

IAC-08-E1.1.4

REXUS and BEXUS – A Swedish-German co-operation for university student experiments on rockets and balloons

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ABSTRACT

In June 2007 the German Aerospace Center (DLR) and the Swedish National Space Board signed an agreement to jointly provide flight opportunities for university students to fly experiments on suborbital rockets and stratospheric balloons during a five year period. The implementation of this unique student programme is handled by EuroLaunch, which is a co-operation between the Mobile Rocket Base (MORABA) of DLR and the Swedish Space Corporation. Students from all ESA member states are eligible to apply to this programme, named REXUS (rockets) and BEXUS (balloons).

The student programme involves two suborbital rocket missions and two stratospheric balloon flights per year. All flights are performed from the Esrange Space Center in Sweden. The REXUS is an unguided, spin-stabilised, solid propellant, single stage rocket. The BEXUS balloon has a volume of 12,000 m³ and a diameter of 25 m at floating altitude.

The programme builds on experience of previous student missions where the best practices for how to carry out this kind of programme has been learnt. It involves students in all phases of a real space programme, from proposal through selection, design, reviews, construction, testing, flight campaign, and ending with data analysis and presentation of results. The students participate in a one week long Student Training Week, during which they learn about the space environment, best practices for design and assembly, integration and testing of space equipment, interfacing to power and telemetry and command links, and lessons learned from earlier students.

A historical resume of previous flight opportunities for university students at Esrange and the current guidelines and procedures for REXUS and BEXUS flight opportunities involving DLR as well as the ESA Education office will be presented. The REXUS/BEXUS programme gives students the opportunity to efficiently build on the experience of today's professional space engineers, and to obtain a flying start on their career.

1. Introduction

A debate started during 2006 in Germany and Sweden how to promote sounding rocket and balloon activities and to attract young people in space activities. These discussions ended up with a cooperative programme between Germany (DLR German Space Agency) and Sweden (SNSB) on sounding rocket and balloon flights for student and were signed on 4 June 2007. ESA has been invited to participate as a user, thus allowing participation from around Europe in the student programme. There is a substantial experience in EuroLaunch (SSC/Esrage and DLR Moraba) from past educational activities in the Rexus and Bexus programmes. With this new agreement it will be possible to raise the standards of the student programme on rocket and balloon flights and hopefully get attention not only in Sweden and Germany but also throughout Europe for student experiments and the participation of student groups in launch campaigns. The efficiency of rockets and balloons for research, within the scope of this cooperative Student Rocket and Balloon Programme of Germany and Sweden, will be demonstrated in modestly complicated experiments where the turnaround times and costs can be kept low. Finally, this new programme is intended to give students, especially in their educational step towards becoming scientists, opportunities to gain valuable experience in planning for and carrying out experiments in association with a professional environment. Within the next 5 years EuroLaunch will launch 2 sounding rockets and 2 stratospheric balloons every year in cooperation with European universities. This is a great opportunity for students to gain valuable experience in planning for and carrying out experiments in association with a professional environment. This paper explains the technical requirements as well as the programmatic for both the REXUS and BEXUS student programmes.

2. Programmatic

The REXUS and BEXUS programmes are providing German and Swedish university students with the opportunity to launch experiments on sounding rockets and stratospheric balloons. Two rocket launches and two balloon launches are envisaged every year, the rocket launches will nominally take place in March and the balloon launches in October. On each launch, half of the payload resources are available to German students, the other half to Swedish/European students. The launches are funded by the Swedish National Space

Board (SNSB) and the Deutsche Forschungsanstalt für Luft- und Raumfahrt (DLR).

3. Educational benefits

Students will participate in almost all parts of the project. From project management to systematic issues and building of experiment and operational activities as safety analyzes, data reception and assembly of rocket motors.

4. Launch vehicle descriptions

5. REXUS

(Rocket Experiment for University Students)



Fig. 1. Orion Rocket

- One stage improved Orion Rocket
- Payload capacity: 100kg
- Experiment mass: 35kg
- Experimental space: Two 14 inch modules
- Ejectable nosecone
- One pop out hatch
- 5 Experiment uplink channels
- 5 Experiment downlink channels
- 3 axis accelerometer
- Roll, Pitch & yaw gyros
- One video channel with possibility to switch between 2 experiments
- Power: 28V, 1 A per experiment
- Apogee: 90 – 105km

5.1. REXUS flight ticket

In the REXUS “flight ticket”, the following services are included:

- General management and planning of the REXUS project
- Provision of launch vehicle and subsystems necessary for a spaceflight mission with recovery.
- Lift-off signals are provided.
- Integration of participating modules into the flight configured payload and testing of payload (telemetry, telecommand, flight

simulation test, dynamic balancing, and determination of physical properties).

- Transport of modules from the integration facility to Esrange.
- Payload assembly and testing at the range during 5 days (nominally).
- Provision of laboratory facilities at the range.
- Launch and recovery.
- Data acquisition with provisions of real time, quick-look and playback data from modules and payload subsystems (e.g. g-levels).
- Disassembly of recovered payload and return of modules for retrieval of processed samples.
- Post flight report.



Fig. 2. Rocket on launcher

6. BEXUS

Balloon Experiment for University Students)

- Balloon: Zodiac 12SF
- Size: 12 000m³
- Gondola: 1.5 x 1.5 x 1.5m
- Payload mass: up to 400Kg
- Experiment mass: 40 – 100Kg
- Float altitude: 30 – 35 Km
- Flight duration: 2 - 5 hours
- Up & downlink: Two 9600bps channels one 4800bps channel
- Position data: GPS
 - Power: as requested by the experimenters but may be limited due to payload mass limitations



Fig. 3. Preparation for a balloon launch

6.1. BEXUS flight ticket

In the BEXUS “flight ticket”, the following services are included:

- General management and planning of the BEXUS project
- Provision of launch vehicle and subsystems necessary for a flight mission of 2-5 hours with recovery.
- Integration of participating modules into the flight configured payload and testing of payload (telemetry, telecommand, flight simulation test, and determination of physical properties).
- Payload assembly and testing at the range during 5 days (nominally).
- Provision of laboratory facilities at the range.
- Launch and recovery.
- Data acquisition with provisions of real time, quick-look and playback data from gondola and payload subsystems.
- Disassembly of recovered payload and return of experiment.
- Post flight report.



Fig. 4. Picture taken from a balloon at 25kms altitude above northern Scandinavia.

6.2. Programme milestones

The annual schedule of activities associated with the REXUS / BEXUS Programme is as follows:

September Call for Experiment Proposals on the ESA Education Website.

November Deadline for submission of proposals.

The deadline for applications is 30 November. In order to apply, student teams should register online and fill in FormA with the details of their proposal. The opportunity is open to students aged between 18 and 28 at the time of the application deadline. Applicants must have the nationality of an ESA Member State or Co-operating State and be enrolled as full-time undergraduate or PhD students in a University in an ESA Member State or Co-operating State. They must also be studying or researching a subject in relevant field of science or engineering.

December Notification of all proposing teams regarding their pre-selection or non-selection.

Mid January Workshop with presentations by pre-selected teams.

The best 10-12 team proposals will be short listed and announced. Short listed teams will be invited to a workshop at ESTEC to present their proposals to experts from ESA and SSC/ Esrang. Before the workshop they have to submit basic technical information by filling in Form B. The final selection will be done immediately after the workshop.

End January Final selection of proposals (primary and backup).

February Student training week at Esrange

The selected teams will be invited to a training week at Esrange in Kiruna, Sweden. A preliminary design review of each experiment will be carried out during this week by experts from ESA, DLR and SSC/Esrang. In the following weeks, students will work on their design, following the advice that they have received and

complete their documentation for a critical design review (CDR)

May Student experiment Design Review for Bexus and preliminary Design Review for Rexus.

Mid September Delivery of Bexus experiment flight hardware to Esrange.
Experiment Acceptance Review.
Flight Acceptance Review.

Early October Flight Readiness Review.
Launch Campaign.

October Critical Design Review for Rexus.

December Submission of Bexus final report.

Mid February Delivery of Rexus experiment flight hardware to Esrange.
Experiment Acceptance Review.
Flight Acceptance Review.

March Flight Readiness Review.
Launch Campaign.

September Submission of Rexus final report.

7. Selected experiments for Rexus/Bexus 2008/2009

Following a workshop held 5-6 March at the European Space Technology and Research Centre (ESTEC) in the Netherlands, 8 student teams from various ESA member states and co-operating states have been selected to fly their experiments on coming sounding rocket and balloon campaigns. The workshop followed on from an announcement of opportunity issued by the ESA Education Office in November 2007 for the Rexus and Bexus programmes (Rocket / Balloon Experiments for University Students). After evaluation of the initial proposals, a number of short listed teams were invited to present their proposals to experts from ESA and SSC/Esrang during the workshop. The final flight selection was made on 7 March. The winners join six teams chosen earlier in the week for the same flights by the German Aerospace Centre (DLR).

7.1. Bexus balloon campaign in October 2008

The experiments selected for the Bexus 6/7 balloon flights are (ESA/Sweden):

TimePix@Space, Luleå University of Technology, Sweden, Charles University Prague and Czech Technical University, Czech Republic. Detection of particles in the stratosphere using a hybrid imaging pixel detector developed at CERN.

Stratospheric Census, An international team of students from the Erasmus Mundus, Space Masters course, currently based at Luleå University of Technology, Sweden. Using Innovative nanofilters combined with a strong airflow from a power-effective air pump to gather dust particles for study with advanced sample-return analysis techniques.

Stratosphere and Magnetic Field Polar Explorer (AURORA-SMF Polar Explorer), La Sapienza University of Roma, Italy. An investigation of polar lights phenomenon by mapping the properties of the stratospheric environment.

Low Cost Inertial Navigation System (Low Co.I.N.S.), La Sapienza University of Roma, Italy. Design and validation of an inertial measurement unit with low cost sensors and components.

Icarus, Warsaw University of Technology, Poland. A study of lifting body technology by releasing a glider from the balloon and piloting it to a designated landing zone by remote control.

7.2. Rexus campaign in March 2009

The selected experiments for the Rexus 5/6 in March 2009 are (ESA/Sweden):

Norwegian Ionospheric Sounding rocket Seeding Experiment (NISSE), University of Bergen, Norway. Water will be released into the ionosphere to form a cloud of ice crystals that will be visible from the ground. The water molecules will be ionized by solar radiation and travel along the magnetic field lines, forming patterns that will be analyzed using the EISCAT radar.

Itikka, Castor Space Club of the Tampere University of Technology, Finland. A test of an inertial measurement unit. They will analyse its performance in the high acceleration, high angular velocity and high vibration

environment and search for unexpected sources of errors.

Vibration effects on biphasic fluids (VIB-BIP), Universitat Politecnica de Catalunya, Spain. A study of the behaviour of biphasic fluid (a liquid containing gas bubbles) in a microgravity environment when vibrations are applied to the system.

8. Previous BEXUS & REXUS flights

Student balloons:

BEXUS 1	2002-11-25	15:53 UTC
BEXUS 2	2004-02-26	10:57 UTC
BEXUS 3	2005-03-22	15:21 UTC
BEXUS 4	2006-06-19	11:13 UTC
BEXUS 5	2007-03-28	11:05 UTC

Student rockets:

REXUS 1	1995-12-04	10:23 UTC
REXUS 2	2004-10-28	19:49 UTC
REXUS 3	2006-04-04	05:56 UTC

9. Conclusion

This programme has so far become a real success and the European students are enthusiastic for this new possibility to fly experiments in space. The funding agencies Swedish National Space Board (SNSB) and The German Space Agency (DLR) are very positive to this new initiative by EuroLaunch to promote sounding rocket and balloon activities and to attract young people in space activities.