33rd Space Symposium, Technical Track, Colorado Springs, Colorado, United States of America
Presented on April 3, 2017

ESRANGE SPACE CENTER – MEETING FUTURE NEEDS FOR ADVANCED SPACE SERVICES

Mattias Abrahamsson
SSC, mattias.abrahamsson@sscspace.com

Anna Rathsman
SSC, anna.rathsman@sscspace.com

ABSTRACT

SSC's Center of Excellence, Esrange Space Center, is located in the very north of Sweden, above the Arctic Circle (68°N, 21°E) and has access to a vast, inhabited impact area, measuring 5200 km^2 or 2000 square miles. Esrange was founded in 1966 by ESRO, the predecessor of ESA. SSC has owned and operated Esrange since 1972.

The facility is presently used by the international scientific community, space agencies and commercial customers for launching sounding rockets for microgravity and atmospheric research as well as high altitude balloons for astronomy, atmospheric research and drop tests. Up to date, over 550 sounding rockets and over 520 balloons have been launched. Esrange has a well-equipped infrastructure and experience of launch operations, range and launch safety. Coordinated measurements using satellites, sounding rockets, balloons and/or ground instrumentation is possible and satellite communication is easily accessed by means of SSC's global satellite ground station network, Universal Space Network (former PrioraNet), where Esrange satellite station is a hub.

The development of reusable space vehicles as well as robotic rovers for space exploration are challenging and expensive projects and thus there is a need for full scale testing to minimize the risk of failures before taking them into operation. Another area with increasing demands is the need for dedicated launch opportunities for small satellites. In order to meet these needs Esrange is now undergoing a major expansion. The new capabilities will include services for affordable and easy access to space such as SmallSat Express, a European launch capability for small satellites, tests of reusable vehicles as well as enabling technology tests for space exploration by means of re-entry and landing tests and robotic rover tests in an analogue Moon and Martian environment.

ESRANGE SPACE CENTER

Esrange Space Center is the Center of Excellence and the launch and main operations facility of SSC. It is located in northern Sweden above the Arctic Circle at lat. 67° 53'N, long 21° 04'E. The town closest to the range is Sweden's principal mining town Kiruna, which is about half an hour away by car.

Image 1: Esrange Space Center. Rocket launch area in right background, balloon launch area in front.

The facility was built by ESRO (European Space Research Organization) and inaugurated in 1966 as a sounding rocket launch facility, mainly for auroral and atmospheric research. Balloon activities at Esrange Space Center started in 1974 and satellite activities in 1978.

The rocket and balloon activities are coordinated and financed by the Esrange Andøya Special Project (EASP) within ESA (European Space Agency). The member states of EASP today are France, Germany, Switzerland, Norway and Sweden.

The assigned missions for Esrange Space Center regarding sounding rockets and balloons are:

- Support of the sounding rocket and balloon programs of the member states of EASP. Non-members can also use the facilities on commercial basis.
- Operation of ground based scientific instrumentation to support scientific research.

The facility is also used for UAV flights, due to its remote location with extremely low air traffic in the vicinity.

Esrange is presently used by the international scientific community, space agencies and commercial customers for launching sounding rockets and high altitude balloons for research under microgravity, astronomy, atmospheric research and technical tests. To date over 500 sounding rockets and over 600 balloons have been launched.

Sounding rocket and stratospheric balloon launches from Esrange can be performed either by individual countries and organisations with permission from SSC, or by EuroLaunch – a collaboration between SSC and DLR providing a flight ticket approach.

Sounding Rockets

Several types of rockets are launched, from small meteorological rockets weighing some tens of kilograms, to the largest sounding rocket launched in Europe – MAXUS, a 16 m long and 12 ton vehicle capable of launching its 700 kg payload to 700 km altitude for a 13 min flight in microgravity conditions.

A majority of the rockets launched are for experiments to be performed under microgravity conditions, but other examples of research fields are ionospheric research and atmospheric research, as well as technical tests.

SSC also helps the scientific community by designing and building the experiment payloads.

Stratospheric Balloons

Stratospheric balloons are launched from Esrange for several types of missions, e.g. atmospheric research, astronomical research and technical tests.

The balloons used range in size from 500 cubic meters (17 000 cubic feet) to over one million cubic meters (40 million cubic feet). A balloon that size can carry a 2 ton gondola to 40 km altitude and fly for several weeks.

Depending on season, the prevailing winds at altitude will take the balloons in different directions. Generally it could be said that from mid-May to mid-August the high altitude winds will take a balloon westwards, in a trans-Atlantic trajectory with landings in Canada or Alaska. During mid-September to late April the winds will take a balloon eastwards for landings in east Sweden, Finland or Russia. In the beginning of May, late August and early September the winds at high altitude will change from easterly to westerly direction, and they will be slow and moving somewhat erratically over north Sweden, Norway and Finland. This is called the “turn-around period” and is used for long flights over Esrange, up to two days.

Esrange Rocket Impact Area

The Esrange Rocket Impact Area is located north of the base area in the Swedish tundra region. It covers a rhomboid area of 5,600 km^2 and is 120 km north-south and 75 km east-west. According to Swedish law the only activities allowed in the area are space related activities, reindeer herding and mobile recreational activities.

The area is divided into three zones - A, B, and C. Zone A, the impact area for boosters, can be extended when rockets with long-range boosters are launched. Zones B and C are impact areas for second and third stages as well as payloads. Above the Esrange impact area lays a restricted airspace covering 6,100 km^2. The restricted airspace

stretches from ground to unlimited altitude (GND/UNL) and is activated whenever needed for rocket, balloon or UAV activities. A 5 NM buffer zone exists inside the R01 restricted airspace. The buffer is only used for UAV flights to avoid the UAV to fly in proximity to other possible aircraft outside R01.

By using a land based recovery area, all experiments are normally back at base within 2 h.

Stratospheric balloon payloads only have to land in the Impact Area if they are free falling without parachute, otherwise balloon payloads can land outside the area, i.e. in Norway, Sweden and Finland. With permission landings have also occurred in Russia and Canada.

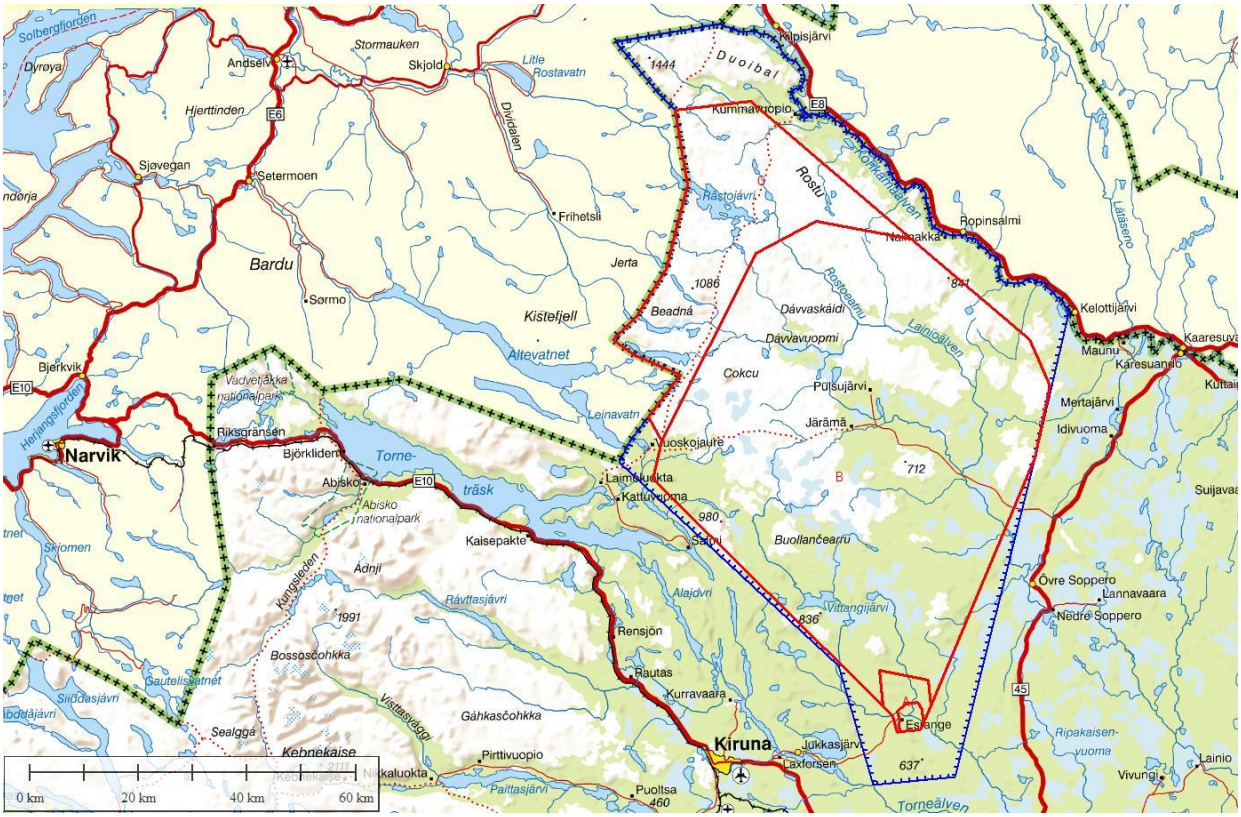

Image 2: The Esrange Impact Area.

Esrange Satellite Station

Due to its advantageous geographical location, north of the Arctic Circle, Esrange is the location of one of the world's busiest civilian satellite ground stations. More than 25 satellite dishes ranging from 3 to 15 m in size receive and transmit data to and from polar orbiting satellites. Some of these antennas are customer antenna systems that SSC provide hosting services for.

Esrange satellite station is a main hub of Universal Space Network (former PrioraNet), and satellite communication is easily accessed by means of SSC's global satellite ground station network.

NEW TESTING CAPABILITIES

Due to the work already performed with rockets and balloons over the last 50 years, Esrange is in an excellent position when it comes to the signals of needs for testing of new space systems, e.g. parachutes for re-entry vehicles, reusable launch vehicles and robotic systems.

The vast Rocket Impact Area is naturally one of the foremost resources to use for many of the tests performed at Esrange. An expansion of the current Esrange facility into the Rocket Impact Area is foreseen, with roads and bridge over a small river built to reach areas where new facilities can be erected.

Drop tests

With an increasing interest to test and validate re-entry systems of various kinds in-flight, an increased demand on flight opportunities from Esrange Space Center can be expected.

Stratospheric balloons that are launched from Esrange has a capacity to lift a mass up to 2 tons and can reach an altitude of 40 km, equivalent to an atmospheric pressure of 3 mbar. The payload or test object (re-entry vehicle, parachute system, etc.) that shall be tested can be equipped with telemetry and tele-command system for real time monitoring and control during the complete flight and free fall.

Sounding rockets launched from Esrange can also be used in a similar way for reaching high altitudes, although with a lower mass test objects. Rockets with different capacities can be launched to any altitude up to 700 km, and can carry experiment payloads up to 300 kg.

Dedicated drop test rocket

SSC has identified the possibility to create sounding rocket missions dedicated to drop tests – or any other activity that requires high altitudes. As a first iteration, a low cost example of such mission would be the use of a 1500 mm long and 14" (355 mm) diameter module structure to send 50 kg of experiment payload to 100 km apogee, all propelled by an Improved Orion single stage rocket motor. Once motor separation has occurred, the experiment can be initiated. There are several possibilities and solutions that can be imagined for carrying out the missions, some of them are;

- Ejecting a re-entry body from the inside of the experiment structure
- Splitting the experiment module open late in the descent phase, to release the experiment once the speed is high (as practiced in drop tests from balloons).
- Using nose-cone and service module as ballast mass for super-sonic parachute tests

With several yearly missions, running cost would be low. First launch could take place in less than a year from mission order, and thanks to land recovery, the flown object(s) would be back with experimenters within a couple of hours after flight.

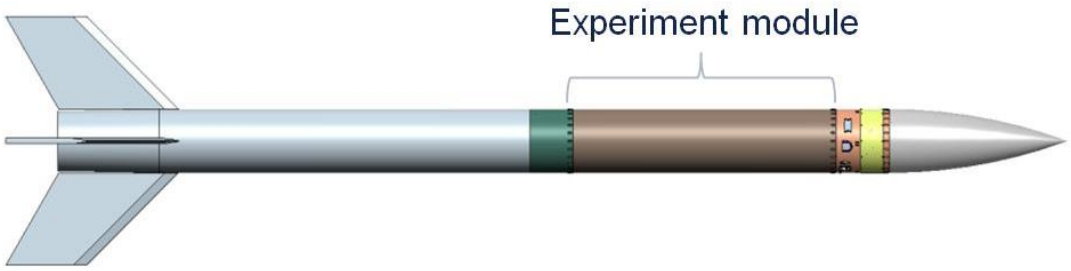

Image 3: Dedicated drop test rocket.

Reusable vehicle tests

Esrange are currently looking at possibilities of building dedicated test facilities for reusable launch vehicles. These facilities include a runway for horizontal landing vehicles, and pads for HOTOL (horizontally take-off and

landing) launch vehicles. The possibility to use lakes in the area for the landing of some vehicles have been examined and also been found feasible.

Robotic tests and sensor trials

There are several areas in the Esrange Impact Area that are very suitable for tests of robotic vehicles. The sparse vegetation and harsh climate makes it possible to build environments for rovers that could be used as "rover playgrounds".

The restricted flight area also makes it possible to test sensors and systems on-board for UAV systems. Complete sensor target areas can be built for long term trials.

SMALL SAT EXPRESS

SSC is currently working with a satellite launch concept called SmallSat Express. The goal is to launch satellites 1 - ≈150 kg at pre-determined dates, one to four times per year and into a standard orbit. Cubesats are the main target payloads. The standard orbit is a sun-synchronous, "dawn-dusk" orbit at 500 km altitude and at the following local times of the ascending node: 2200, 0600 and 1400 (or 1000, 1800 and 0200). The use of the Esrange Impact Area for possible first stage impact is one of the reasons for locating the launch facility at Esrange.

A phase B1 study has been finalized which aimed for political endorsement, mainly in Sweden as well as obtaining data for the different launch vehicle options. As a result, the Swedish government has appointed a coordinator with the task to, on behalf of the government, take the project one step further by evaluating the business conditions including financing of the launcher infrastructure needed. The assessment of the launch vehicle options resulted in choosing the Brazilian/German VLM launcher as the base case. However, the final decision has not yet been taken and other launcher alternatives will be considered. The launch vehicle should be able to carry a payload of 100 - ≈150 kg to a 500 – 600 km Solar Synchronous Orbit and not use toxic propellants such as Hydrazine. Since the launches will take place all around the year, the vehicle must withstand low temperatures (≈ -20°C) and have a track record of at least three successful launches. There are also some restrictions for the ascent, i.e. first stage impact, second stage ignition and impact and a "dog leg" capability.

Funding for a B2 phase study has just been approved and this study will include flight safety risk assessment of launchers, design of infrastructure at Esrange and orbit raiser design (concept and main engine) if the need for an orbit raiser is verified. A preferable choice for an orbit raiser will be based on ECAPS' High Performance Green Propulsion.

Strong support from Swedish politicians has made it possible that funding for infrastructure will be added in the Swedish state budget from 2018. The goal is to launch the first satellite early next decade.

CONCLUSION

Esrange Space Center has, due to a beneficial geographical location as well as a legacy of rocket and balloon launches, the potential to become an even more useful facility for scientific and technical organizations and companies in need of new advanced flight and testing opportunities. The expansion of the base and the addition of new services such as dedicated drop test vehicles and satellite launchers, as well as new facilities such as pads for reusability tests, has the possibility to cement Esrange as the European center of excellence for advanced testing with rockets and balloons into the next decades.