

Increased capabilities at Esrange –Tests of reusable motors and stages**Christian Krokstedt^a, Anne Ytterskog^{b*}, Philip Pålsson^c,**^aSSC (Swedish Space Corporation), P.O. Box 4207, SE-17104 Solna, Sweden, christian.krokstedt@sscspace.com^b SSC (Swedish Space Corporation), P.O. Box 4207, SE-17104 Solna, Sweden, anne.ytterskog@sscspace.com^c SSC (Swedish Space Corporation), P.O. Box 802, SE-98128, Kiruna, Sweden, philip.pahlsson@sscspace.com**Abstract**

SSC (Swedish Space Corporation) is investing alongside funding decided by the Swedish Government, in a new test bed facility at SSC's Esrange Space Center. Esrange is since a couple of years undergoing a major upgrade in order to meet the increasing demand of access to space and test facilities for motors and reusable stages. The test bed facility will enable validation of new liquid, hybrid and solid engines as well as of new sounding rockets and reusable first stages through tethered tests, jump tests and controlled landings. A test facility for static firing of solid rocket motors is already in operation, facilities for liquid rocket motors are expected to be operational by Q3 2019. The plan is to carry out validation of new sounding rocket motors by 2019 and reusable stages by 2020. Esrange Space Center, owned and operated by SSC since 1972, has an ideal location in the very north of Sweden, above the Arctic Circle (68°N, 21°E) with access to a vast, unpopulated recovery area, 5200 km². It has a well-equipped infrastructure and proven experience of operations, range and launch safety, handling of large rocket motors and launching of guided rockets. 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. This paper will develop the test bed services and facilities in more detail.

Keywords: Launch service, Small satellites, Esrange Space Center, Test bed, Reusability, Sounding rocket tests, Rocket motor tests

1. Introduction

It is not currently possible to test and develop reusable rockets in Europe. The market for launching small satellites is expanding, and the demand for developed rocket technology is increasing. This is why the Swedish Government and SSC have invested in a testbed for the development of in-demand technologies: reusable launch technology for small and large rockets, test flights, liquid rocket engine testing and satellite technology.

The testbed program is aimed at providing testing of these key technologies for small satellite launch vehicles and reusable test vehicles for commercial companies and agencies. This will stimulate the development within Europe and make European companies and agencies competitive on an international market.

With SSC Esrange extensive expertise in sounding rocket launch and aerospace testing for more than 50 years makes it an obvious location for testing of these new in-demand technologies.

2. Esrange Space Center

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, unpopulated recovery area, 5200 km². Esrange was founded in 1966 by the European organization ESRO, nowadays ESA. SSC has owned and operated Esrange since 1972. The facility is since a couple of years undergoing a major upgrade to manifest its status as a Center of Excellence for space services. This now also includes services to meet an increasing demand for access to space and test facilities for motors and reusable stages.

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 630 balloons have been launched. Esrange already has a well-equipped infrastructure and experience of operations, range and launch safety as well as handling large rocket motors and launching of guided rockets.

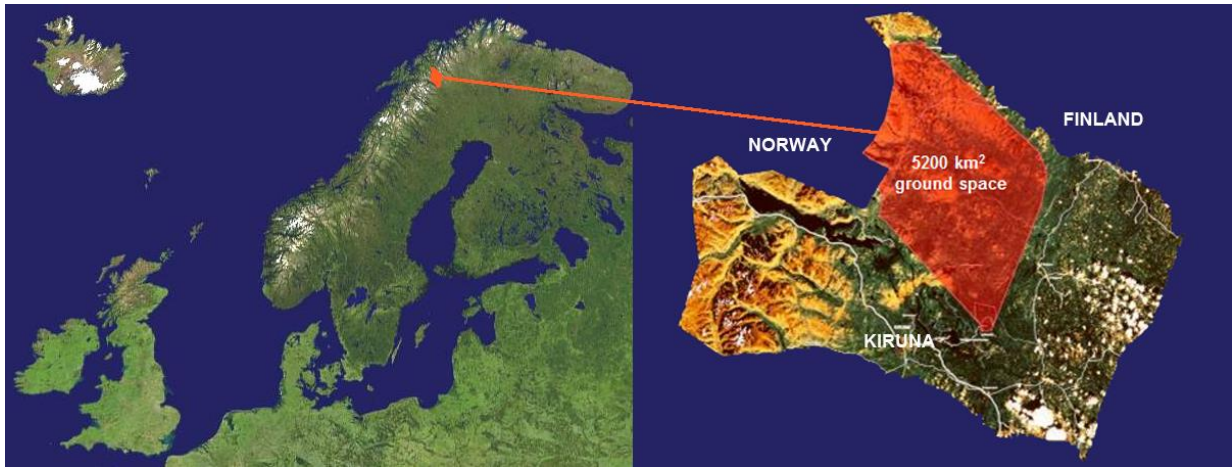


Figure 1 Esrangle impact area

Esrangle also hosts one of the world's largest civilian satellite ground stations, a hub in SSC's global satellite ground station network, SSC Universal Space Network.

On the contrary to what maybe can be believed from the location above the polar circle, the climate at Esrangle not in any way extreme. The Gulf Stream warms northern Scandinavia, for instance the port west of Esrangle is ice free all year round

3. Testbed Esrangle – the services

The Swedish Government strongly supports SSC's initiative to establish a European launch facility for small satellites at Esrangle. In July 2018, SSC decided to invest in a test bed facility at Esrangle, alongside funding decided by the Swedish Government.

The test bed will enable validation of new sounding rocket motors and reusable stages by 2019 and 2020 respectively. Examples are launches, tethered tests, jump tests and controlled landings. This test facility will be located in the same launch complex as the satellite launches, Launch Complex East.

Through the testbed programme SSC can provide services for:

- Reusability testing for launchers
- Engine development and tests
- Stage development and tests
- Sounding rocket test launch
- Exploration vehicle and system tests

3.1 Reusability testing

SSC has far reaching plans for establishing a facility for reusability tests. The location of the launch site is identified and an analysis of the type of buildings needed and the logistical flow between them and ports/roads has been made. Detailed design and projecting of infrastructure including permits required have been initiated with the aim to have the facility operational in 2020. The facility will enable validation of reusable boosters and sounding rockets by means of tethered tests, jump tests and controlled landings.

The expected infrastructure investments will overlap in capability with SSC's current activities undertaken within the Swedish orbital launch initiative "Smallsat Express" (S2X).

Remote landing zones are primary planned at two locations, Maltosrova and Järämää. The down range distances to the two locations are 4.5 km and 54 km respectively. The distance by road to Maltosrova is 130 km and to Järämää 170 km. A complementary remote landing zone is Sekkujärvi which is located 22 km downrange. Alternative sites are also available upon request.

During a test campaign SSC will be responsible for:

- All ground infrastructure required at Esrangle for preparation, launch, flight, landing and recovery
- Permits from Swedish authorities
- Ground and flight safety
- Tracking systems, including radar
- TM/TC and service systems to be integrated in the vehicle including GSE.
- Fuelling, launching, flight safety and recovery operations



Figure 2 Launch Complex East; Reusability testing and Orbital launch

3.2 Rocket engine testing; Liquids and Solids

In late 2017, a rocket motor test facility for static firing of solid rocket motors in a horizontal position was completed. The test stand is designed for a maximum motor thrust of 500 kN. The facility became operational in the spring of 2018. In November, static test firing of Taurus solid boosters took place. The motors were tested up to four times a day during a four week campaign.

Due to the location of Esrange Space Center and the past activities, the site does not have any restrictions in terms of sound levels. This, together with easy availability of gases and fluids thanks to the mining activities in the northern part of Sweden, make Esrange an ideal place for fast and reliable testing.

Test firing with the first customer for liquid rocket motors in horizontal position will begin in Q4 2019. SSC is, at the time of writing, installing 30m³ tanks for fuel and oxidizer storage and vacuum insulated piping to support horizontal long duration testing of liquid rockets up to 500kN. The testing setup is to be agnostic in terms that customers arrive with mobile testing rigs that connect to SSC infrastructure on the site. This enables the testing to be flexible without any large customer installed infrastructure. This gives way to supporting multiple customers from one single site.

The site has access to:

- 220V AC
- Ethernet fibre connection
- Water
- Deflector ramp
- Rails & dolly for custom installations
- Pressure plate
- Safety systems and firing lines



Figure 3 Test fire of 500kN motor in 2018

3.3 Stage testing

As an evolution of the motor testing, whole stages for European small satellite launch vehicles will need to be tested. SSC aims at building up a new infrastructure at Esrange to support commercial companies and agencies in this endeavour. This capability will enhance the European capability to independently test and verify

whole small satellite launch vehicle stages without going overseas for performing the tests.



Figure 4 SpaceX stage testing of Falcon 9 booster

3.4 New and Experimental launch vehicle testing

SSC Esrange has now opened up the range for testing of new launch vehicles with a low flight heritage. This enables the development and testing of experimental vehicles containing key technologies for larger and more mature launch vehicles in the future. These new vehicles are launched from the existing launch area into the vast 5,200 km² impact area. Technologies being tested range from new innovative fuels and oxidizers to student rockets.

Esrange has a long heritage of launching European student rockets and has launched rockets for the German STERN programme, the French Perseus programme and the Dutch DARE.

Starting from 2019, SSC Esrange is open for suborbital testing of small satellite launch vehicles, a campaign is already booked for 2020.



Figure 5 Test launch of micro launcher

3.5 Exploration vehicle testing

Today, SSC performs drop tests of aerospace vehicles and parachutes using stratospheric balloons as well as drop and re-entry tests using sounding rockets. Vehicles/drop bodies weighing +2000 kg can be lifted up to 40 km altitude with a stratospheric balloon. By using a sounding rocket, a drop body of 700 kg can be lifted up to 700 km altitude. Re-entry bodies can be released from up to 700 km altitude. The vehicle/drop body is then released over Esrange restricted land impact area (5200 km²).

SSC has, since 1986, a long experience of exploration vehicle testing with famous missions such as ExoMars and the Huygens probe being tested at Esrange Space Center. Esrange is available to test new exploration technologies for lunar and mars landers thanks to the vast open spaces available and the expertise in ballooning, aerospace testing and sounding rockets.

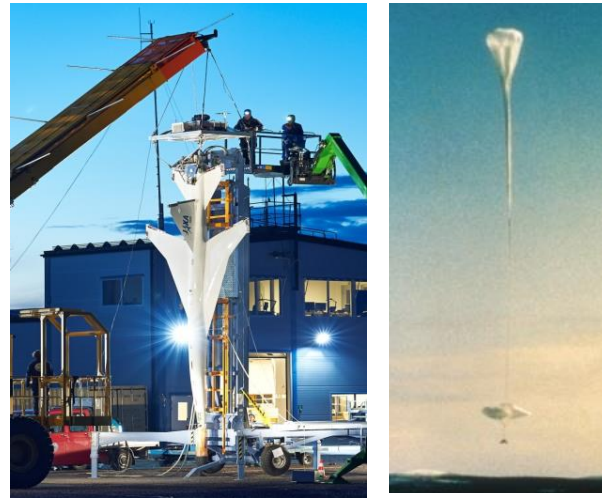


Figure 7 Drop test of JAXA D-send mission and the Huygens probe

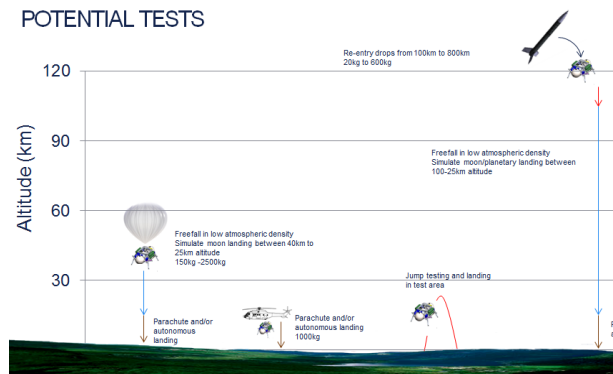


Figure 6 Drop tests of exploration vehicles

6. Conclusions

The Swedish Government's decision to invest in new test facilities along with SSC funding as well as the co-financing of the SmallSat Express, show the strong support in Sweden for developing the capabilities at Esrange. Esrange geographical location, the vast, unpopulated land impact area, the well-equipped infrastructure and the proven experience of operations, range and launch safety as well as handling of large rocket motors and launching of guided rockets are all excellent prerequisites.

This makes Esrange Europe's new leading test site for advanced aerospace testing for reusability, exploration vehicles, experimental rocket propelled launch vehicles and small satellite launch technologies.