



# What happened to ?

## Third part of the Success Story of NISSE

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The REXUS 6 rocket carrying the student rocket experiment NISSE onboard (see Spaceprobes 3/2008 and 1/2009, available online at <http://www.sats-saff.fi>) was launched from Esrange (European Sounding rocket Range) in Kiruna, Sweden March 12, 2009. In the NISSE experiment, 8.3 kg water was to be released into the daytime upper atmosphere at an altitude of about 95 km. The aim was to study possible effects of the released water on the ionosphere with the tri-static EISCAT UHF incoherent scatter radar.

The REXUS 5/6 launch campaign was carried out on 2-15 March 2009. NISSE, the German student project AGADE and the Swedish IMEGO were the three experiments to fly onboard REXUS 6. (for further info, see <http://rexusbexus.net/>).

The first week of the campaign started on Monday, March 3rd 2009, and it was filled with preparation of the experiments. The NISSE payload and additional equipment had been sent to Kiruna Esrange before our arrival to the launch site. The payload was completed, filled with water and tested in-system to ensure it worked as expected. In addition, our team carried out some EISCAT test measurements for NISSE. During the following weekend both REXUS 5 and REXUS 6 rockets were finally assembled.

In the beginning of the second week, on Monday, 9th of March, a test countdown for REXUS 6 was successfully performed. All critical actions related to the experiment for the hot countdown were practised, including communication between the three sites: the launch area, the science room at Esrange and the EISCAT Kiruna site. However, due to the simultaneous MIPAS B/TELIS and TWIN balloon campaigns, the rocket launches were delayed until the end of the week. The time during the delay was filled with lectures on various topics e.g. presentations, job interviews, meetings and outreach, given by people from Esrange, ESA and DLR. Then, on 12 March 2009 at 11:08 LT REXUS 6 rocket with NISSE onboard finally left the surface of the Earth.

### LAUNCH ON 12 MARCH 2009 AT 11:08 LT

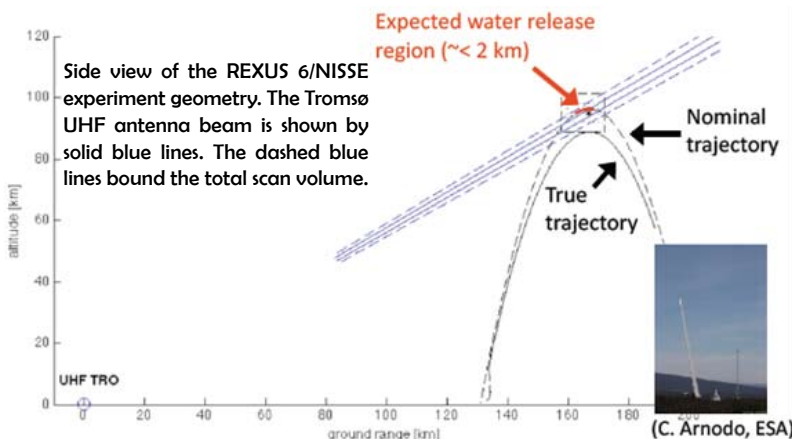
Blue sky and no wind; the launch conditions are perfect. Before eight in the morning the helicopter scans the impact area for human beings. The wind balloons are launched for the trajectory calculation of the rocket. The sirens start and the radio silence is announced. But then the first shock: the EISCAT UHF radar does not start properly. Calls go back and forth between the three NISSE stations. But then one hour before the launch, the relieving message from the EISCAT site: EISCAT UHF radar is ready for action. By using

the calculated nominal trajectory, we redirect the EISCAT radar to point to the expected water release position. Temperature and pressure are constantly observed. Nothing unusual happens. Then we hear from the loudspeakers: ten, nine, eight,...,two, one, zero.

It is a textbook launch (see YouTube: REXUS 6 launch). Dozens of cameras follow this unique scenario, the gratification of intensive work. With a total rocket weight of 551 kg the payload lifts off. An enormous spectacle of power. REXUS 6 reaches an altitude of about 89 km above ground 143.9 s after the lift-off, a few kilometers below the predicted apogee of 96.4 km. But it is far enough for an onboard camera to bring back pictures to the ground, showing the earth curvature with its atmosphere and the dark outer space (see e.g. the pictures of the Finnish ITIKKA team, <http://itikka.servu.org/>, whose experiment flew on REXUS 5).

The water release operating system is monitored real-time on the ground during the entire flight. After the breathtaking moment of the launch follows 30 minutes of doubts and insecurity: there is no sign of a release in our operating system monitors at the start of the experiment time. Did something happen to NISSE on its way to space?

After about half an hour the payload is recovered from the impact area by a



helicopter and moved to Esrange for inspection. The experiment modules are in a perfect condition. The parachute has safely landed the payload back on the ground. The mechanical parts of the NISSE experiment have obviously withstood the forces during launch seemingly without problems. The water tank has kept tight - too tight. The NISSE module is as heavy as before the launch. The analyzed data from the EISCAT radar only echoes from the rocket flying through the antenna beam side lobe, but no change in the background ionization. The NISSE electronics has experienced a fatal failure. The fire-circuit has malfunctioned. No water was released. The numerous tests of the fire-circuit on the ground before and even after the flight had always been successful, but something during the launch made it fail.

### INVESTIGATIONS OF THE MALFUNCTION

The error analysis indicates two main failure possibilities. One is the vibration during the launch, which could have caused parts of the fire-circuit to get in contact with the aluminium box and thus in direct contact with the rocket. Such a process grounds the circuit to the rocket skin, so that the fire capacitor cannot sufficiently charge before firing. This on the other hand lowers the subsequent current, which in turn is not high enough to ignite the explosives. Another failure possibility is a malfunction of the baroswitch. There was a safety baroswitch installed to ensure that the fire-circuit does not get charged before the internal pressure has fallen to the equivalent of the atmospheric pressure at 6 km altitude. There are indications that the baroswitch activation may have been delayed leading the fire capacitor not to charge.

The fact that the horizontal projection of the rocket trajectory remained very close to the predicted nominal trajectory suggests that provided a sufficient high apogee altitude, we would have hit the release region with the radar. Whether the amount of water used would have been enough to have any measurable effect to the ambient ionosphere, remains still obscure.

But there is still some good news in the end: since NISSE came back to ground in one piece, it could in principle be flown again.

### OUTLOOK

Despite the failure of NISSE's electronics, we can proudly say that it was a partial success. All educational objectives were fulfilled.

The project taught us a lot about teamwork, project management, rocket science and outreach. We learned something more about ionospheric physics and EISCAT. In addition, the project gave us experience in participation in an interdisciplinary engineering project and collaboration with international space organizations like ESA, DLR and SSC. We also made new friends and valuable contacts to researchers working in space science.

For students who are planning or are interested in participating in the REXUS program (more info about the program can be found at [www.rexusbexus.net](http://www.rexusbexus.net)) we would like to say: go for it! It is a unique chance to learn about rocket science and educate yourself in many ways.

Finally, we would like to use the opportunity to thank a few people that helped the project with plain support, constructive comments, suggestions and discussions. Asbjørn Søreide and Svein Njåstad for supporting the experiment payload design, Kåre Slettebakken for the experiment payload construction, Carl-Fredrik Enell for ionospheric response modeling, Juha Vierinen and Ilkka Virtanen for EISCAT raw data sampling, and Werner Olsen

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NISSE team in front of the EISCAT Kiruna UHF antenna. Starting from left: Gisela, Gard, Vidar and Timo.