

THE SWEDISH SPACE SCIENCE PROGRAMME TECHNICAL ASPECTS

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ABSTRACT

The Swedish Space Science programme comprises sounding rockets, balloons and satellites. The investigations relate to geophysical disciplines, astrophysics and microgravity research.

Current and future scientific projects using sounding rockets, balloons and satellites are planned for investigation of the Earth's atmosphere, the aurora and its origin, sub-millimeter observations of interstellar medium and fluid physics.

These investigations require increased technical capabilities with respect to payload and spacecraft design and ground based equipment.

1 INTRODUCTION

The Swedish space science programme is concentrated on four main areas:

- Magnetospheric and ionospheric physics, including measurements of charged particles and electric and magnetic fields.
- Upper atmospheric physics and chemistry, including studies of the composition of the atmosphere at altitudes of 80-150 km.
- Astrophysics, including studies of stars and galaxies in the ultraviolet, infrared and sub-mm parts of the spectrum.
- Microgravity, including material and fluid science.

Authority for the Swedish sounding rocket, balloon and small satellite program is the Swedish National Space Board. The Swedish Space Corporation is responsible for the execution of the projects as well as the operation of Esrange. Addresses to the scientific groups participating in the Swedish sounding rocket, balloon and small satellite programme, together with other useful addresses, can be found on: www.astro.su.se/srs

The programme comprises several launches every year from Esrange and other ranges. Many of the sounding rocket and balloon campaigns are coordinated with measurements made by the EISCAT facility.

In addition to the activities described in this paper, it should be noted, that Swedish scientific groups participate within programmes of other nations.

2 ON-GOING PROJECTS

The presentation below covers launches performed as from Dec 2001.

2.1 MASER

In the MASER programme SSC offers microgravity flight services for the international microgravity community. SSC also offers design work and manufacturing of specific experiment modules. By using an improved Black Brant IX or Skylark 7 rocket seven minutes of microgravity can be provided for a payload comprising a maximum of 375 kg experiment module weight.

The first MASER rocket was launched on March 19, 1987 and since then one MASER has been launched almost every year.

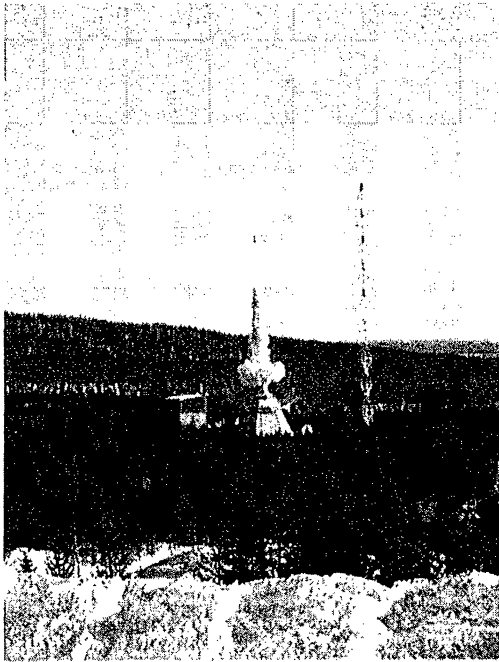


Fig 1 MASER-9

Payload number 9 in the MASER programme was successfully launched from Esrange in March 2002. A new service module for MASER has been developed jointly by SSC and DLR on behalf of ESA. The payload also comprised the Cyrène-2 and ITEL microgravity modules developed by SSC on behalf of ESA. MASER 10 will be launched spring 2005.

2.2 Telefoton

A Telescience Support Unit developed by SSC on behalf of ESA is a stand-alone module enabling users to conduct telescience operations in an interactive mode on experiment facilities onboard the Russian microgravity spacecraft Foton. The first flight supported the Fluid Physics Facility and was launched in Sep 1999. A re-flight as Telefoton-2 took place in Oct 2002. Unfortunately the Soyuz launch vehicle failed shortly after launch from Plesetsk and the Telefoton-2 was lost. The launch of Telefoton-3 is planned for spring 2005.

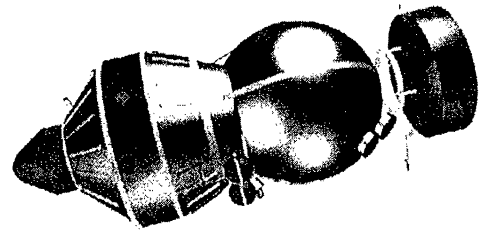


Fig 2 Foton

2.3 MAXUS

A German-Swedish joint venture offers a sounding rocket microgravity launch service in a program designated MAXUS. The Castor IV B TVC by Thiokol is used as the rocket motor. MAXUS is launched from Esrange and gives up to 15 minutes of microgravity. The experiments are recovered by parachute and retrieved to the launch site within an hour after launch.

The first successful MAXUS launch from Esrange took place in November 1992. Since then one MAXUS has been launched almost every second year. MAXUS 5 was launched in April 2003. The MAXUS 5 payload comprised i.a. the Biological Gravi-sensitivity module, BIG, developed by SSC on behalf of ESA. MAXUS 6 will be launched in the fall of 2004.

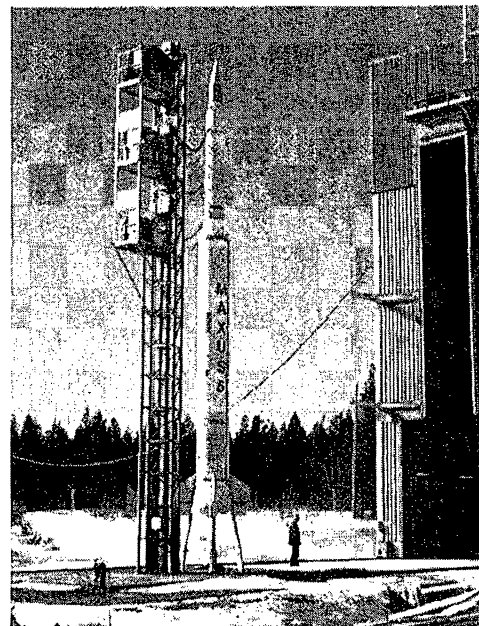


Fig 3 MAXUS-5

2.4 WIS-GAS

WIS-GAS was flown on the Space Shuttle STS-108 in Dec 2001 and was used for studying the influence of weak convection caused by surface tension forces on radial dopant segregation in seven mirror furnaces.

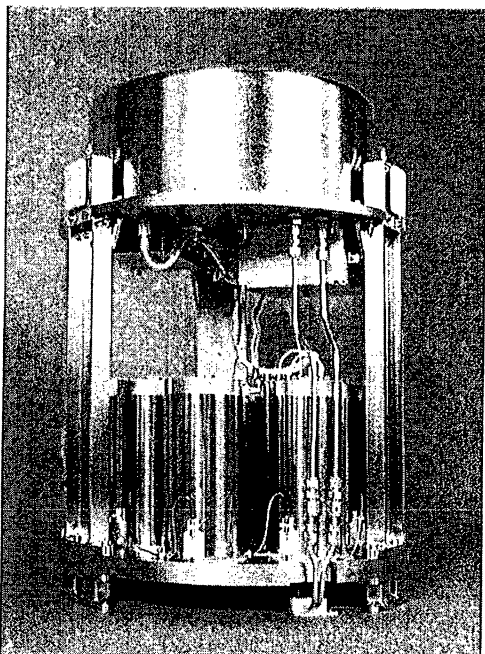


Fig 4 WIS-GAS

2.5 Hygrosond-2

Hygrosond-2 was successfully launched in December 2001. The payload was the refurbished and modified Hygrometer by MISU. The absorption module was replaced by an Ice Cluster Ion Detector from University of Colorado. The Hygrometer will be flown again onboard MAGIC, see below.

2.6 Odin

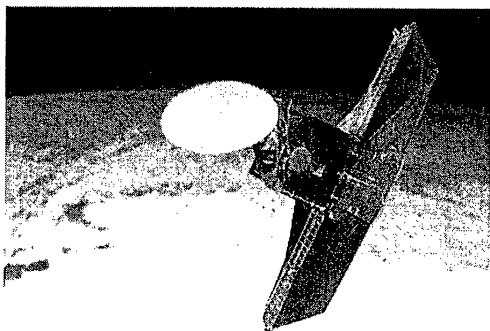


Fig 5 Odin

Odin is a Swedish research spacecraft for both astronomical and atmospheric topics, like star

formation in interstellar molecular clouds and the ozone layer depletion in the Earth atmosphere. Odin will search for important atoms and molecules using spectroscopy in previously unexplored wavelength bands, complemented by measurements at near optical wavelengths. Despite challenging goals and advanced equipment Odin will be a small, low-cost spacecraft, like the earlier Swedish research satellites VIKING and FREJA. The Odin project is carried out in collaboration with France, Canada and Finland.

Odin is 1.8 m high and 3.0 m wide and the mass is 250 kg. Odin is a dual-mission satellite with both astronomy and aeronomy and is 3-axis stabilized with a pointing accuracy of 15 arcsec. The design lifetime is 2 years and the orbit is 600 km, sun-synchronous. Odin was successfully launched in Feb 2001 onboard Start-1 and has celebrated two successful years in orbit. During these two years, Odin has circled the Earth nearly 11,000 times.

2.7 SMART-1

SSC has developed ESA's SMART-1 probe destined to the Moon. SMART-1, planned for launch in August 2003, will be used for both research and as a technology demonstrator for future projects.

SSC's project methods, as a supplier of small cost effective satellites to the Swedish national space science program, have been used as a model in the project.

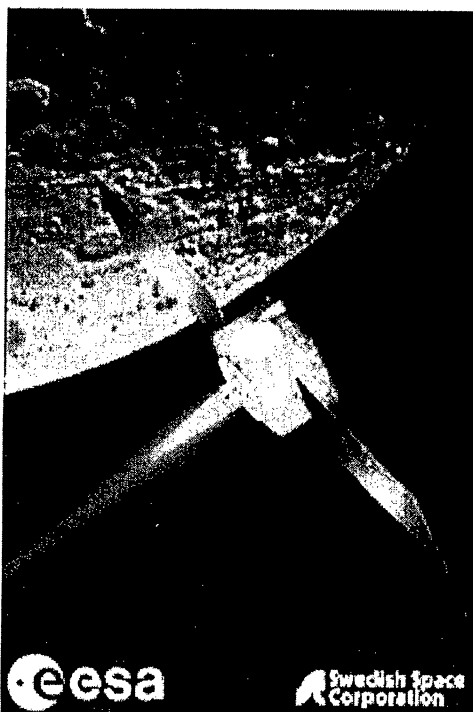


Fig 6 SMART-1

SSC's design features navigation and a star-tracker based attitude control system, derived from Sweden's Odin satellite.

The main mission objective of SMART-1 is to demonstrate innovative and key technologies for scientific deep space missions. One key technology is the solar electric propulsion used as primary propulsion.

The spacecraft will arrive at the Moon by means of the electric propulsion system (accelerated ions) after injection into GTO (geostationary transfer orbit $h_a=35781$ km, $h_p=622$ km) by Ariane 5. The propulsion system will also be used for orbit control around the Moon.

2.8 MAGIC

MISU propose the re-launch of Hygrosond-2 with additional aerosol detectors from the Naval Research Laboratory, the USA. The Mesospheric Aerosol-Genesis, Interaction and Composition (MAGIC) payload will be launched from ESRANGE in the winter of 2004/05.

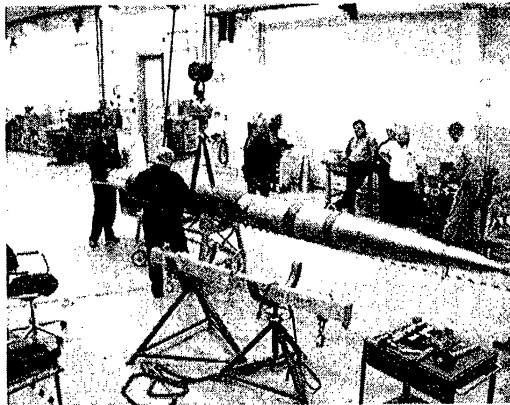


Fig 7 Hygrosond-2

2.9 Atmosphere and Climate Explorer Plus

ESA has selected SSC for a Phase A study during 2003/04. ACE+ is a constellation of 4 small satellites in different polar orbits for atmospheric profiling using radio occultation technique, for determination of the temperature and humidity in the atmosphere. With thousands of profiles per day, from ground to 100 km, theoretical models of the Earth's climate can be enhanced, for studies of climate change and better weather forecasting.

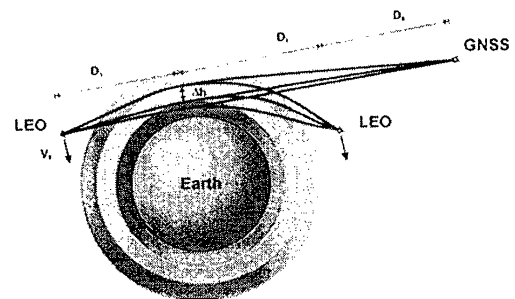


Fig 8 ACE+ radio occultation technique

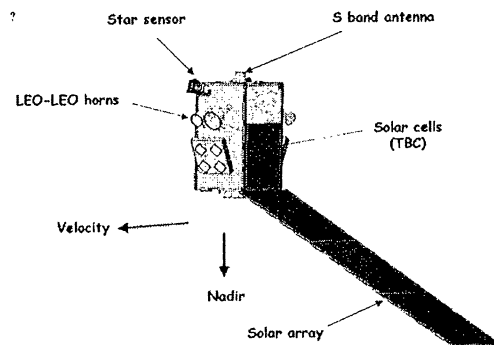


Fig 9 ACE+ in flight configuration

2.10 Unmanned Aerial Vehicles

In May -June 2002 a "historical" event took place in the Kiruna area with the flight of the Eagle-1 UAV. The Swedish Armed Forces and the Swedish National Space Board commissioned SSC for contracting EADS/IAI for demonstration flights of the Eagle UAV system. The Eagle was equipped with instruments for reconnaissance and surveillance, atmospheric research and air traffic management.

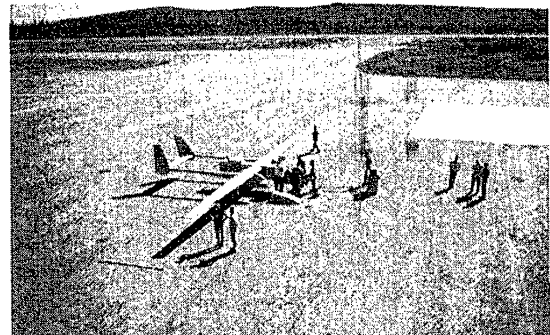


Fig 10 Eagle-1

The Eagle is a 1100 kg airplane with a wingspan of 17 m and flies with max 125 kts at 10 km during 30 hrs. MISU provided a Condensation Particle Counter for atmospheric research. The particle concentration was measured in two aerosol layers at 4 and 6 km.

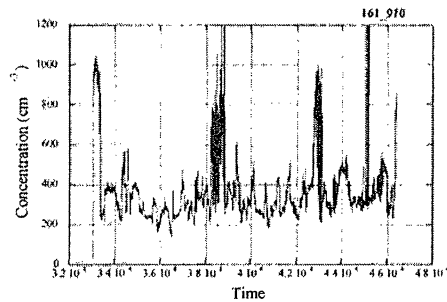


Fig 11 Particle concentration

3 PROPOSED FUTURE PROJECTS

3.1 Low cost sounding rocket

With a 14" Orion rocket with recovery, simplified payloads and procedures, and an initial investment of 50 k€, the recurrent price for the launch can be 150 k€, provided a continuous programme with at least one launch per year. A 65 kg payload can be launched to 100 km and give 5 Mbits/sec.

A possible project is a student rocket where every last class at the Space University could be given the opportunity, as a master thesis, to design, manufacture and launch a low cost sounding rocket payload.

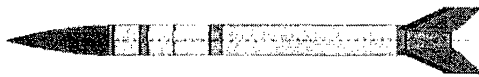


Fig 12 Orion sounding rocket

3.2 STEAM

The Stratosphere-Troposphere Exchange And climate Monitor for climate research has been discussed. STEAM will make careful measurements of water vapour, most important but least understood greenhouse gas. STEAM will use further developed, leading Odin technology. STEAM is proposed by French and Swedish scientists and others and is recommended by the Swedish SRAC.

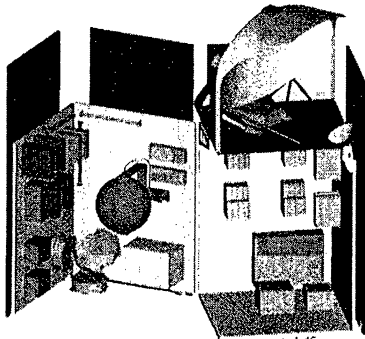


Fig 13 STEAM

3.3 PRISMA

Prototype Research Instruments and Space Mission technology Advancement is a precursor for future science missions including interplanetary mission to Mars/Venus, combined plasma and atmospheric research instrumentation and a free flyer plasma pack, providing multipoint measurements.

PRISMA will also demonstrate key technology development as AOCS onboard autonomy, data handling systems, green propellant for 1 N motor and micro thrusters. Target launch date is 2006.

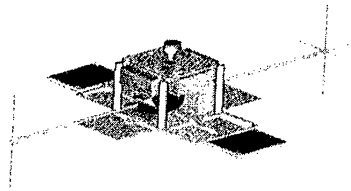


Fig 14 PRISMA

4 NORTH EUROPEAN AEROSPACE TESTRANGE

Esrangle and Vidsel have been used for many years as ranges for sounding rocket launches and missile firing tests respectively. The ranges have restricted airspace and a corridor between them can temporarily be restricted creating Europe's largest aerospace test range covering a land area of 360 by 180 km. Large investments in technical infrastructure and support facilities have been made during the years for advanced aerospace testing. An agreement between Vidsel and Esrangle for co-operation has been signed. An increased interest for Unmanned Aerial Vehicles has been noticed. UAV's need airspace for testing and training, which is limited in Europe and other heavily populated areas but can be provided by the unique NEAT. The long term objective for NEAT is to be a Center of Excellence in Europe for UAV testing and training. High altitude scientific research with aircrafts and stratospheric balloons is ongoing. Testing of scale models of future reusable space transportation systems are ongoing. The area has a favourable subarctic climate allowing operations all the year around. A well developed regional infrastructure is available as well as a rich environment for recreational activities.

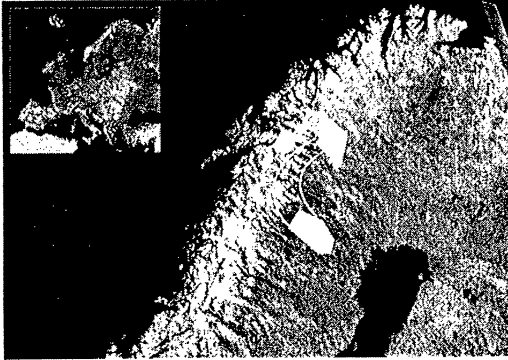


Fig 15 NEAT