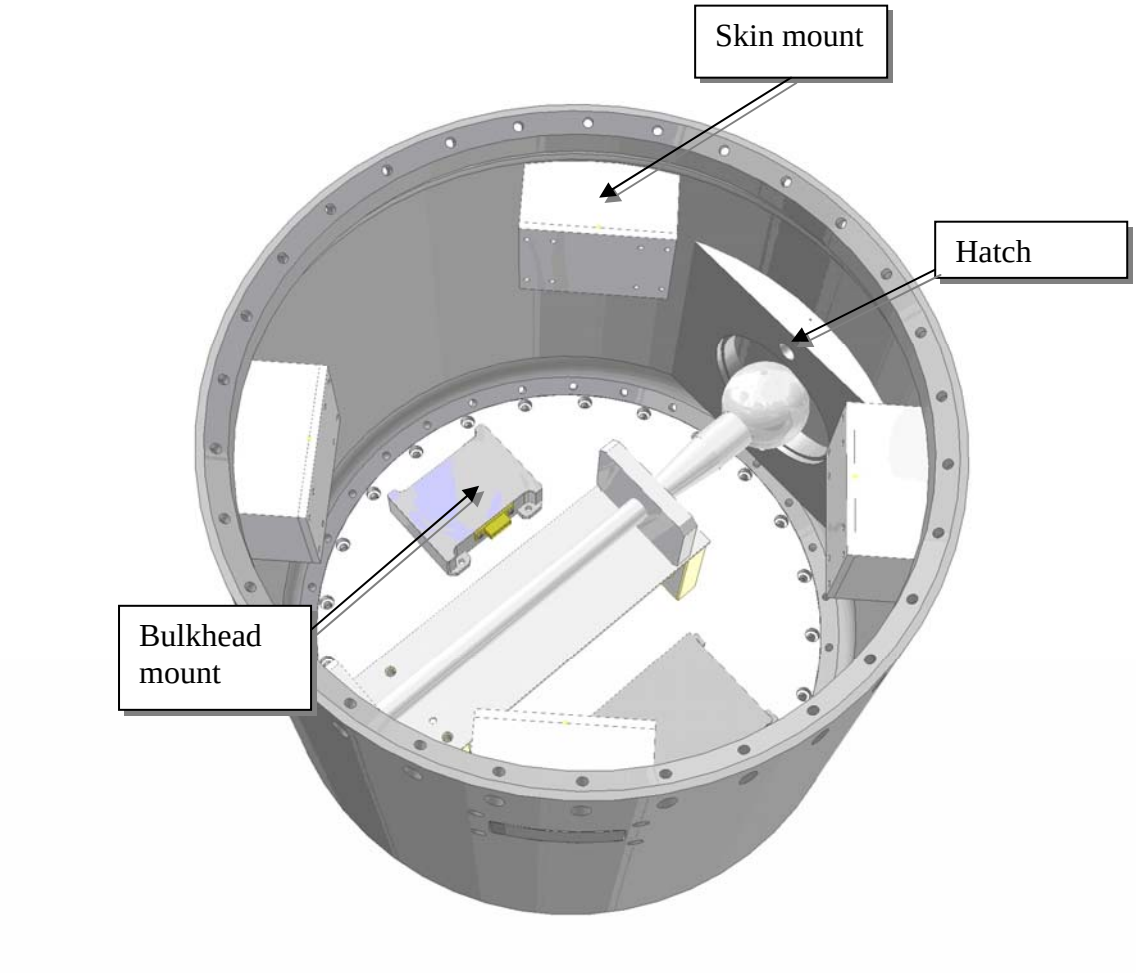

Figure 5: Experiment Mountings in an Experiment Module

Hatches in the module skins can be provided to give an experiment the possibility to take measurements outside the module (see Figure 6).

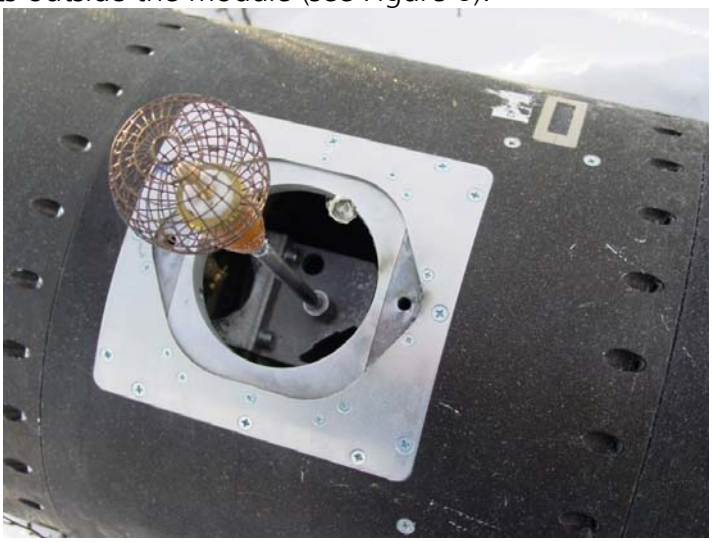

Figure 6: Experiment protruding from a Module Hatch

One experiment can be mounted below the ejectable nosecone on an adapter structure (see Figure 7). It is possible to release this experiment from the payload during the flight. This separated experiment follows the same ballistic trajectory as the total payload but will not usually be recovered.

Figure 7: Example of an Experiment situated below the Nosecone

b) Environmental Conditions

The experiment modules of a standard REXUS payload are not pressurized. During flight the air escapes from the modules through openings while the ambient pressure decreases to 10^{-4} mbar.
The integration of the modules and payload is carried out at normal room temperature of ca. 20 °C. After integration, the payload is mounted on the motor. The ambient temperature at the launcher can be low (down to -30 °C) depending on the launch date and time.
The thermal environment of the outer structure of a front-end positioned parallel bay module on the launcher can reach 110°C at 50 seconds after lift-off. Peak temperatures above 200 °C are reached during the re-entry phase.
After landing, the payload will be subjected to snow and cold air in the impact area for a period of typically one to two hours. The temperature during the season when REXUS is launched is normally between 0 °C and -30 °C.

c) Electrical Interface

The service system provides five 28 V power lines. One experiment cannot use more than one line. The average current is 1 Ampere and the peak current is 3 Amperes. Please check the REXUS Manual for further details.

d) Experiment Control and Data Acquisition

A Telemetry/Telecommand serial data interface is available for 5 experiments (RS422 transparent data Interface). One experiment can use a TV channel that will usually be switched to the recovery camera before the parachute deployment.

Table 3: Telemetry Downlink Structure

Downlink	
Data Rate	500 kbit/s
PCM-Frame Rate (Word frequency)	325 Hz
Experiment Data Interface	5x38.4 kBaud (thereof 2x57.6 kbaud or 1x115 kbaud possible)
Housekeeping Data	60 Hz
PCM Forward Correction, Packed TM	

Table 4: Telecommand Uplink Structure

Uplink	
Data Rate (over all channels)	19.2 kbit/s
TC-Frame Rate (rocket control)	20 Hz
Experiment Command Rate	20 Hz
Experiment Data Interface	uplink bitrate same as downlink rate (5x38.4 kbaud)
GMSK/Hardline, Packed TC	(max.15-300 bytes/s), depd. from total load

Additional data provided by the Service System:

The Service System provides:

- Position and Velocity (GPS)
- Acceleration data (3-axis accelerometer)
- Angular rate (3-axis rate gyros)

4) Abbreviations

GPS	Global Position System
PCM	Pulse Code Modulation
REXUS	Rocket Experiments for University Students
TC	Telecommand
TM	Telemetry